Factors Affecting Drivers' Willingness to Engage with a Mobile Phone While Driving

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Abstract

This thesis investigates drivers' willingness to engage with a mobile phone while driving. Many studies have looked into the effects on driving performance that can result from phone usage, but few studies have directly considered what can encourage or inhibit phone engagement behaviours in the first place.

An initial exploratory study (Study 1) was conducted, for which a photo elicitation interview (N=20) was designed and implemented. This aimed to find the extent to which factors influencing phone use transferred from out of the car to the driving environment. In particular, the study aimed to explore whether the driving environment could be considered unique. The results indicated that the high demands placed on the driver by the road environment clearly distinguished it from the other environments and the reported propensity to use a phone seemed to reflect this. Only factors which either changed the level of attention required by the task, such as a change in task demand as a result of changes in the traffic environment, had any substantial influence on willingness to engage. Driving may not be unique in terms of the overall factors influencing phone use but it is unique in the extent to which this particular factor seems to have such a strong bearing on interaction.

Building on findings from Study 1, that the demand and attention required seemed to influence willingness to engage, it was noted that Fuller's (2005) Task Capability Interface model would serve as a useful framework for the remainder of the thesis. This model suggests that driver behaviour is dictated by the level of task difficulty perceived; an interaction between task demand and capability. Therefore, the effects these two elements might have on willingness to engage with mobile phones while driving were tested separately in the two remaining studies.

Previous research suggested that task demand should comprise a combination of roadway demand and the intended phoning task. Study 2, therefore, experimentally tested the extent to which road *demand* and *phone function* intended to be used influenced drivers' decisions to engage with their phone. Participants (N=20) viewed video clips of real road environments of varying demand. Rating scales were used by participants to rate their willingness to engage with various phone functions according to the scenario they had just viewed. It was found both roadway *demand* and *phone functionality* affected *willingness to engage* with a mobile phone whilst driving. There was a higher propensity to engage in phone use in road environments perceived to have a *lower demand* and lower propensity to engage in phone use in the *highest demand* scenarios. *Answering a call* was the most likely function to be engaged with by the participants and *sending a text message* was the least likely.

The final study investigated how capability (comprising both phone and driving capability) influenced willingness to engage. Participants (N=40) were required to drive in a simulator under two conditions, simulated *low* and *high* road demand. Their willingness to interact with their phones, when faced with a number of phone tasks, was then observed. It was found that *driving capability* had an effect on willingness to engage in *high demand* scenarios with the less capable, novice, drivers having a higher propensity to engage with *placing a call, sending a text message* and *reading a text message* than the more experienced drivers. Novice drivers were willing to engage with some functions on their phone at possibly inappropriate times. It was further found that, in the simulated *low demand* road environment, *phone capability* influenced willingness to engage, with those who were more capable at *placing a call* and *sending a text message* found to be more willing to engage with these functions.

The research reported in this thesis represents the first attempt in the literature to study, in depth, the factors which can influence phone engagement behaviour while driving. Novel contributions include investigating if factors influencing phone use transferred from out of the car to the driving environment. Further novel contributions included whether the phone function and road demand interact to influence willingness to engage and whether capability can affect phone engagement behaviour while driving.

Extending the model developed by Fuller, the thesis offers an original model that describes the factors affecting phone engagement behaviour while driving. Suggestions are proposed for how the findings presented in this thesis can effectively be used and how future work should build on these initial foundations.

Publications

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Contents

Chapter 1: Introduction

1.1 Introduction Overview

This chapter will first outline the purpose of the thesis. This will be followed by definitions of willingness to engage and smartphones as used in the thesis. It will then establish the reasons why driving and phone studies are important and the gaps in the research in this area which the thesis will address. The introduction will be concluded with the specific aims and objectives of the thesis and an overview of each chapter.

1.2 Background and Motivation for Research

This thesis addresses drivers' willingness to engage with a mobile phone. It will investigate the problem using an open, exploratory, approach and then narrow down to test how specific factors, including roadway demand and capability, can influence willingness to engage with a phone while driving. Many studies have shown driving while using a phone to be dangerous but little is known about when or why drivers interact with the device in the first place, so the extent to which drivers are aware of, and try to mitigate, the risk of phone use while driving is unknown. The thesis, therefore, has an overall aim of gaining a greater understanding as to what can determine the precise factors which influence engagement with phone use while driving

1.3 Definition of Willingness to Engage

A small number of studies investigating willingness to engage with mobile phones while driving exist, such as Horrey et al. (2009a), Lerner (2005), Horrey et al. (2008) and Atchley et al. (2011). However, none clearly define what is meant by the term 'willingness to engage'. Rozario et al. (2010) used Gibbons et al. 's (1998) prototype willingness model and stated '*behavioural* *willingness is described as being more prevalent than intentions in situations when the opportunity to perform the behaviour presents itself (spontaneous action), aside from whether the individual planned/intended to perform the behaviour*', this suggests willingness is different to intention. Gibbons et al. (1998) further mentions Walsh et al.'s (2007) viewpoint that '*mobile phone use is often a more spontaneous rather than planned behaviour'* but they do not at any point give an exact definition of what they regard willingness to engage to mean. A definition of willingness to engage has therefore been created for this thesis:

'A willingness to engage indicates that taking into account perceived risk or barriers, the subject has deemed that interaction with the task would certainly occur if a sufficient need or desire arose'.

It should be noted that having a willingness to engage does not necessarily mean the subject is actually going to use the phone. They may be willing to engage but have no motivation for phone usage. For example, when driving on an empty stretch of straight road the driver may judge that they would be willing to engage with a secondary task, such as phone use, but may not actually be on their phone as they have no reason or desire to do so.

There is considered to be a difference between willingness and intent to engage, with willingness taken as more concrete a judgement on engagement behaviour, whereas intention may still be thwarted by barriers or risks that have not yet been considered. It is considered possible to have an intention to engage but then be unwilling to do so, for example the subject intends to phone another party, such as to inform they are running late, but are unwilling to engage at that specific moment due to experiencing a high road demand at the time. Similarly, an intention is not always necessary for willingness judgements to occur. Willingness can sometimes be considered a more reactionary, snap judgement. For example, if a subject has answered an incoming call they have demonstrated a willingness to do so but may have had no intention prior to the phone ringing, both can be considered 'transient' states depending on the circumstances.

1.4 Smartphone Definition and Reason for Study

Over half of the UK (51%) now own a smartphone, constituting 56% of all phones used in the UK (Ofcom 2013). These percentages will vary based on what is taken to be meant by the term smartphone. Currently there is not a definitive definition of what constitutes a smartphone in either the phone use literature or technology sector (Himmelsbach 2012). Numerous different definitions are in use, varying in detail and prescriptiveness. Some examples include:

‘Smartphone - a category of mobile devices between cellular phones and personal computers. A smartphone should include the following characteristics: a) is always able to connect to the Internet; b) runs a decent operating system; c) can be extended through hundreds of add-on applications’ (Litchfield 2010).

Vodafone Group PLC (2013): ‘*A smartphone is a mobile phone offering advanced capabilities including access to email and the internet’.*

For the purpose of this thesis a smartphone will be defined by its capabilities for ease of identification. Therefore, a phone will only be taken to be a smartphone if it features functions in advance of talking or texting and these must include internet connection capabilities along with the possibility to download applications onto the device to further expand its capabilities. These functions, which include internet, email, applications, games, satellite navigation and MP3 players will be referred to as ‘advanced functions’ within this thesis. Advanced functions can be defined, for the purpose of this thesis, as ‘features on the phone which transcend traditional phoning and texting mediums, extending the phone’s capabilities’. Smartphones can be defined as ‘a phone which features advanced functions, allowing for the extension of its capabilities beyond traditional phoning and texting capabilities’.

As a result of these advanced functions the usage of smartphones may differ vastly from earlier talk and text phones. The factors encouraging or inhibiting someone's willingness to engage with the phone may also therefore have changed.

1.5 Introduction to the Research Area

1.5.1 Phone Use While Driving

The invention of the telephone can often be taken for granted but its extraordinary ability to allow conversation between two people in two different places, even so far as being in a completely different country, is unparalleled. As Katz et al. (2002) highlighted, even in the natural world there is no equivalent which would have allowed humans to imagine how this ability might change their lives, as birds had offered prior to airplanes or horses offered for cars.

This augmented ability to still communicate, even from very disparate locations, has helped to increase the modern pace of life by allowing communication in otherwise 'dead time', such as when walking around the shops or sitting during a lunch break. This technology also offers a far more worrying capability though: phone use while driving.

This may initially not sound cause for concern, passengers and drivers have been talking to one another since the advent of driving. However, studies have shown a difference between passenger conversations and those conducted via a mobile phone, with conversing with car passengers found to be far less distracting than to a caller on the end of a mobile phone line, even when in a hands-free medium (Drews et al. (2008), Charlton (2009)). This effect is likely a result of the vehicle passenger being aware when driving demand increases meaning they can understand why the driver may suddenly become inattentive to their conversation and so not press the conversation further until the road demand had dropped again. However, the mobile caller may be unaware of the road situation, or even in some cases that the other phone user is driving at all, so the pauses in conversation are less tolerated.

With the increase in capabilities that modern smartphones now offer this has led to an extension in possibilities for distraction far beyond simple conversation but now extending to text messaging, email and internet access to name just a few of the temptations for interaction while driving, far less is known about how these impact driving performance.

1.5.2 Mobile Phone Adoption and Rate of Use While Driving

There are now more mobile phones in use than ever before with around 92% of the UK population owning a mobile phone in the first quarter of 2013 (Ofcom 2013). Eby et al. (2006) said this increase in phone adoption would inevitably lead to increasing usage while controlling a vehicle, more recent studies supported this with between 32 to 60 percent of drivers found to use their mobile phones while behind the wheel (Brusque et al. (2008), Young et al. (2010)). This equates to a large number of people using a phone while driving at any moment in time and shows the importance of research on this topic.

1.5.3 Young Drivers and Phone Use

The rate of phone use also varies based on age. It has been found that younger generations are typically early adopters of technology, this is particularly true for mobile phone technology with 98% of 16-24 year olds owning a mobile phone compared to 68% of over 65's (Ofcom 2012). This high adoption rate of mobile phones by younger people has been found to also transfer to a high phone usage rate behind the wheel compared to other age groups (Lamble et al. (2002), McEvoy et al. (2006) and Young et al. (2010)). This is of particular concern as younger drivers are already known to be over represented in road traffic accidents worldwide, this is at least partially a result of their driving inexperience affecting their performance while controlling a vehicle (Lourens et al. (1999), De Craen et al. (2011)). Lower levels of driving experience and performance, combined with a higher propensity towards phone engagement, may lead to ever increasing representation in accident statistics for this age group. Older, more experienced, drivers may be able to compensate for this increase in distraction to some extent due to their higher level of driving skill. Although, the extent to which this skill set can offset the impairment caused by phone use and still allow safe driving is unknown. The younger generation also bring up unique questions as they are the first to have grown up with mobile phone technology from an early age. The extent to which this has led to high levels of capability with the devices, both in and out of the car is unknown. Similarly, whether this level of phone capability could mean phone use leads to less impairment in driving performance for this user group, due to the phone task taking up fewer attentional resources, is also not currently known.

1.5.4 Phone Use Accident Statistics

As adoption levels for mobile phones are now high amongst most age categories an increasing proportion of drivers using their phone is to be expected. With this increase in phone use, leading to higher numbers of distracted drivers, it seems inevitable that there should also be an increase in road accidents as a result. Despite this the number of road accident deaths has generally been falling year on year, with 1,754 deaths reported in 2012 in the UK, the lowest figure since national records began (Department for Transport 2013b). It could be possible these advances in safety technology are able to mitigate the effects of increased accidents as a result of phone use while driving. However, a closer look at the statistics shows phone use while driving contributed to only 17 reported road accident deaths in 2012 in the UK, representing just 1% of all the reported road fatalities, they also contributed to just 67 serious accidents and 294 slight accidents (Department for Transport 2013a). This may partially be down to the way these statistics are collected, this is because phone use while driving is an illegal act in all but hands-free medium in the UK so drivers may not confess they were using the phone when asked at the scene of the accident for fear of being penalised. The Royal Society for the Prevention of Accidents (2002) noted this, highlighting it is difficult to quantify the exact increased risk caused by using a phone while driving because in the UK, and most other countries, whether the use of a mobile phone lead to an accident is not collected at the scene of the accident, or adequately followed up at a later date, except occasionally in the event of very serious accidents. The effects of phone use may therefore be underrepresented in many accident statistics.

It could also be that phone usage increases the number of near –misses whereby distraction from phone use causes the driver, or other drivers, to react to avoid a collision and these too would not be represented by accident statistics. There have been a small number of naturalistic driving studies- which observe and report on drivers' actual behaviour- which can help to give an account of the extent to which secondary tasks can lead to traffic accidents. From these studies it has been found that 78% of all accidents involved some form of driver inattention and wireless devices (predominantly mobile phones -mostly conversations more so than dialling) were prevalent in 7% of all events (Klauer et al. 2006). Sayer et al. (2007) found from their naturalistic driving study that, of all the secondary tasks engaged with, mobile phone use led to the greatest impact on steering angle variance. Phone use also had the greatest impacted on variance in lane position, suggesting this task affected car control to a greater extent than other secondary tasks. These findings help to justify concerns related to mobile phone use while driving. There is a higher prevalence of use and impact on driving performance as a result of phone use observed in these studies than is currently captured by accident statistics.

There is a disparity between the highly distracting effects of phone use found in controlled studies and phone uses' low representation as a contributing factor in accident statistics. This could be the result of drivers having effective coping mechanisms for using the phone while driving. Many laboratory based studies testing distracting effects of phone use have forced interaction with the phone to test how distracting its usage is. However, as Lerner (2005) highlights 'the actual risk associated with some device will be a joint function of how the use of that device interferes with driving and the circumstances under which drivers are willing to use it'. It may be possible that drivers are only engaging with their phone if they feel capable and that it is safe to do so and are perhaps very good at judging this, which is why the thousands of road users who are using a phone while driving at any given moment aren't having accidents at the rate that would be expected based on current literature findings. The extent to which drivers delay their phone interaction based on current road circumstances is under some debate in the literature and other factors, such as to what extent an individual takes into consideration their driving ability or skill at using the phone before engaging with it while driving, is very under researched. These questions will be attempted to be answered in the course of this thesis.

1.5.5 Phone Use and Driving Summary

This section has demonstrated that a very high proportion of the population now own a mobile phone and therefore a very high proportion of drivers carry this temptation with them every time they get behind the wheel. There is currently a lack of understanding as to why distraction from using a phone still contributes a very low rate to accident statistics. Previously demonstrated distracting effects show the importance of gaining knowledge of factors which can influence an individual's decision of whether to engage with their phone or not while driving.

1.6 Aims and Scope of the Thesis

The main aim of the thesis is to understand the factors that affect willingness to engage with a mobile phone while driving. This aim will be addressed through answering three research questions:

1) To identify the factors which influence smart phone usage when outside of the car and the extent to which these transfer to the driving context
2) To determine if road demand has an effect on willingness to engage with phone functions while driving
3) To determine whether *driving capability* or *phone capability* affect the situations in which drivers are willing to engage with their mobile phone

1.7 Thesis Structure

This thesis will feature a literature review followed by three studies. Both quantitative and qualitative methodologies (a multi-modal approach) will be used to address the aims and objectives of this thesis. The literature review aims to identify current knowledge in the phone use behaviour literature as well as highlighting any important gaps which exist, emphasising potential avenues for investigation in the process. The first study was designed to take a broad look at factors which may influence willingness to engage with a phone while driving and the extent to which these are unique to the driving environment. This study revealed a number of factors which had an effect on engagement in phoning behaviour while driving and allowed for prioritisation of factors which most required further exploration. The second study aimed to test if specific factors, which were informed by Study 1, affected mobile phone engagement while driving. It focuses on the extent to which road demand experienced by the driver leads to a delay in mobile phone engagement with a number of phone functions. The third study also focussed on specific factors which could influence willingness to engage with a mobile device while driving, this time specifically relating to capability. Both phone capability and driving capability were tested to see to what extent, both perceived and actual, ability to conduct the phoning task while driving then influenced willingness to engage with such tasks in a simulated road environment.

1.8 Synopsis of Thesis Chapters

1.8.1 Chapter 2- Literature Review

The literature review chapter focuses on all aspects relevant to the issues of phone use. It starts by establishing the extent of phone use out of the car, the factors which can influence this, such as age and gender, and the current findings on research of typical locations where phones have found to be used or not used. It goes on to consider in-car phone use specifically. First models of driver behaviour are investigated and how these may relate to phone use behaviour considered. Current knowledge on the distracting effects of phone use while driving are then reviewed, along with what is currently known about the factors influencing willingness to engage with mobile phones while driving.

1.8.2 Chapter 3-Methods

In this section different research approaches and methods are reviewed in relation to their appropriateness for the studies carried out in the thesis. The method chosen for each study is given along with the reasoning why. This is further supported with a review of methods that were discarded and the rationale behind why they were not chosen.

1.8.3 Chapter 4- Study 1- Interviews

This chapter describes photo elicitation interviews (N=20) conducted with smartphone users who were also drivers between July and August 2010. It aimed to find the factors which influence whether someone engages with their phone or not while driving in a number of environments. These included when in meetings, restaurants, shopping or on public transport as well as when driving. The study further sought to find the extent to which factors which influence phone use when out of the car transfer to when driving also, i.e. whether driving could be considered a unique environment in terms of willingness to engage. Discussion of the study's findings is included in this chapter.

1.8.4 Chapter 5- Study 2- Willingness to Engage Ratings

This chapter describes a study which took place between February and April 2011. Drivers (N=20) viewed video clips of various road environments, representing different levels of road demand, then using rating scales rated their willingness to engage with various phone functions if they had been driving the scenario depicted in the videos. They were also asked to 'think aloud' when making ratings to allow insight behind their answers to be gained. Discussion of the study's findings is included in this chapter. The results of this study were presented at the 2012 European Conference on Human Centred Design for Intelligent Transport Systems in Valencia, Spain. They were also published in the proceedings to this conference. An extended version of the conference paper was then published as a journal paper in IET Intelligent Transport Solutions, Human Centred Design Special Edition in 2013.

1.8.5 Chapter 6-Study 3- Driving Simulator

This chapter describes a study which took place between May and July 2012. This used a driving simulator to test if participants' (N=40) willingness to engage with their phone varied based on either their level of driving capability or phone capability. Their phone capability while driving was measured by recording the participant' performance on the Lane Change Task (LCT) while using different phone functions (placing/ answering a call and sending/ reading a text message). Their self-rated capability for both the driving and phone tasks were also collected and analysed in terms of how this influenced their willingness to engage while driving. Actual driving capability was measured using years of driving experience. Discussion of the study's findings is included in this chapter

1.8.6 Chapter 7-General Discussion and Future Work

This chapter adds to the discussion of findings in the individual study chapters as well as discussing the overall findings of the thesis as a whole. Based on results of the studies reported in previous chapters, this chapter shows how the studies fully addressed the thesis aims, the extent to which the findings support Fuller's (2005) model (see literature review for more on this model) and to what degree the findings may explain why phoning while driving is not a prominent contributory cause of accidents in the current road accident statistics. Several avenues for possible future research are also discussed.

Chapter 2: Literature Review

2.1 Introduction

This review will first establish current phone adoption rates and the reasons behind this adoption. As phones are now a ubiquitous technology, knowledge on current phoning behaviour and common places for usage, when out of the car, will then be reviewed. How these behaviours are affected when a driver takes control of a vehicle will then be considered starting with a review of models of driver behaviour, moving then to the possible consequences for driving performance of using a phone whilst driving. This will be followed by investigating factors which may influence these consequences and finally exploring what is known on why drivers may choose to engage in such behaviours in the first place.

2.2 Out of Car Phone Use

In recent years mobile phone adoption has risen greatly, in the year 2000 only half of UK adults reported owning a mobile phone, in 2011 this had risen to nearly 92% (Ofcom 2012). These devices were originally developed with business use in mind but have since seen a very high adoption rate by the mass market. The most recent development in phones (termed smartphones) has seen an increase in device capability with functions, such as email and internet access, being added to the communication options they provide. Smartphone adoption is already high with 39% of the British adult population in possession of one in 2012, an increase of 12% compared to 2011 (Ofcom 2012). In the 16-24 and 25-34 age categories the smartphone adoption rate was even higher at 66% and 60% respectively. This increase in smartphone ownership has led to a change in the way mobile phones are used, with talking on the phone now representing less than half of the traffic on mobile phone networks (CTIA 2012). This section will first review the literature on phone use behaviour before moving on to review the intrinsic motivations found to drive these behaviours.

2.3 Behavioural Characteristics of Phone Use

As mobile phones can be used anytime, anywhere and in a number of different ways (such as talking, texting or emailing) this has resulted in studies being conducted to help build a picture of phone usage patterns in terms of the phone functions people engage with, the frequency and duration of these interactions and the locations in which these interactions most commonly occur. This section will, therefore, focus on how, when and where people have been found to use their mobile phones.

2.3.1 Rate of Phone Use

With the capabilities of phone technologies constantly evolving the rate of usage and the functions being used are also constantly changing.

For example, in comparable self-report phone usage studies, there was an increase in phone use duration from 9.5 hours a month in 2006 (Campbell 2006) to 4.5 hours a day in 2011(Sutter et al. 2011). Some of this increased time appears to be taken up by text messaging, with the amount of messages sent in the USA more than doubling (from 1.005 billion to 2.190 billion respectively) between 2008 and 2011 whereas the amount of voice minutes consumed barely increased (from 2.203 billion to 2.300 billion respectively) (CTIA 2012).

Europe has been shown to have adopted SMS earlier and to a greater extent than the USA (Zhang et al. 2005). On average in the UK 200 text messages were sent a month per inhabitant in 2012 (Ofcom 2012). The rise in text based mobile phone communication has increased to such an extent in the UK that it is now the most heavily used medium for daily communication with friends and family, replacing organised face to face catch ups and talking on the phone (Ofcom 2012). There was, however, found to be a marked difference in favoured communication type based on age with 90% of 16-24 year olds using text messages more than any other medium. In contrast, just 15% of over 65 year olds were found to text message daily; calling using a landline phone was their most favoured medium (Ofcom 2012). Although older phone users are less frequent users, in terms of the amount they use mobile phones and the mediums they adopt, even this age group are showing an ever increasing willingness to use such technologies, with those over 65 years of age having a mobile phone adoption rate of 47% in 2005, increasing to 68% in early 2012. However, this was still some way behind the 16-24 age groups' 98% phone ownership rate (Ofcom 2012).

Just as text messaging is being used to a far greater extent than was ever predicted, the next significant technical development in mobile communication is equally hard to foresee. Social networking sites, such as Facebook, may be one such trend after developing in response to the increasing capabilities of modern smartphones, leading to a high proportion of younger phone users in particular now using their phone to access such sites. In 2011 62% of 16-24 year old accessed Facebook on their smartphone in the UK (Ofcom 2012). Similarly internet data usage was 424 Mb per person on smartphones and tablets in 2011, a 60% increase over 2010, demonstrating a change in usage behaviours for these modern devices (Ofcom 2012).

These facts and figures demonstrate the pervasive usage of modern mobile phone technology. Such high adoption and usage levels raises questions as to where it is, and is not, being used and why. These factors will be considered in the next section.

2.3.2 Location of Phone Use

Although the development of mobile capabilities now allows complete freedom of location for phone use it has been found that people don't take much advantage of this technology's nomadic capabilities. Mobile phones are used most frequently in their owners' homes, most commonly between the hours of 6pm and 12am (Totten et al. (2005), Lee et al. (2009)). This shows a change in phone behaviour compared with a number of years ago, when fixed landline phones would take precedence over mobiles when at home (Wan et al. 1999). The reversal is presumably a result of the high adoption rate and usage of mobiles leading to lower costs for mobile calls compared with fixed line calls.

Further popular venues for mobile phone usage include: in the street, at school, places of business, gyms, in cars, while shopping, in restaurants, and while on public transport (Wan et al. (1999), Aoki et al. (2003), Totten et al. (2005)). The day of the week has also been found to influence which of these locations phones are used in and for how long, with LaRue et al. (2010) finding mobile phone calls were of longer durations at weekends but used in more varied locations on weekdays.

The findings suggest that people are, to some extent at least, taking advantage of the nomadic nature of mobile phone technology, with few places where people haven't reported to have used their phones. Although, there is some evidence to suggest it isn't just the 'mobile' nature of these phones that appeals to people as this technology is increasingly used in the home as a replacement for fixed landline phones.

2.3.3 Gender Differences in Mobile Phone Usage

The review has outlined what functions people use on their mobile phones, and where. However, there is indication that the gender of the phone user can also affect this. It has been found that females are more inclined to initially purchase their phone for safety or security reasons than are males. Furthermore, once purchased females use the phone for calling immediate family for longer durations as well as more often than males do. Women are also more likely to use a range of applications that focus on communication including voice, text and social network sites. Males on the other hand have been found to use their phone predominantly for business or entertainment purposes, as opposed to as a tool for socialising, taking a more utilitarian approach to phone use (Rakow et al. (1993), Henderson et al. (2002), Skog (2002), Totten et al. (2005), Lee et al. (2009), Haverila (2011)).

The next section of the review will investigate this area further and will consider underlying motives for phone purchase and engagement.

2.4 Intrinsic Motivation for Mobile Phone Usage

The preceding sections indicated considerable variation in when, where and how mobile phones are used. The following section will investigate what has currently been found with regard to the underlying factors that drive and motivate the phone usage behaviours described as well as initial phone purchase and adoption.

The mobile phone literature shows a great variety of reasons given for both initial purchase and continuing usage of mobile phones. There is some suggestion that people can even be categorised based on their usage behaviours and motivations for phone use (Aoki et al. 2003). It should be noted, however, that phone use motivation studies can only investigate the stated reasons for phone purchase – users may obviously have other motivations that they don't choose to declare. A frequently cited reason for mobile phone usage, and especially initial phone adoption, is to provide safety or security. Mobile phones appear to be viewed as a means of getting help in the event of an unfortunate event occurring. Diverse groups of people including road users, people who regularly walk alone and the elderly have been cited as indicating safety or security as the predominant reason for phone adoption and continued usage (Ling (2000), Palen et al. (2000), Aoki et al. (2003) and Conci et al. (2009)).

Another cited reason for mobile phone usage is to save money. Aoki et al. (2003) termed this group as 'cost conscious' phone users and suggests this group predominantly features students who live away from home and would otherwise have to pay high tariff rates on dormitory landline phones to stay in touch with their family. This point may be less credible now with the advent of Skype, Facebook and other free, or very inexpensive, means of communication. However, a smartphone can clearly be used to access such services in a more convenient or nomadic medium than on a fixed location computer.

Phone use has also been shown to be driven simply because of the importance that users place on social communication and keeping in touch with people and this technology allows them to do so anytime, anywhere (Chen et al. 2009). People who fell into this group were termed 'dependant' phone users by Aoki et al. (2003) as they were found to have strong emotional reactions if they were away from their phone, with descriptions such as feeling 'lost' when kept away from the technology. In a similar vein some users reported having the phone so they were permanently contactable, with more of an emphasis on the device as a means of being reachable when necessary, as opposed to themselves using the phone to contact others just for the pleasure of social interaction (Totten et al. 2005).

Further cited reasons behind mobile phone adoption or usage have included as a means of entertainment or stimulation when the user is bored (Totten et al. 2005) and for micro-coordination, such as informing others that they are running late for a pre-arranged meeting when they are on their way to the destination (Ling 2000). As well as the device being used for its communication abilities it has been found some users derive pleasure from the style of the device itself, with the choice of handset and use of the phone acting as a status symbol (Aoki et al. 2003), this is thought to be a particularly prevalent motivation behind adolescents' phone adoption and use (Katz et al. (2005), ChÓliz (2010)).

There has been speculation that for some people phone use is no longer a choice but in fact an addiction. Block (2008) noted a need to distinguish heavy technology use from addiction. He gave the four following components as necessary to be present to be defined as technology addiction: *'1) excessive use, often associated with a loss of sense of time or a neglect of basic drives, 2) withdrawal, including feelings of anger, tension, and/or depression when the device is inaccessible, 3) tolerance, including the need for better equipment, more software, or more hours of use, and 4) negative repercussions, including arguments, lying, poor achievement, social isolation, and fatigue'.* A number of these behaviours have been observed, and taken as evidence of addiction, in the phone usage literature (Katz et al. (2005), ChÓliz (2010), Dixit et al. (2010), Aggarwal et al. (2012), Krajewska-Kułak et al. (2012), Ritu et al. (2012)). Although there is also some evidence to the contrary, instead suggesting phone users can adopt unhealthy practices towards phone use, which can be considered technology abuse, but not addiction (Sanchez-Carbonell et al. (2008), Beranuy Fargues et al. (2009)).

The review outlined the primary stated motivations for how and why phone users may have decided to use their phone, but these studies give little attention to the environmental factors which may still pose limitations on peoples' actual ability to do so. John et al. (2002) separated environmental factors which may affect technology usage into four categories: 'The Micro Environment' which encompassed the immediate physical surroundings which support or inhibit technology use, for example whether the person is sitting, standing or walking; or the ambient lighting and other immediate physical factors which can influence phone use. The second factor was termed 'The Physical Macro Environment', this referred to issues such as *'the available infrastructure for power, connectivity and other resources, mode of transportation, climate and geography'*. 'The Temporal Environment' was concerned with the time available and demands on both time and attention. Finally, 'The Socio Cultural Environment' which took into consideration what was constituted as appropriate for use in a particular environment, for example the necessity to talk aloud whilst using a device. These variables bring to our attention possible limiting factors for nomadic technologies when used in everyday life. Unfortunately, attention to this topic seems to be limited with little, if any, specific reference, use of, or attempts to validate these classifying factors in the current phone use literature.

It seems from the review conducted that there are many potential reasons for phone adoption and usage and it may even be possible to separate phone users based on common propensities towards phone usage and underlying motivations for phone ownership. These differences in usage propensities and attitudes towards mobile phones may also influence peoples' views on the acceptability of using phones under certain circumstances. For example (Aoki et al. 2003) found a strong correlation between heavier phone use and the feeling that mobile phones are necessary in today's world. The next section will review the literature on phone use attitude and perceived acceptability.

2.5 Acceptability of Phone Usage

There are relatively few studies into mobile phone use behaviours given what might be expected for such a pervasive and influential technology. It was suggested by Lasen (2005) that this is probably a result of the 'neutrality' of the device, given landline phones already exist so not much 'new' was expected to be added with the introduction of mobile phones. The internet and cinema, amongst other technologies, could be considered far more spectacular and thus better researched. This may now be changing with the introduction of smartphones as their capabilities are significantly more sophisticated than those available on simple voice and text oriented mobile phones. This section will look at the factors that influence how phones are used in different contexts and the factors which can influence this. Related to John et al. 's (2002) 'Socio-Cultural' variable, it will also investigate what are considered to be acceptable and unacceptable phoning behaviours and the extent to which this can dictate phone engagement behaviour.

Conversations on a mobile phone can be considered a publicised, private behaviour, i.e. a behaviour which benefits the individual privately, but which may also inconvenience or irritate those in the same public space (Wan et al. 1999). Two possible causes of annoyance from mobile phones are loud ringing and overheard conversations. It has been found that one sided mobile phone conversations (only one part of the conversation can be heard) were deemed more annoying, noticeable and intrusive than two sided mobile phone conversations (where the device is on speaker phone so both sides of conversation can be distinguished). Similarly, one sided mobile phone conversations were also deemed more annoying, noticeable and intrusive than one sided face to face conversations (where both the people involved in the conversation could be seen but only one side of the conversation could be heard) and two sided face to face conversations (see and hear both conversation participants) (Monk et al. (2004), Sutter et al. (2011)). This suggests it isn't just the one sided nature of mobile phone conversations that cause the annoyance but more specifically the act of having a one sided conversation on a mobile that causes the heightened levels of irritation.

Furthermore, it does not appear that the volume of speech is a leading factor for what causes annoyance when on a mobile phone either as, when matched for volume, mobile phone conversations were deemed more annoying than were face to face conversations (Monk et al. 2004). Although, an overheard one sided mobile phone conversation has been found to be more distracting than overhearing two people in the same room talking to one another (Emberson et al. (2010), Galván et al. (2013)). This inability to 'block out' the one sided mobile phone conversation may be one of the reasons why there is evidence of phone use being particularly annoying. A greater amount of attention also seems to be given to phone conversations, with people able to recall more of an overheard phone conversation than an overheard face to face one, even when they had not been asked to listen in, which may be another explanation for why phone calls are considered more irksome (Galván et al. 2013). It is also possible that one-sided overheard calls are so intrusive because the annoyed person can't stop themselves contributing the missing dialogue.

It has also been found that when asked people are able to give a coherent and well-rehearsed criticism of phone users' behavior, suggesting the problem is a social and well discussed one.

Words used to convey the feelings evoked by inappropriate phone usage included: *disgusting, unreasonable, awful, I could throw up, repulsive and unacceptable*. Such strong words indicate the intensity of feelings which inappropriate phone use can induce (Ling 1997).

In terms of the feeling of discomfort the phone users themselves experience when intending to talk on the phone it has been found that generally people feel more comfortable answering as opposed to placing a call when other people are around. Also locations where participants felt most comfortable to use their phone were the locations where they rated it least annoying if others did the same, suggesting perception of other peoples' opinions about phone use acceptability may dictate the level of comfort induced when conducting a call in a public location (Turner et al. 2008). More specifically, phone users reported feeling most comfortable calling on the phone in open and populated environments, such as when in the street or shopping. They felt least comfortable in more closed environments, such as in the office, bars or restaurants (Turner et al. 2008). These findings suggest John et al.'s (2002) Socio Cultural Environment factors were a stronger driver against usage than the technological infrastructure or other environmental factors. This led to higher phone use in environments where there were likely to be fewer social 'punishments' for phone use, such as stares and comments from those nearby as a result of using the phone.

Turner et al. (2008) also found those who scored higher on psychoticism (less regard for the feelings of others) and to some extent extroversion were also more likely to engage with their phone. Extroverts were not found to feel any more comfortable about using their phone in public than introverts were; their higher phone use could possibly be explained by a larger desire to connect with others, as opposed to feeling more comfortable or having a different view on acceptability of phone usage.

It was further discovered that younger people are less likely to become annoyed when in proximity to a phone user than those of an older generation (Turner et al. 2008). The younger generation also believed the general publics' phone manners in public places to be more acceptable than older generations did (Hakoama et al. 2012). It has similarly been found that males become more easily irritated by others' phone use than do females (Turner et al. 2008).

Although phone use may be considered unacceptable and annoying under some circumstances when conducted in public, there has nevertheless been shown to be certain social practices performed to help deal with being in close proximity to a phone user. It seems that a feigned inattentiveness is a common way to behave when overhearing private phone calls, such as facing away from the phone user, having closed body postures or looking away at fixed points around the room. However, it is apparent that such behaviors are only for display as, when tested, people recalled much of the conversation they had been indirectly implying they were not listening to, suggesting it to be more of a ‘social ritual’ than actual disinterest (Love et al. 2004).

Specific locations have also been revealed in the literature as being considered acceptable or unacceptable in which to undertake a phone conversation in. Locations generally considered inappropriate places for phone use include: places of worship, restaurants and libraries. There seems to be some debate about the appropriateness of using phones in meetings and on public transport and phone use appears to be generally acceptable in supermarkets and on the street (Wan et al. (1999), Ling (1997), Lipscomb et al. (2007) and Krajewska-Kułak et al. (2012)). These findings may be explainable based on factors already mentioned in this review. For example the supermarket and the street represent large, open, public spaces which have been found to be environments people feel most comfortable using their phone in. Places of worship, restaurants and libraries have social rules attached to them (such as not exceeding a certain amount of noise) and may be considered quite formal and/or intimate spaces thus discouraging phone usage. There is less consensus on the acceptability of using phones in meetings and on public transport. This is possibly derived from meetings having the ability to be both informal and formal so will depend on the type of meeting attended. Public Transport could be considered quite a small intimate space in terms of area, but it can also be considered a public space. There is generally also a fair amount of noise from conversations and the train itself and will be a less formal environment than meetings or places of worship for example, so these are all possible the reasons why public transport is more of a ‘grey area’ in terms of acceptable phoning behavior. The studies reviewed have all only investigated the vocal element of phone tasks i.e. calling; there is no current research on appropriate text messaging behavior, the findings of which may be expected to vary as a result of being primarily visual as opposed to auditory.

In terms of addressing the social mores relating to phone use it has been found that self-discipline was rated as the most conducive way to reduce inappropriate phone use, as opposed to posting public notices, imposing fines or doing nothing (Wan et al. 1999). Aoki et al. (2003) highlighted how acceptable phone use practices may be constantly evolving saying: '*to fully understand the social and cultural changes brought about by the technology, it is important to continue investigating individuals' current attitudes and uses toward the technology'.*

This section has addressed the extent to which mobile phones have been currently adopted, locations that phones have generally been found to be used in, along with the reasons for this, as well as the factors affecting how acceptable this usage is considered to be. The next section will look to address one specific location of phone usage, namely in-vehicle phone use. Phone use behaviours are subject to significant testing in this specific location throughout the thesis due to the safety criticality of using a phone in such an environment. The section will investigate factors specific to vehicles which dictate phone engagement behaviour choices, as well as the possible consequences of conducting phoning tasks simultaneously to driving.

2.6 In-Car Phone Use

This section will first address what dictates driving behavior through a review of driver behavior models. It will then investigate the possible negative effects on driving performance if secondary tasks (such as using a phone) are undertaken while driving. Finally, it will review what is currently known about factors which can influence the timing of, and willingness to engage with, a phone while driving.

2.6.1 Driver Behaviour Models

Before looking into the impact of phone use behaviours on driving it is important to first understand the driving task in terms of the cognitive and physical mechanisms that form it. Driving is a complex, safety critical task undertaken by millions of people on a daily basis. It is therefore important to understand how and why people behave the way they do while driving in order to maintain and improve on the levels of safety on the road. To carry out the driving task people use three sets of functional abilities: cognitive, perceptual and motor abilities. The cognitive abilities include memory, decision making, supervision and attention. The perceptual abilities include tactile, visual, auditory and proprioceptive. Finally, the motor abilities include fine motor control of actuators (accelerator pedal, steering wheel and brake pedal). Cognitive, perceptual and motor abilities are highly interactive and are critical to the development of skilled behaviour (Cacciabue 2007). Many driver models reflecting the interplay and importance of these three functional abilities have been proposed. This thesis is concerned with understanding factors influencing drivers' decisions to engage with their phone while driving. Therefore, it is first necessary to establish currently accepted findings regarding the mechanisms that underlie drivers' driving behaviours. As well as how these models may help to explain phone engagement decisions while driving.

Early driver models were very basic, simply suggesting some people are less skilful drivers and therefore more prone to accidents. These kinds of theories were widely accepted and allowed some people to claim more freedom on the road as skilful drivers who had not had any accidents and so did not need to adhere to speed limits or wear seatbelts (Summala 1988). Recent models are relatively sophisticated in comparison and consider the motivation behind driver behaviour and the cognitive processes relevant to the driving task.

One of the most widely cited driver models is Michon's (1985) Hierarchical Control Model which comprises three levels, the strategic level, manoeuvring level and the control level. The strategic level comprises the general planning stage of a journey and includes knowing how to get to the destination, the route choice, if the car has enough fuel to get there and any time constraints; it only determines a general strategy rather than specific behaviour. The tactical (manoeuvring) stage involves interacting with the traffic system such as obstacle avoidance, overtaking, negotiating intersections and predicting other drivers' behaviour. Finally, the operational (control) stage refers to basic car control such as braking, changing gear and steering - all of which soon become highly automated actions (the process of how this automation is believed to occur is detailed later in this section). The time frame in which each of these stages takes place is another important element of the conceptualisation with the strategic level decisions generally having minutes in which to take place, whereas the tactical level manoeuvres generally only require seconds in which the driver reacts and the operational level actions are executed in even less time.

Although phone usage doesn't fall under any particular part of this model, as it is not a driving related task, it can affect all stages of the model. For example inappropriate timing, and amounts of attention, assigned to the phoning task leads the driver to miss their junction or holding the phone affects their ability to steer the car. An understanding of this model helps to explain why phone use while driving can influence how successfully the driving task is conducted.

2.6.2 Motivational Models

Michon (1985) proposed that for driver behaviour models to be successful a cognitive processing conceptual framework is crucial in order to not just have 'the cake' but the 'recipe' as well. In other words it is important to know not just the behaviour of the driver but the processing behind their behaviour. This is true for phone use as well; in order to reduce the number of occurrences of phone use while driving it is not just important to study the effects of such behaviour, but why such interactions happen in the first place. Driving behaviour models can help explain why simultaneous phone use and driving can lead to unsafe driving behaviour, but do not offer any insight into why drivers would be willing to conduct non-driving related tasks in the first place. For this motivational models are far more useful.

Motivational models emerged as alternatives to the skill based models that existed prior to them. They '*seek to capture the driver's internal or mental state in terms of cognitive functions (e.g. emotions, intentions, beliefs*)' (Dorn 2005). The main assumptions of motivational models are that driving is a self-paced task and that drivers select the amount of risk they are willing to tolerate (Ranney 1994).

There are two dominant motivational models that are frequently cited, compared and contrasted against one another. The first is Wilde's (1998) risk homeostasis model and the second is Summala's (1988) zero risk model. Wilde's (1998) model is based on the idea that drivers have a target level of risk, whereby drivers compare the risk they perceive at any given moment to their target level of risk and modify their behaviour to match this target. In this model it is argued that drivers try and 'optimise risk' as opposed to minimise or avoid it. In Wilde's model a safer driving situation, e.g. enforced wearing of seatbelts, leads to a reduction in perception of risk and this results in a compensatory action, for example driving faster. It is therefore suggested that improvements in measures intended to enhance traffic safety will not necessarily lead to improvements in road safety indicators as drivers will compensate for these improvements. This model would explain that the risky act of using a phone while driving may occur as a behavioural adaption to a perceived improvement in traffic safety achieved by other methods; an acceptable level of risk can still be maintained as the additional risk arising from the phone use only restores the original (acceptable) level of risk. The corollary to this situation, also predicted by the theory, is that some drivers who have a lower target of acceptable risk may be expected to reduce their speed or increase their headways in order to maintain their target risk level when making use of their phones.

Conversely, Summala's (1988) model takes the viewpoint that drivers, over time, learn limits which they drive within and as long as they don't exceed these then they perceive no risk at all. The level of perceived risk will reduce as drivers become more experienced, with drivers usually perceiving zero risk in most situations, this leads to inadequate safety margins and so results in accidents caused by 'normal' driving behaviour. The model suggests that phones are used while driving because the driver believes using the phone to be within their capabilities (below their risk threshold) so perceive no risk in conducting such behaviour.

In comparison with the risk homeostasis theory, where drivers adjust their performance in order to maintain a desired level of risk, the zero risk theory states behavioural adjustment only happens when a threshold is exceeded, at which point a risk compensation mechanisms is initiated. Until this threshold is exceeded drivers perceive no risk at all. The contrasting viewpoints of the two theories outlined show how little is known about what dictates driver behaviour – both theories are largely descriptive and have not been substantially tested by experimentation. Drivers' internal, and often unconscious, decisions are hard to measure, making it particularly difficult to tell exactly what is motivating drivers to conduct safe or unsafe driver behaviour and even more difficult to prove any theories on the subject. Are drivers continuously comparing their current level of risk to their accepted level of risk and compensating for any deviations or are compensatory mechanisms only exhibited when a tolerance limit is exceeded?

2.6.2.1 Task Capability Interface Model (TCI)

In a more recent paper Fuller (2005) proposed that it is not risk that drivers are trying to keep in homeostasis but in fact task difficulty. It was suggested that task difficulty was determined by two factors: driver capability and driving task demand. '*Where capability exceeds demand, the task is easy; where capability equals demand the driver is operating at the limits of his/her capability and the task is very difficult. Where demand exceeds capability, then the task is by definition just too difficult and the driver fails at the task, loss of control occurs…for instance, the use of a mobile phone can be an additional task, which pushes demand beyond driver capability'* (Fuller 2005).

This theory brings in the concept of driving capability acting as a mediator to driving behaviour. There is an expectation that a more capable driver would have greater spare resource capacity. Therefore, they should be able to engage in behaviours, such as going at greater speeds or engaging in secondary tasks, without impeding driving performance, so long as these behaviours did not exceed their capability.

It has been suggested in previous studies that drivers might have up to 50% 'spare' attentional capacity during 'normal' driving (Hughes et al. 1986), suggesting that some secondary tasks may be conducted with no increase in crash risk. Therefore, for this risk to manifest itself other contributing factors also have to occur, for example a sudden increase in traffic demand, an unanticipated event or a deterioration in road surface quality. A distinguishing feature of the TCI model is the focus on the driver meeting dynamically changing task demand rather than consciously adjusting risk acceptance. This model will feature as a framework in this thesis with phone capability while driving, perceived driving capability, perceived phone capability and task demand all assessed as possible determinants of the driver's willingness to engage with a mobile phone while driving. This was chosen based on a good fit between the theory's task orientation and the problem, with the TCI model offering a framework for testing possible influences on willingness to engage with a mobile device while driving.

As task difficulty is moderated by driver capability in the TCI, the proposed mechanisms which lead those of greater driving capability to possess more spare capacity (leading to reduced task difficulty) will be briefly described.

It should be noted that there are a number of criticisms directed towards the TCI model. Firstly the model assumes that drivers are aware of, and can accurately predict, their capability of carrying out the task. It also presumes drivers can accurately predict the upcoming task demand at the time. It has been shown in studies such as that by De Craen, Twisk et al. (2011) that young drivers are not as accurate at predicting task demand as experienced drivers are. This disparity may have an effect on the level of overall task difficulty perceived, thus influencing driving behaviour in ways, and for reasons, the model may not have accounted for.

Lindstrom-Forneri et al. (2010) and Lewis-Evans et al. (2009) have criticised the TCI for not clearly differentiating task difficulty from the feeling of risk. For example, drivers may be very aware that the task is difficult i.e. the task demand may exceed their capability, but may actively be seeking this feeling for entertainment purposes. Individuals' risk averseness is likely to affect their willingness to seek out or maintain this threshold. The model does little to take this risk taking propensity into account. Lindstrom-Forneri et al. (2010) also highlights that the individual may not always feel capable of maintaining their desired level of task difficulty. For example, an older driver may exceed their normal desired task difficulty level by driving at night in order to help out a relative (Rothe 1992). Similarly a driver may feel under pressure to drive in a less demanding way than normal as a result of there being a passenger in the car, the TCI model does not take these social factors into consideration.

There are further examples of where the model fails to take into account the driver's internal motives. For example, there may be instances when the driver is willing to compromise on matching their capability to the task demand in circumstances when the driver is drunk, in a foul mood or in hurry (Rothengatter 2002). Carsten (2002) levied a criticism not just towards the TCI but at driver behaviour models in general for being merely descriptive, many models (including the TCI) aim only to model the variables which may influence behaviour without any attempt to predict behaviour. This makes testing and verifying the accuracy of the model very difficult. It also severely limits the usefulness of the model as it ultimately has little purpose other than to highlight the complexity of drivers and what can influence their behaviour which in itself will not help to address any driving behaviour or performance issues.

2.6.2.2 Cognitive Model for Task Capability

Anderson (1982) observed that much of the driving task can be seen as an automatic process for all but learner drivers. This allows the driver to drive while using few conscious mental resources ensuring there is spare capacity to engage in other activities.

Anderson (1982) formulated a framework for acquiring skills which features a declarative stage and a knowledge compilation stage. The first stage is the declarative stage where the learner receives facts and information about the skill, the facts have to be rehearsed in working memory and are often practiced verbally. Michon (1985) applied this to the driving task using the example of changing gears, where the learner driver struggles to change gear and carry out any other task and has almost no idea of when and why to shift gear. With practice knowledge is converted from declarative to procedural form, this is termed the knowledge compilation stage. In this stage declarative information is converted to far simpler *if - then* rules, termed productions. For example in the instances given for changing gear the production would say:

IF the goal is to change gear

THEN release the accelerator and engage the clutch

This refinement makes the process, and thus the task, both faster and far less demanding of the drivers' mental resources, demonstrating how, with practice and increased capability, the demands placed on the driver by the driving task can be reduced.

This section has considered how phone use can impact on the driving task through affecting certain stages of the skill based models, leading to impaired driving performance. The mechanisms which may actually cause drivers to think they can use the phone whilst driving were then reviewed through investigating motivational models and this was concluded with a cognitive model to explain how, with sufficient driving experience, it is possible to enjoy greater spare resources. This beneficial situation then may lead drivers to allocate such spare capacity to a secondary task, such as phone usage. The next section will look at the possible effects of conducting secondary tasks concurrent to driving.

2.7 Dual Task Operation, Attention and Distraction

Phone use whilst driving can influence driver safety through reducing the amount of attention the driver can pay to the road and traffic environment. This section will investigate the nature of attention and how phone usage can lead to distraction through inappropriately placed attention.

Attention has been defined by James (1890) (as cited in Eysenck et al. (2005) page 141) as '*the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneous possible objects or trains of* *thought. Focalisation, concentration, of consciousness are of its essence*'. Attention can be active, where it is controlled by someone's goals or expectations in a top down way, or passive where external stimuli such as a loud noise controls attention in a bottom up way (Eysenck et al. 2005). To relate this to driving, visual attention can be consciously focused on the road way ahead (active) and then drawn to a car that suddenly pulls out from a side road without warning (passive).

A further crucial distinction is between divided and focused attention. Focused (selective) attention is studied by presenting subjects with two or more stimulus inputs at the same time and asking them to respond to only one. This enables an experimenter to study the nature of the selection process and how well people can select certain inputs rather than others as well as their ability to block out stimuli (Eysenck et al. 2005). An example in the driving environment is when there are many possible stimuli that a driver can focus on such as bill boards, mobile phones, iPods etc. but the driver chooses to only attend to the task of maintaining a safe distance between themselves and the car in front.

Divided attention also requires presenting at least two inputs at the same time, however, participants are asked to try and attend and respond to all the stimuli (Eysenck, et al. 2005). For example maintaining a safe distance from the car in front and finding a contact's phone number on a mobile phone at the same time. Eysenck, et al. (2005) also acknowledges that it is possible to attend to the external environment or the internal environment (the individual's own thoughts) but most research is concerned with the external environment due to it being easier to identify and control.

As the current research is directed at factors which affect when drivers engage with their mobile device it is primarily divided attention which is of interest (between the primary task of driving and the secondary task of using the mobile phone) therefore divided attention theories will be considered in more detail.

The way that information is processed when people attempt more than one task at the same time is the subject of considerable theoretical and research interest with competing theories regarding dual task performance. One such theory proposed by Kahneman (1973), and known as the single resource theory, argues that attention is a single resource with a limited capacity so an individual's ability to perform two tasks at the same time is based on the effective allocation of attention to each. The interference between these tasks is a product of the demands each task imposes on the resource. The limitations of the single resource theory were established when experiments confirmed that, under certain conditions, two demanding tasks could be carried out together with no reduction in performance (Young et al. 2002). This lead to the generation of the multiple resource theory.

Wickens's (1980) multiple resource theory states that similar tasks compete for the same specific limited capacity resources which can produce interference; whereas dissimilar tasks use different resources and so do not interfere with one another. For example, driving and listening to the radio involves visual and auditory resources so would not be expected to interfere with one another. Driving is primarily a visual task (Kramer et al. (1982), Spence et al. (2009)), therefore, driving and reading a map would be predicted to cause interference, as both rely on the visual medium (this was found to be the case with multi-modal personal navigational devices (PNDs) found to be less distracting than purely visual paper maps (Guy 2001)).

The theory further predicts greater task interference when resources are in competition for the limited and overlapping resources and when the task is difficult, as opposed to tasks that are easy in nature that draw on non-overlapping resources (Horrey et al. 2003). The multiple resource theory is widely regarded as the most successful account of how humans process information required for the completion of dual tasks and will therefore be adopted as the underlying theoretical framework for this thesis.

2.7.1 Definition of Distraction

'*Driver distraction occurs when a driver is delayed in the recognition of information needed to safely accomplish the driving task because some event, activity, object or person within or outside the vehicle compelled or* *tended to induce the driver's attention away from the driving task'* (Stutts et al. 2001).

'*Driver distraction is a diversion of attention away from activities critical for safe driving towards a competing activity'*, (Regan, Lee & Young's 2009).

The examples given are just two of many different definitions of distraction. They indicate that while there is considerable overlap there is also variation in the characteristics that are regarded as particularly relevant. This can have a great effect on the way data is analysed, as what one researcher may consider to be a distraction another may not, leading to conservative or exaggerated results (Pettitt et al. 2005). For example Stutts et al.'s definition mentions that distraction can come from within or outside of the vehicle but it does not definitively acknowledge distraction from within the driver due to them thinking or daydreaming. Regan et al.'s definition overcomes this problem by being more general and simply suggests that a distraction is anything that affects the driver's safety due to not paying attention to the primary task of driving. Therefore throughout this thesis Regan, Lee & Young's (2009) more comprehensive definition of distraction will be used as all causes of distraction, e.g. visual or cognitive distraction, are accounted for and it encompasses all distractions from within or outside of the vehicle.

This thesis is only interested in willingness to engage with a phone while driving, not the effects phones can have on performance or objectively measuring the distracting effects of the devices. This limits the impact that the choice of definition of distraction has on any findings or assertions made, through not having to make a judgement on how to measure or code distracting effects, e.g. eyes off road time etc. However, choosing this, quite broad, definition of distraction could have an impact on some conclusions made about participants' engagement decisions. As having a conversation (in either in auditory or written form) is not considered 'critical for safe driving' phone use will always be considered a 'competing activity' in this thesis and therefore constituted participants being engaged in a distracting act. Viewing and categorising phone use as being an unnecessary task removes the need to make judgements on what constitutes 'appropriate' or 'inappropriate' phone engagement decisions. Instead, through the choice of definition, this thesis takes a clear stance that any phone engagement is not critical for safe driving, and therefore could possibility compromise driver safety.

The current section has identified how a person's attentional systems work and their limitations. Distraction was then noted as the inappropriate placing of attention. One thing nearly all definitions of distraction have in common is the likelihood that distraction will impact on the safety of the driver. The next section therefore looks into what has been found about causes of distraction when driving in more detail.

2.8 In Car Distractions

There has been shown to be many possible distractions inside an automobile cockpit and interior of cars are becoming increasingly complex (Summerskill et al. 2004,), demonstrating a need to take the driver's capabilities into account when designing and introducing new technologies for use in vehicles (Burnett et al. 2001). With advances in modern technology it is now possible to be told where to go by a satellite navigation system, talk to people using a mobile telephone and listen to music through the stereo, as well as adjusting the car's operating characteristics through a user interface, all while carrying out the complex task of driving. Although the scope of this review does not allow for investigation into the distracting effects of in vehicle displays, including personal satellite navigation devices (PNDs) and car manufacturers' inbuilt electronic interfaces, research into this area is growing (see Young et al. (2007) for a comprehensive review and Burnett et al. (2005), Horberry et al. (2006), Reed-Jones et al. (2008), Maciej et al. (2009), Memarovic (2009), Burnett et al. (2011), Burnett et al. (2012) and Pitts et al. (2012) for evidence on how particular design features can influence driving performance).

Each of these in-car interaction opportunities can affect the driving task in terms of the driver's behaviour and their performance while driving. The increasing number, complexity and capability of devices and almost every driver now being a mobile phone owner means the number of crashes due to distraction is expected to increase (Young et al. 2010). It has been found that approximately 64% of distracters that lead to crashes could be classed as being in vehicle visual distractions e.g. adjusting the radio, adjusting the climate control or dialling a mobile phone (Stutts et al. 2001).

2.8.1 Mobile Phones and Distraction

There are now more mobile phones in use than ever before with around 92% of the UK population owning a mobile phone in the first quarter of 2013 (Ofcom 2013). In 2012 the number of homes with access to a mobile phone was higher than the proportion of households with a fixed landline phone (Ofcom 2009). Eby et al. (2006) found this has inevitably led to increasing usage while controlling a vehicle, with studies finding between 32 to 60 percent of drivers use their mobile phones while behind the wheel (Brusque et al. (2008), Young et al. (2010)). White et al. (2010) established that drivers use their phones in vehicles on a daily basis mainly for answering calls (43% of drivers), followed by making calls (36%) then reading text messages (27%) and finally writing text messages (18%).

Trying to interact with a phone while driving, such as dialling a number, could potentially be hazardous if the driver needs to remove their hands from the steering wheel, so compromising manual control, and taking their eyes off the road, resulting in reduced situational awareness of what is happening in the road environment. Alm et al. (1994) proposed the effect that a mobile phone will have on the driving task is largely determined by the priority a driver gives the phone task, if the phone task is given priority over the driving task then performance issues are likely to be observed.

This section will address current findings on the extent to which dialling on a phone, talking on a phone (hand held and hands-free) and text messaging on a phone whilst driving can compromise safe driving performance.

2.8.1.1 Dialling While Driving

The amount of time spent on a non-driving related task affects the extent to which it compromises driving performance. The average time required to place a call (including dialling the number) was found to be between 9.8 and 12.9 seconds (Stutts et al. (2005), Green et al. (1993)). It should however be noted that Salvucci et al. (2002) found dialling time was not a good indicator of predicting the distracting effect on driver performance, as voice activated dialling took considerably longer but led to far fewer deviations than conditions that required manual interaction with the phone. Instead visual demand measured by the number and length of phone glances is a more accurate method for predicting the distracting effect on driver performance.

Most drivers believe dialling on a phone to be more dangerous than other phone and driving related tasks (Smith 1978). However, when this was experimentally tested it was found by Kames (1978) that both tuning the radio and dialling on a telephone impair the driving task an equal amount.

When compared to a baseline of driving only, dialling whilst driving has been found to lead to more violent steering wheel movements, of up to ten times the amplitude, as well as an increase in heart rate (suggesting an increase in driver stress) (Brookhuis et al. 1991) increased reaction times (Brookhuis et al. (1991), Lamble et al. (1999)) reduced lane discipline and speed control (Reed et al. 1999). Age may act as an important moderating variable with older drivers having greater performance decrements than younger drivers (Reed et al. (1995), Reed et al. (1999)) though, Reimer et al. (2011) did not find a difference in workload between late middle age (51 – 66) and younger adults (19 – 23).

It has further been discovered that the location of the phone in the car can influence performance. With a low mounting position for a mobile phone leading to greater lateral lane deviations than when mounted higher on the dashboard (Svenson et al. 2005).

Using a different medium to enter the number may reduce this problem as Salvucci et al. (2002) found using voice controlled dialling or using a speed dialling function led to significantly less severe steering deviations than did manually dialling whilst driving. Similarly, the type of phone used may also have an effect with traditional push button phones leading to lower eyes off road time than iPhone type touch screens (Reimer et al. 2012). This is presumably a consequence of ‘hard’ buttons giving better tactile feedback than the touchscreen device.

2.8.1.2 Hand-held and Hands-free Phone Use

Hand-held mobile phone use is deemed to be so dangerous that many countries have made the act of using a hand held mobile phone whilst driving illegal (Lamble et al. 1999). This has been observed to lead to a decline in hand-held phone use in the short term (McCartt et al. (2003), Johal et al. (2005)) but not in the long term (Hill (2004), McCartt et al. (2004)).

Many studies have investigated the distracting effects of hand-held compared to hands-free phone usage and the effects both these modalities can have on performance. Although only hand-held phone usage is banned in many countries (including the UK) there is a growing body of evidence finding that hands-free usage is equally distracting. Both hand-held and hands-free mediums of calling have been found to lead to an equal amount of impairment in the effects they have on reaction times to critical events, such as reacting to other vehicle’s brake lights (Strayer, Johnston (2001), Burns, Parkes et al. (2002), Consiglio, Driscoll et al. (2003), Patten, Kircher et al. (2004), Strayer, Drews et al. (2006), Törnros, Bolling (2006)). Performance effects on longitudinal control (head way) and lateral control (lane keeping) have also been tested with phone use found to impair performance compared to control condition for both variables but no significant difference were found between hand-held or hands-free modalities (Haigney, Taylor et al. (2000), Strayer, Drews et al. (2006)).

All of these findings are from controlled experimental studies. However, epidemiological studies, which investigate using accident statistics, also support that using hands-free compared to hand-held modality has no effect on reducing crash risk. These studies have shown phone use to increase crash risk by four fold regardless of the phone modality (hand-held or hands-free) used (Redelmeier, Tibshirani (1997), McEvoy, Stevenson et al. (2005)).

There is further evidence that drivers may be more aware of the dangers of using the phone in hand-held as opposed to hands-free medium. Studies have found that drivers reduced their speed when using their phone hand-held but not when hands-free (Haigney, Taylor et al. (2000), Burns, Parkes et al. (2002), Patten, Kircher et al. (2004), Törnros, Bolling (2006)). A reduction in speed is believed to represent a way of reducing demand placed on the driver, the reduction in speed acting as a coping mechanism in high demand situations (Ishigami et al. 2009). It appears from these studies that drivers are perhaps not fully aware of, and underestimate, the demands that hands-free phoning can place on their resources while driving demonstrated by them not attempting to adapt to the task demand to the same extent as when using a hand-held phone. Although, it should be noted that reducing speed did not seem to have the desired results in reducing task demand as highlighted by the findings that both hand-held and hands-free phoning impair driving performance in equal amounts despite the adaption of reducing speed in the hand-held phoning condition.

2.8.1.3 Holding a Conversation while Driving

Many of the studies in the previous section found there to be little or no difference in driving performance for hand-held compared to hands-free phone usage. This suggests that it is not the physical act of holding the phone which alters driving performance but instead the cognitive distraction that results from holding a conversation while driving.

Just et al. (2008) confirmed this through the use of functional magnetic resonance imaging (fMRI) when people were conducting a conversation simultaneously to conducting a simulated driving task. It was found that language comprehension drew cognitive resources away from the driving task, even though participants were only conversing and driving and no phone was present. Haigney et al (2000) supported this by finding that vehicle speeds were slower during a call as opposed to pre-call or post call. This reduction in speed is likely an attempt to manage the increased demand which was being experienced from trying to simultaneously drive and converse. They also found heart rate to be elevated which supports this assumption. Rakauskas et al. (2004) and Beede and Kase (2006) supported the finding of conversation having an effect on speed. Beede and Kase further found conversation to have a negative impact on lane position, running red lights and brake reaction response.

Patten et al. (2004) tested to see if the complexity of the conversation could influence driving performance. It was found that responding to a simple digit shadowing task led to far less impaired driving performance than a more complex memory addition task. Furthermore, complexity of conversation had a greater impact than did the phone medium (hands-free or hand-held). Driving whilst holding a conversation has been consistently found to be more dangerous than driving without phone usage, but Burns et al. (2002) also tested it against driving under the influence of alcohol in order to give its distracting effect a benchmark. It was discovered that holding a phone conversation had a greater impact on driving performance than under the influence of alcohol and was rated by participants as being more difficult than driving under the influence of alcohol as well.

It should be noted that a large number of other, differing, methodologies have been used to simulate conversation while driving including a paced serial addition task (Törnros and Bolling 2005), word puzzles (Burns et al. 2002), verbal reasoning tests (Haigney et al. 2000) and naturalistic conversations based on topics identified as of interest to the participant before the experiment began (Strayer et al. 2006). Nevertheless all studies found the simulated conversation task to impair driving performance compared to the driving only task.

2.8.1.4 Text Messaging While Driving

It isn’t just talking on the mobile phone which is a prevalent behaviour while driving, text messaging is now also an important concurrent activity. As many as 91% of drivers have been found to have text messaged while driving with drivers least likely to send or reply to a text message and most likely to read a text message (Madden et al. (2010), Atchley et al. (2011), Harrison (2011)).

Thus passive text behaviour, such as reading, occurred more frequently than did active behaviour, such as initiating text-based conversations.

There is now a growing body of studies which have investigated the effects of texting behaviour on driving performance. Text messaging while driving has been found to lead to a crash risk 23.2 times higher than non-distracted driving (Virginia Tech Transportation Institute 2009). More specifically, this appears to be a result of impaired reaction times, lateral vehicle control and increased driver workload (Reed et al. (2008), Drews et al. (2009), Hosking et al. (2009), Zhou et al. (2009), Harrison (2011), Rudin-Brown et al. (2013)). The distraction effects may be reduced when the message is read aloud by a system integrated within the car (Owens et al. 2011) or the phone used has hard touch buttons rather than a soft touch screen, such as on an iPhone, as these are associated with longer glance durations away from the roadway (Samuel et al. 2011).

This section indicates that phone use while driving, whether in the form of hands-free or hand held conversations or text messaging, can seriously impair driving performance when compared to a baseline of driving only. The next section will investigate the factors which are known to influence willingness to engage with such distractions while driving in the first place.

2.9 Willingness to Engage with Technology While Driving

The review has so far identified the risk and effects of using mobile phones whilst driving but as Lerner (2005) points out ‘*the actual risk associated with some device will be a joint function of how the use of that device interferes with driving and the circumstances under which drivers are willing to use it’*. A similar observation was made by Horrey et al. (2009b) commenting how there are now many tasks that can be carried out consecutively with driving and drivers aren’t just passive responders to these tasks. Instead they choose whether to actively engage with them, such as deciding whether or not to place a phone call.

These points highlight how the level of demand faced by the driver as a result of using the phone is not constant but influenced by many factors, including the road design itself and the traffic demand when they chose to engage in a task. For example sitting in stationary at traffic lights will place far less demand on the driver than when they're trying to negotiate a roundabout. Yet surprisingly few studies have investigated the circumstances under which drivers are willing to use their devices and the extent to which they delay their interactions based on perceived demand. As highlighted by Lerner (2005) there could be many possible factors affecting this such as the technology type, personal motivations and driving style.

It has been found that as cognitive workload increases the speed drivers chose to drive at reduces, this is believed to be an adaption to compensate for the higher workload. The effects of this adaption to the increased workload have been found to vary based on the roadway environment experienced at the time (for example urban compared to motorway road environments) (Son et al. 2011). As it seems that different road environments have varied effects on driving workload and behaviour it also appears plausible to suggest when and why people interact with a phone may vary for each road environment. A small number of studies exist which have investigated how the roadway may influence willingness to engage with non-driving related tasks. These studies have used a number of different research methods such as a test track (Horrey et al. (2009b), Liang et al. (2012)), on road (Lerner 2005) and viewing video footage (Horrey et al. 2008).

The results from these studies are somewhat inconclusive with both Horrey et al. (2009b) and Liang et al. (2012) finding task engagement to be insensitive to the roadway demand experienced at the time, as opposed to Horrey et al. (2008) finding that as roadway demand decreased willingness to engage in a secondary task increased.

It further appears from Liang et al. (2012)'s findings that '*drivers may avoid the transition of immediate and foreseeable increase of driving demand when initiating secondary tasks. They may want to react and adjust to the new demands before undertaking additional workload*'. This suggests drivers prefer to engage in secondary tasks when under a stable workload, even if they are in a high demand environment. These findings were however based on a test track study. The variety of variables (such as pedestrians stepping out) that a real road environment encompasses may make the desired stable road situation hard to attain and therefore influence where they choose to engage.

Similarly, there is some confusion in the current literature on the extent to which the intended secondary task may influence willingness to engage. Lansdown (2004) found when participants were required to attend to a task that was un-paced, and was to be given priority over the other secondary tasks, this significantly added to the driver's self- rated mental workload. Reaction times for interacting with this prioritised secondary task were faster than for the lower priority secondary task- suggesting the priority was taken into account when deciding when to engage with the task. However, this impacted on task accuracy with more mistakes in the prioritised secondary task than the others. This suggests if a secondary task is seen as important and requiring a rapid response from the driver then the performance on that task, as well as the appropriateness of the decision to engage or not with the task, may be compromised. Horrey et al. (2008) found the type of secondary task to have little effect (phone conversation as opposed to changing a CD, changing track on an MP3 player or looking at a map) on whether a driver engaged with it or not. However, Lerner (2005) found a preference and higher likelihood towards engagement with phones as opposed to satellite navigation devices or PDA's. Although, Horrey et al. (2009b) found no difference in timings of engagements for phones as opposed to satellite navigation devices. This suggests drivers may possibly be more inclined towards phone use than other secondary tasks but once they have decided to engage, the timings of interaction, and therefore factors encouraging or inhibiting interaction, do not vary between tasks.

One reason why there may be a reported higher engagement with phone tasks as opposed to other in car tasks could possibly be due to drivers frequently using phones outside their vehicles, and therefore feeling more inclined to extend their use to in-vehicle situations compared with less frequently used devices. This effect was found by Bayer et al. (2012) who investigated to what extent addiction to phone use out of the car can transfer to drivers being more likely to text when behind the wheel. Their results supported not just the obvious link between texting frequency and texting habits behind the wheel but automaticity of texting behaviour played a large role as well. This suggests many people may interact with their phone without consciously deciding to, even when in a safety critical situation such as when driving.

Another reason for a higher engagement rate with phones as opposed to other in-car distractions may be the perceived importance of phone-based communication. It has been discovered that users are more likely to answer a phone call if it is perceived to be important (Nelson et al. 2009). This may also be one of the factors influencing the likelihood of a driver accepting an expected email or text message, though further study is needed in this area. Related to this, White et al. (2007) found that drivers tended to express what they termed 'comparative utility', this was similar to an optimism bias whereby the driver believed the technology to be of more use to them than to others and thereby warranted usage as a result of this importance. Similarly, drivers have been found to be most likely to answer a call, followed by placing a call, read a text and least likely to send a text message (Walsh et al. (2007), Atchley et al. (2011)). This may be influenced by the perceived higher importance placed on some mediums as opposed to others and/or the perceived safety or ease of use, more research is needed to find the motivation for higher usage propensities towards some phone activities compared to others.

It isn't just the road environment or task intended to be engaged with that may influence willingness to engage but the driver's perceived ability to conduct the task while also driving. Bayer et al. (2012) investigated perceived driving ability along with phone usage and found that driving confidence played a large role in predicting variables, including phone use engagement, in their model. They suggest this shows 'certain individuals may feel they can overcome perceived risk of dangerous driving if they are skilled (in their own opinion) at the wheel'. This was the only study that took perceived driving capability into account; more research seems warranted on this topic.

Currently there has been no attempt to measure if there is a difference in urgency of interaction between answering a phone compared to placing a call. The forced time constraint that a ringing phone places on a driver may encourage more prompt interaction than the less time constrained placing of a call would, as well as possibly causing a state of panic from the pressure of wanting to answer the phone before the ringing has stopped. This may leave less time, or a less clear mind, to consider the appropriateness of phone use at that moment. There is a need for studies to be conducted in order to confirm or oppose this suspicion. However, Zhou et al. (2012) found a higher likelihood of engagement with hands-free calling than hand-held when asking about drivers' answer a call intentions.

The findings from the controlled test track and on road studies seem to be in some conflict on the extent to which the road environment influences willingness to engage with a secondary task. Many observation studies have also been conducted on this subject and help add further insight to these findings.

Many of the observation studies were in agreement that drivers not only elect whether or not to engage in a secondary task based on the current road demands but also the expected future demands, when the driver was familiar with the road (Esbjörnsson et al. (2003), Esbjörnsson et al. (2007)). This could include delaying engagement based on an expected low demand opportunity upcoming shortly, as well as withholding from engaging due to an expected increase in demand in the near future.

This is clearly demonstrated in a quote from Laurier (2004): '*Not only do roads, by being 'motorways', 'dual carriageways', 'country roads' provide categorically organised expectations of hazards, acceptable speeds, absence or presence of oncoming traffic and so on, but they also have typical rhythms that their regular drivers get to know ...they are busy and quiet at certain times of day… On assembling the type of road by its time of day, its normal busyness or quietness and other local features, in the course of* *driving, mobile workers ... then make assessments as to whether they might be able to get their paperwork out, make a few quick phone calls or make long phone calls, or whether they have to stick to driving alone*'.

However, there is also suggestion in the literature that although the roadway can be perceived to have characteristics which lend themselves to interactions with the non-driving tasks, these opportunities are preferential rather than essential for diverting attention away from driving. Laurier (2004) states that the observed participant '*does not wait until the lorry stops before he makes a call, he is in no way dependent on that situation to establish a phone conversation. The intersection and the traffic signal is rather a resource, which occasionally makes his life easier*'.

There appear to be some differences in the literature between what the controlled studies found about how the road environment affects non-driving task interaction, and what was actually observed in real road driving studies. Similar differences were noted by Esbjörnsson et al. (2007) from the level of risk phone use was found to cause from laboratory studies and the actual observed number of incidents in real world driving. They suggested if phones were as risky as found in laboratory studies a far higher number of incidents would be expected. Esbjörnsson et al. (2007) propose that 'the drivers' own work to reduce risks could be an explanation to the difference between the number of actual crashes due to mobile phone use, as identified in crash data analysis, and the risks as suggested based on controlled experiments'. They suggest drivers are aware of the risks of phone use and therefore try to manage them more than is apparent from the laboratory studies. It follows that one of their criticisms of many current studies examining the effects of phone use while driving is that people were forced to use the phone 'the test-subject cannot fully adapt his behaviour, regarding the timing of mobile phone use in relation to the traffic situation'. This suggests they believe the road environment to play a crucial role in the timing of when people use the phone while driving. It also highlights the importance of studying phone engagement behaviour without forced interactions in both controlled and observational studies.

Studies have also tried to characterise specific road characteristics that can encourage and inhibit phone engagement while driving. It has been established drivers are most likely to engage with their phone when stationary, on straight, familiar, roads and when on motorways (Walsh et al. (2007), Atchley et al. (2011), Huemer et al. (2011), Ferreira et al. (2012)). They were least likely to engage with their phones while changing lanes, merging with traffic, approaching a roundabout, in inclement weather, in heavy traffic and when in a city environment (Walsh et al. (2007), Britschgi et al. (2012), Ferreira et al. (2012)). This gives some consensus on the fact that specific roadway characteristics can be considered to encourage or inhibit phone interaction. Although it should be noted these studies mainly used self-report methodologies, what the drivers say they do with their phone when driven and actually do when observed on the road may be different.

Overall, it appears that there is little consensus on the extent to which the roadway environment can influence willingness to engage with mobile phones whilst driving. Similarly the limited evidence available suggests phone use is a particularly tempting secondary task to engage with, although how this varies based on phone task intended to be engaged with (such as placing a call compared to reading a text) and the factors which may influence this are not currently understood.

The next section will investigate the extent to which drivers perceive a difference in risk for interacting with different phone functions while driving and the extent to which this perceived risk has been found to influence willingness to engage.

2.10 Social Acceptance Theories -Theory of Planned Behaviour Research

The Theory of planned behaviour methodology (TPB) has been used in a number of studies in an attempt to ascertain what motivates drivers to intend to use their phone while driving. Through the use of questionnaires facets of respondents’ phone use beliefs are collected including: their attitudes towards phone use while driving, how normal they considering using the phone while driving to be and their perceived ease of which the phone task can be conducted while driving. Along with this, the respondents' intention to engage with a mobile phone while driving is collected and this allows for insight into how a number of variables may or may not influence intended phoning behaviour in the future. It should be noted this methodology only intends to study the factors which can influence someone's intention to use the phone while driving. It does not study factors affecting actual engagement with the phone while driving, which may differ due to the differences between intention to conduct an act and actual behaviour.

2.10.1 Attitude/ Behavioural Factors

One of the factors that may have an effect on drivers' intentions to use their phone is their attitude towards phone use in vehicles. Studies have found that having a positive attitude towards phone use and driving had a large effect on the strength of intention to do so. This finding extended to both making and receiving calls (Walsh, White et al. (2008), Zhou, Wu et al. (2009)) and reading and sending text messages (Nemme, White 2010). White, Hyde et al. (2010) supported these findings for hand-held phone use. However, contrary to previous research found, when operating a phone in hands-free mode, that attitude had little effect when deciding to use a phone or not while driving. Respondents had similar attitudes; reporting no differences in perceived benefits between frequent and infrequent phone users. Generally it seems that current research agrees that having a positive attitude toward phone use and driving will lead to a greater intention to use a mobile for both calling (except possibly in hands-free medium) and texting. Currently no research has investigated the effect that attitude has on intention to use more advanced functions on the phone while driving such as the internet or emailing while driving. This could be an interesting future direction.

2.10.2 Subjective Norms

Subjective norms test whether the respondents' perceptions of other peoples' attitudes towards phone use and driving have an effect on the respondents' own intention to engage in the activity.

Walsh, White et al. (2008) found if respondents perceived other people to have a positive attitude towards phone use and driving then intentions to engage in the activity strengthened. Zhou, Wu et al. (2009) supported this finding and found a greater perceived approval from significant others when the phone was in hands-free mode compared to hand-held. White, Hyde et al. (2010) found closer people (such as friends and family) had a greater influence on whether drivers used their hands-free mobile than distant people's opinions (such as other drivers and police). Also, frequent hand-held phone users perceived a much greater approval from close persons than infrequent users did, though the level of approval was still relatively low. Infrequent hand- held users reported significantly lower levels of approval from other drivers and the police, suggesting this may be what restrained infrequent users from using the phone more often.

Nemme, White (2010) found that reading a text while driving was not effected by subjective norm but interestingly sending a text was. With a greater perceived subjective norm towards sending texts leading to increased intention to do so. It is possible that drivers do not perceive reading a text to be as dangerous as sending one so are not as affected by other people's opinions. Whereas sending a text will likely require more time looking away from the road and hands off the wheel so drivers feel they need approval in order to carry out this act. This may be supported by Nemme, White (2010) finding that respondents believed that reading texts is less of a moral concern than sending texts while driving.

Walsh, White et al. (2008) also found that a perceived positive attitude towards phone use and driving from others may strengthen intention to use a phone. This was not just because they perceive approval to conduct the activity but because of a perceived pressure to use the phone because of the positive subjective norm. People were found to be especially susceptible when other people and time commitments were involved. It was suggested that in order to reduce this effect drivers should be educated that other people do not expect calls to be answered or messages to be read while they are driving.

2.10.3 Perceived Behavioural Control (PBC)

PBC is the amount of control someone perceives they have to carry out a task. It could be considered to represent the perceived ease or difficulty of using the phone while driving or how much free choice they feel they have for engagement behaviour. For example, they may feel limited as a result or laws or road conditions which in turn may influence intention to engage.

Walsh, White et al. (2008) found PBC had little effect on intention to use a mobile phone while driving. Conversely Zhou, Wu et al. (2009) found PBC to be the most important of the TPB's three factors on influencing intention. Increased perceived control lead to a stronger intention to use their phone. Interestingly Nemme, White (2010) found the phone task effected how much influence PBC had on intention. When reading a text message PBC was not found to be a factor influencing intention to use a phone while driving. However, when sending a text message it was. This suggests people who perceive they have more control when sending text messages will be more likely to do so whereas perceived control had no effect on whether someone intends to read a text or not.

Unlike many TPB studies that ask questions such as 'how likely are you to use your phone in this situation' to ascertain PBC, White, Hyde et al. (2010) established PBC factors by asking about which of six limiting factors would prevent someone using a mobile phone while driving. Examples include a police presence or risk of accident. It was found infrequent hands-free mobile phone users perceived a greater chance of getting caught by the police and higher distracting effect than the more frequent users. This suggests these factors reduced perceived control and so limited phone use, even for legal behaviour such as talking using a hands-free kit. Frequent and infrequent users reported a lack of hand-free kit as a limiting factor to intention to engage.

In the hand-held phone condition both frequent and infrequent hand-held phone users reported police presence and heavy traffic as a limiting factor (White, Hyde et al. 2010). Walsh, White et al. (2008), in contrast, found drivers who reported a higher perceived risk of being caught and fined by the police were more likely to text, not less. This surprising result may be explained as those using the phone illegally were perhaps more conscious of the risk of getting caught. They therefore perceived the risk to be greater; although the benefits of phone use were perceived to outweigh the costs of getting caught as people used the phone anyway.

White, Hyde et al. (2010) also found frequent users were less likely than infrequent users to report that risk of an accident, risk of fines, lack of a hands-free kit and heavy traffic would prevent them from using their mobile phone while driving. Walsh, White et al. (2008) however, found that neither the risk of fines nor the risk of being in an accident had an effect on a drivers' intention to use their mobile to phone while driving, apart from for text messaging where risk of apprehension had a negative effect.

Overall it seems there is some conflict within the limited literature which uses TPB to study phone use behaviour while driving as to which factors can influence phone engagement behaviours. It does however generally seem that those with positive attitudes towards phone use, those who feel it is socially acceptable to use a phone while driving and those who feel the most in control of their ability and freedom to engage with their phone are the drivers who have the highest likelihood of phone use while driving.

2.11 Perceived Risk and Phone Usage

A small number of studies have used risk ratings to compare how participants perceived one in-vehicle task with another, in terms of the level of risk expected by the driver if they conducted the task while driving. Overall, answering a call while driving was considered far less risky than was placing a call (Lerner 2005). Furthermore, using a hand-held phone, while driving, was considered significantly more risky than in hands-free mode (Zhou et al.

2009). Sending a text message has been found to be considered more risky than reading a text message while driving, although both were believed to be more dangerous than talking on the phone while driving (Atchley et al. 2011). There has also been found to be a small relationship between initiating a text message and the perceived risk of doing so (the greater the perceived risk the lower the driver's willingness to engage). It was suggested by Atchley et al. (2011) that this showed drivers may feel a greater pressure to respond to incoming messages, where perceived pressure to respond perhaps overrides their judgement of risk.

It is clear that there is still further scope for investigating whether perceived risk of engaging in a phone task while behind the wheel then influences willingness to engage with the task concurrent to driving.

2.12 Literature Review Summary

Overall the literature review for out-of-car phone usage found there is some assessment of the factors which influence willingness to engage with speech supported functions, such as a situation's formality, the amount of space and degree of privacy. Similarly, there were also common environments identified in the literature as being considered acceptable or unacceptable for vocal phone tasks (such as churches generally considered unacceptable and shopping centres considered acceptable). However, currently little is known about the factors which influence engagement with non-vocal phone tasks (such as text, internet or email) and the extent to which the acceptability of these tasks differ to vocal tasks and if so why? Furthermore, the factors which can inhibit phone engagement (such as the Socio-Cultural Environmental factors compared with Temporal factors) is an under researched area.

In terms of in-car phone use there seems to be some debate in the literature as to the extent that drivers delay their interaction with secondary tasks in response to changes in the road environment. However, the literature generally agrees that engagement with these secondary tasks while driving leads to significant impairments in driving performance as a result of driver distraction. There appears to be a particular paucity of qualitative studies attempting to gain in-depth understanding, from a driver’s perspective, of which factors influence their decision to engage with a phone and why? Furthermore, how the intended phone tasks influence willingness to engage, such as text messaging as opposed to placing a call, has not been substantially investigated and, once again, the qualitative reasoning behind such decisions is lacking. How capability can influence willingness to engage (both driving and phone capability, as well as actual and self-rated capability i.e. if someone is, or believes themselves to be, a proficient phone user or a more proficient driver does this influence their phone engagement behaviour?) has received little attention and is considered an important gap in the literature which warrants further investigation.

Chapter 3: Method

In this chapter the methods that are available to explore and gain insight into the research questions will be analysed and a rationale presented for the methods which will be selected. The review will investigate experimental design; outlining the benefits, limitations and findings of a number of relevant methodologies which need to be taken account when designing driving and phone use behaviour studies. Kvale (1996) said that a method in its original Greek meaning was a '*route that leads to a goal'* therefore it is important for researchers to know their end goals and then select an appropriate route (method) that will allow them to reach it.

The first research question of the thesis is 'to identify the factors which influence smart phone usage when outside the car and the extent to which these transfer to while driving also'. This can be considered an open question and therefore exploratory methodologies are considered to best address the problem's requirements.

3.1 Exploratory Studies

Exploratory studies aim to seek out information, views, ideas and beliefs in a specific area to gain an insight and knowledge on how, what, when, where, and why people behave as they do. They are also lightly resourced studies undertaken to help guide the design of more extensive and sophisticated studies that will follow. They help define key issues, formulate precise research questions and test potential methods. This is done through selecting relevant respondents and asking appropriate questions in order to meet these goals. There is also an attempt to avoid constraining the participants' responses, for example through open ended questions and bottom up data analysis. The most commonly used exploratory studies include questionnaires and interviews.

For this research question interviews are considered to best address the needs of the task. This is concluded because smartphone usage, both in and out of the car, is a very under researched area in the literature. This indicates that instead of asking targeted questions based on gaps in the knowledge a more general overview of peoples' behaviour with such technology is required. In particular insight into what drives such behaviours is needed and in-depth discussions with no limitations placed on the answers is believed the most appropriate format to gain this.

Questionnaires are also considered an appropriate option to address this research question. However, there may be too much exploration required for questionnaires to be used for this particular research question, after reviewing exploratory research methods it is clear they are better suited to more closed questions which can be formulated based on previously gained insight (McQueen et al. 2002). Questionnaires have some advantages over the interviews. Interviews, for example, require a larger amount of time to conduct, as well as transcribe and analyse, as opposed to questionnaires which often take only minutes for respondents to complete. Questionnaires can also be analysed relatively quickly due to their, often, more closed questions design, limiting the possible responses and thus decreasing analysis time (Gillham 2000). This allows far larger samples to be used in questionnaires, adding to the generalisability of the results. However, the more open-ended and less focused approach an interview offers outweighs the disadvantage of lack of generalisability, as insight behind why drivers did or did not engage with their phone is deemed necessary to help inform further studies in the thesis.

Another advantage of questionnaires over interviews is the possibility for anonymity, which may lead to more honest answers. The effects of the lack of anonymity offered by interviews will be reduced by assuring participants that although the experimenter is aware of their identity all data and results will be reported anonymously. However, participants answering in a socially desirable manner, or in a manner that they believed would please the experimenter, will always be a possible disadvantage of the interview methodology which is difficult to control for. Interviews do, however, have an advantage in allowing a rapport to be built between interviewer and interviewee which may lead to more personal information being given, even though the information is not anonymous, as a result of the level of trust gained in this environment (Gillham 2000).

A factor which had to be considered for both questionnaires and interviews is bias. The interviewer is the experimenter and will go into the interview process with some idea of the results they want, or expect, to find. It is important that the experimenter is aware of this and ensures they do not ask questions in a leading manner either in the way the question is phrased or tone of voice or body language used (Gubrium et al. 2001). As this can be an issue in both questionnaire and interview methodologies it offers little help in deciding which methodology to use but will be kept in mind when designing the study.

An advantage the interview methodology has over questionnaires is the ability to gain more in-depth information. Although it is possible to send out very open question questionnaires and ask respondents to fill in the information, this approach generally has a very low response rate. There is also a risk of very brief answers being given as a result of there being little incentive to complete them and being fairly time consuming through having to write or type out every word. Conversely interviews have a high level of social interaction inherent in the methodology which can be considered a reward in itself and lead to higher participation rates and more extensive answers being given. The respondent can also give feedback in a fast and effective manner through simply having to say their answers, as opposed to write them. They also allow the interviewer to prompt the interviewee to continue their answers further if not enough information has been gained, leading to more in-depth insight than is often garnered using a questionnaire methodology.

The type of interview methodology considered for this research question is a non-traditional one, comprising a photo-elicitation interview methodology. This method has been shown in the past to help gain more insight than a traditional, verbal questioning only, interview. This occurs as a result of the images helping to prompt memories by acting as a cue (Clark-Ibanez 2004) as well as activating a different part of the brain to verbal only interviews

(Harper 2002). This method will aim to use the images to help participants to become immersed in the interview process and put themselves in the location being questioned about at the time (Collier (1957), Petre et al. (2006),Chamorro-Koc et al. (2008)). For example, a number of images of meeting environments may help participants to recall that they can be in formal or informal meetings and thus give more diverse answers than if recalling their phoning behaviour in meetings simply from being questioned.

Overall interviews have been chosen as the methodology to answer the first, exploratory, research question as they offer the best possibility for exploring phone behaviour in-depth in an unconstrained way, which should help in gaining a thorough insight into why phone users report engaging, or not, with their smartphone. As this subject has received little attention in the literature this is considered necessary to fully understand all factors which can influence such behaviour. Smartphone usage may vary from traditional mobile phone use as a result of the extended functionality of smartphones. This study's unique interest in how out-of car phone use transfers to in-car use also shows why a methodology giving a great deal of reasoning behind answers given is needed. Furthermore, a novel approach involving photo elicitation methodology will be adopted to help immerse and prompt the participants, aiming to gain insight that might otherwise not be gained.

3.2 Experimental Studies

The second research question aims 'to determine if the road demand has an effect on willingness to engage with phone functions while driving?' This question has a more defined required outcome than the previous research question. Therefore, an ideal methodology to answer this question will allow for a definite cause and effect relationship to be attained. It must also maintaining validity and reliability so any findings can be applied to the roadway environment. This section will look into possible methods to answer this question as well as establishing the weaknesses and compromises that each methodology has in relation to the question.

Possible methods to meet the requirements of this research question include: test track studies, simulator studies, on road trials and naturalistic driving observations.

The major strengths of test track methodology are that studies can be conducted with minimal risk to the participant or other road users through the use of a controlled test track setting, whilst still actually being in control of a vehicle, making it well suited to when realistic vehicle dynamics are needed. The major drawbacks of this method are that it is often hard to fully recreate the dynamic environment of a road scene on a test track, such as the variation between a motorway, rural and urban environment (Regan et al. 2009). Participants may also behave in an unrealistic manner as they aware they are in a more controlled, safer, environment than the real road environment offers. For these reasons this method lacks ecological validity, making it difficult to generalise any findings to a real road setting.

Simulator studies share many of the same strengths and weaknesses with the test track methodology such as offering a safe environment for testing but also lacking in ecological validity as a result of this. It is better for recreating the changes of road environments, for example allowing the driver to transition from rural to urban environments in one drive. It can be considered even more controlled than test track studies with subjects able to be exposed to the exact same environment each time through the fixing of weather, traffic levels and other drivers' behaviour etc. It can also be particularly useful for testing factors deemed to unsafe to test on the road, such as drivers' reactions to pedestrians stepping into the roadway or illegal behaviours such as driving under the influence of alcohol or whilst conducting a highly distracting secondary task all without putting the participant under any real danger. However, simulator studies can lack ecological validity not just through the driver feeling safer, and therefore acting unrealistically but also through the driver not controlling a real vehicle. This can mean the dynamics of the simulated vehicle may not fully match those of a real car, the sensation of acceleration for example is particularly hard to recreate in a virtual environment (Hancock et al. (1999), Reed et al. (1999), Engström et al. (2005)). A possible side effect of driving in a simulator is the feeling of 'simulator sickness'. This is a form of motion sickness and has the same side effects such as nausea and vomiting. It has been suggested these span from a conflict in sensory information in the body such as the participants' sense of balance telling them they are sitting stationary but their eyes informing them that they are moving (Treisman, 1977). It has been found that older adults are more prone to simulator sickness than younger, possibly resulting from clogged or narrowed ear canals or simple loss of sense of position (Brooks et al. 2010). It is possible that a high fidelity simulator can help to reduce these effects as a result of giving more consistent feedback to all senses of movement. Lack of simulator sickness has been proposed as a possible way of classifying a simulator's fidelity (Harms, 1996).

One specific form of simulator is the Lane Change Task (LCT). This is a low fidelity simulation which combines primitive driving simulation with a reaction time test (Mattes et al. 2009). It provides a low cost method of measuring the distracting effects of one secondary task compared to another through measuring driving performance compared to an ideal. The participant is only required to give steering inputs as the speed is set at a constant. The participant is presented with instructions to change lanes, through the use of arrow signs, on the side of a simulated test track. Participants performance of the lane change manoeuvre is then compared to an ideal in terms of how swiftly they moved across and how well they maintain lane positioning. The result is given as a numerical value known as the 'MDev', which represents a calculation of the mean deviation from the ideal path, which the simulator has programmed into it.

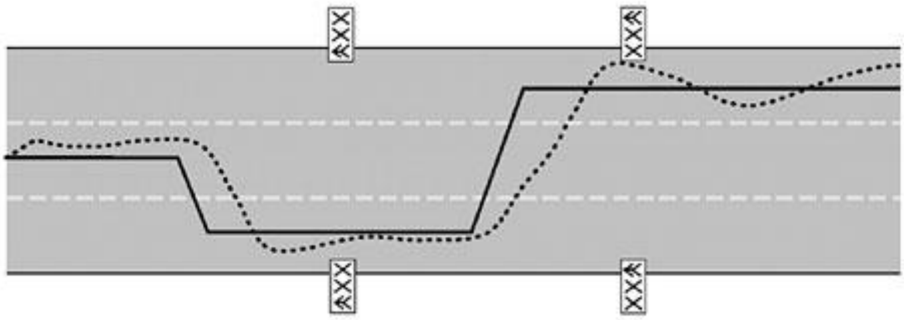

Figure 1: Showing the ideal path compared to actual path taken.

In Figure 1 the ideal path or 'normative model' is shown in the solid line and the actual path taken by the participant is shown by the dotted line. The MDev is the measured difference between these two lines, the higher the MDev the worse the performance and therefore the more distracting the secondary task is deemed to be. The main advantages of the LCT is that it is fast, cheap and simple to set up and it gives an easy to interpret output for comparison of the distracting effects of each task conducted.

The main disadvantage is its lack of ecological validity. It possesses the same drawbacks as any other low fidelity simulator. However, as a result of the participant not having to control throttle response or react to normal roadway hazards, it is even more questionable to what extent findings from the LCT can be applied to the real world. A path which simulates that of the 'normative model' is also very hard to attain and requires a rapid turn of the steering wheel, as opposed to the progressive steering often observed in a real world driving environment. This again limits the validity of any of the findings. Related to this it has been found that there is a significant learning effect associated with the task, a likely result of having to adapt to the unusual steering manner required (Petzoldt et al. 2011).

Another possible method for investigating the second research question is the use of video clips or roadway environments. In this method the participant is not required to control or have any input but simply views the recorded roadway scenario and makes ratings or judgements based on this. This has the advantage of being very cheap, quick and easy to set up as well as not putting the participant under any risk of harm, as a result of simply having to view video clips. This methodology is particularly advantageous when high levels of information or insight is needed. This is a result of the participant having time to form their views and opinions and, if desired, discuss as the video is being played due to not having to be in control of a vehicle in any way. It also allows for strong comparisons across participants as they will all have viewed the exact same video clips and therefore 'experienced' the same roadway scenario for which to make their ratings on. Even in simulators there is likely to be some variability such as having slightly different interactions with simulated vehicles. Therefore, it can allow for strong cause and effect relationships to be made. It also maintains validity to some extent as the video clips can be taken directly from recordings of real road environments so opinions and insights come from actual roadway events.

This method has a large drawback though as a result of the participant not having to actual drive themselves, not even in simulated form. What they say they would do in a scenario and how they would actually behave could be very different, severely limiting the ecological validity of the findings (Jupp 2006).

On road studies have far greater validity than the previously mentioned methodologies as drivers are driving on a real roadway and often in their own vehicles. This does not necessarily ensure true driving behaviour though as the participant may be very aware they are being observed and may, therefore, drive in a more socially acceptable or cautious manner than they would natural do so. They can also be very expensive to set up as a result of the equipment needed and take a very long time to collect and analyse the results. There is a further drawback in that some studies will simply not be possible to be conducted on a real road environment as a result of being unethical, illegal or highly dangerous, such as driving under the influence of significant amounts of alcohol.

Naturalistic driving studies involve equipping cars, often the participants own, to record peoples' everyday driving behaviour over a longer period of time. Data frequently collected includes: vehicle speed, distance, location, lateral and longitudinal control and video capture of each journey. Naturalistic driving studies' largest strength lies in their ecological validity as drivers' real road behaviour is collected. This allows for any findings to be applied to real life as they were observed and recorded from drivers' actual behaviour.

This methodology does however still have some drawbacks. Firstly there are not many guidelines yet in existence which informs on how to reliably and effectively conduct this type of study, this leads to a large variability in the data which each study collect. This methodology also inevitably leads to a huge amount of data being collected as a result of the length of time that data is recorded over and the number of measures taken from each vehicle. This means a lot of time and money is involved in running such trials even once the data collection stage is over. The complexity of the equipment needed to the vehicles to capture all the required data introduces issues and it is not uncommon for large amounts of data to be corrupted, or the data capture to be incomplete even if every measure is put in place to minimise this risk (Sagberg et al. 2011). Once the data has been collected only certain 'events' are reported, these are usually the occasions when heavy braking, lane deviation, increase in speed or a crash have been recorded. This processing stage is open to interpretation with it being possible to select too many incidents (false positive) or exclude some incidents which should have been included (true negative) (Dozza et al. 2012). Furthermore this methodology is ineffective for when cause and effect relationships are needed to be identified due to the real roadway environment always having the potential to introduce a multitude of confounding variables.

After reviewing the choice of methods, the method proposed for the second study is a video methodology. This involves participants viewing videos of real road environments and then rating how willing they are to engage with a number of phone functions, if they were driving in the scenario depicted by video (similar to that used by Lerner (2005)). This has a number of advantages over other methods, the most important is that participants will not actually be required to drive but simply watch the videos. This is necessary as participants will further be asked to think out loud when making their judgements, allowing insight behind their decisions to be gained. This ensures that if there is something specific about the scenarios which is frequently mentioned as a deterrent to phone engagement then this information will be captured. The act of having to drive may have limited the information about the road scene taken in by the participant, on which they have to base their judgements, so would limit the insight gained, this methodology overcomes this problem.

This method has a further advantage that all participants make their ratings based on exactly the same scenario. This is important as something as trivial as heavier traffic or inclement weather will adjust the demand of the scenario and thus make it difficult to know to what extent the demand of the roadway is influencing willingness to engage if every participant experiences a different level of demand on which they base their ratings. This sort of control does have a downside, however, as the study will have reduced ecological validity as a result of the participants not actually driving the car themselves and not being in a car on a real road environment at the time of making ratings. This is considered an acceptable compromise in order to be able to make stronger cause and effect conclusions.

Other methods allow this control to be maintained, such as simulator studies or test track studies, although both of these methodologies still require the participant to drive, limiting their ability to talk through why they are giving the ratings they are. Furthermore, these methodologies still have impaired ecological validity as mentioned previously.

A further advantage of the video clips is the speed with which they can be implemented as there is little setup required other than sourcing the initial appropriate videos. The cost of this methodology is also very low, simply requiring a laptop computer and rating scales, as opposed to test track, high fidelity simulators and on road studies which all require significant costs to setup and maintain the equipment.

3.2.1 Rating Scales

In this study participants will be required to indicate their willingness to engage with their phone after viewing each video, therefore rating scales will be used to make such ratings. The optimum number of points in a rating scale has caused considerable debate in the literature. The scale chosen can affect the results in that it may allow for differentiation more precisely than a person is able to discriminate, this can lead to different values being selected on different occasions due to the scale rather than their actual opinion. For example on a scale of 1-10 a participant may select 8 on one test and if asked the same question again may score it a 9, not because their opinion had changed but simply because there was too little differentiation between the numbers in the scale. In other words '*the differentiation is due to the scale design rather than the trait being measured'* (Weng 2004). Conversely too much differentiation and the options may not adequately express their opinion, for example a 3 point scale representing strongly disagree, neutral or strongly agree may be too extreme if the participant agrees only to some extent but there is no way for them to represent this opinion correctly.

Findings in the literature are generally in favour of 3 point (Bendig (1953), Preston et al. (2000)), five point (Bendig (1953), Lozano et al. (2008), Weijters et al. (2010)) and seven point (Bendig (1953), Preston et al. (2000), Lozano et al. (2008)) scales being used. With (Miller 1956)'s finding that humans struggle to process more than seven items (plus or minus two) at a time was given by Preston et al. (2000) as a possible reason why scales with more than seven points have generally been found to be less reliable or valid than those with fewer points on the scale. There is also some debate whether it is necessary to have labels (e.g. 'never' or always') on every point of the scale (Weijters et al. 2010) or just as anchor points at the end values of the scale (Dixon et al. (1984), Weng (2004)).

For this Study 3 point rating scales will be used for participants to rate their willingness to place or answer a call and send or read a text message against (1: 'I would absolutely not do this task now', 2: 'some chance of doing the task' and 3: 'I'm very willing to do this task now'). Due to the number of participants intended to be used (20), utilising three point rating scales ensures there will be enough participants within each cell to allow statistical testing to take place on the data whilst still offering enough choices on the scale to clearly differentiate between when the participant are, and are not, willing to engage with their phone.

3.3 Experimental Studies Continued

The final study's research question is to 'determine whether *driving capability* or *phone capability* affects the situations in which drivers are willing to engage with their mobile phone?'

This research question, similar to Study 2's, is quite targeted and therefore experimental studies will once again be the most appropriate methodology.

However, unlike Study 2 the emphasis will be more on finding how drivers behave with their phone under different circumstances with little emphasis put on finding insight as to why. This question therefore needs to test when drivers will or will not use their phone and needs a methodology that will allow this. Similar to Study 2, some parts of the environment will need to be held constant in order to test cause and effect relationships, in this case high and low demand environments are needed and they are required to remain the same across all participants to test whether driving capability or phone capability influences willingness to engage under high and low demand conditions. This means the environment has to be entirely replicable for each trial in order to ensure it is the phone or driving capability variables which influence the engagement behaviour and not as a result of the environment being slightly more or less demanding for some participants compared to others.

As a result of all these requirements a simulator study methodology will be used as this method allows for observation of drivers' behaviour with their phones, although in a simulated roadway, and enables the demand experienced to remain exactly the same across all participants. As mentioned previously, controlling the road environment in this way affects ecological validity but is deemed necessary for cause and effect conclusions to be made. Drivers will be able to drive and engage with their phone, unlike in Study 2, as it is simply their interaction behaviour that is of interest and no insight is required, meaning being in control of a (simulated) vehicle will not limit the outcomes of the study.

The simulator methodology has advantages for this research question in that it allows drivers to use their phone without the possibility of harming themselves or others in the roadway environment (Hancock et al. 1999). This again will affect ecological validity, as being aware that their driving behaviour will not affect their safety may make participants carry out actions which they would not attempt in a real road setting (Engström et al. 2005). Although, there are also a number of studies which have found equal validity between on-road trials' and simulator study trials' results (Godley et al. (2002), Bella (2008), Yan et al. (2008)) suggesting the findings should, to some extent at least, be generalisable. As it is deemed unethical to conduct such a study on a real roadway, as a result of requiring engagement in a secondary task known to cause distraction, the only other option is to use a test track. However, the test track methodology has the disadvantage that if the driver is severely distracted they could possibly still come to some harm, as a result of being in control of an actual vehicle, as well as having far higher set up costs and more limited control of variables compared with the simulator methodology.

Overall a range of methodologies will be used to answer the research questions needed to complete the thesis. These will comprise: interviews, video clips and rating scales and a simulator methodology. These have been selected after reviewing the advantages and disadvantages of different research methods, allowing a fully informed decision to be made before opting for one methodology over another.

Chapter 4- Study 1: Factors Affecting Willingness to Engage with a Smartphone While Driving

4.1 Introduction

As driving is a self-paced, safety critical task it would be reasonable to assume that drivers would prioritise driving and try and fit in secondary/tertiary activities according to driving demands. Lee (2010) said that '*there is not a strong differentiation of appropriate and inappropriate times to engage in interactive technology use...many teens described being on the phone "all the time" and felt that "the cell phone is my life." Technology use is not guided by finding the opportunity to engage in the task but rather only occasionally constrained by some exception to refrain from the task*'. This brings into question what are the factors which lead to '*refraining from the task*'?

Matthews et al. (2009), when studying phone usage, found that '*context strongly affected mobile phone use, from when users interacted with them to what they did with them and for how long*'. With driving being a safety critical activity it would be easy to assume that this would be one of the contexts which would lead phone users to refrain from use. However, many studies have found the contrary with high rates of both hand-held and hands-free phone usage while driving. As yet, few studies have looked into the factors which affect willingness to engage with mobile phones in different environments, in particular looking into whether the factors which influence phone use out of the car also transfer to influencing phone usage while driving.

Along with a paucity of studies into how context affects phone usage there is also very little knowledge on the extent to which the phone function intended to be used can affect willingness to engage with a mobile phone. Recent smartphones have a diverse range of functions and now extend mobile phone capabilities far beyond simple phoning and texting capabilities. With such a wide range of 'advanced functions' (such as email, camera, mp3, internet access and downloadable applications) the usage of smartphones may differ vastly from earlier talk and text phones. The factors encouraging or inhibiting someone's willingness to engage with the phone may also therefore have changed.

Does the driving environment count as one of the areas where phone users 'occasionally refrain from the task' and are there certain factors which influence this judgement?

The following study, therefore, investigated factors affecting willingness to engage with a smartphone in environments where mobile phones had been found to be frequently used before. The focus was mostly on the driving environment, investigating if this was always considered a context to refrain from phone usage or if willingness to engage with a phone, while driving, varied between different journeys or within a journey based on specific factors. The study also investigated if the driving environment could be considered unique in terms of the factors which promoted or inhibited phone interaction or if the same factors which dictated willingness to engage out of the car affected phone usage when driving also.

The study in this chapter was designed to be exploratory and open in order to gain grounding in any issues that may be relevant to the new area of smartphone usage while driving and the under-studied area of factors affecting willingness to engage with mobile phones. It was intended to highlight issues which may require further investigation as opposed to testing specific theories or hypotheses.

The study involved participants imagining they were in different environments (such as shopping, in a meeting or driving) and within these environments they considered their propensity to use a mobile phone in varying scenarios (such as when they had a time pressure, when they were bored or when they had a high demand placed on them). Participants were asked to complete rating scales as a quantitative measurement of their phoning behaviour as well as give think aloud, qualitative, reasoning as to why they would or wouldn't use their phone based on the environment and scenario they were in.

4.2 Aims

The aims of the study were to gain insight into the factors which influence smart phone usage while driving and the extent to which these transfer from when outside of the car to while driving. Specific objectives were to:

- Determine which phone functions were currently used while driving and what factors influenced this.
- Identify which phone functions were used outside of the car, in a number of different environments, and determine what factors influenced this usage.
- Find if there was a transfer in factors which influence phone usage outside of the car to when driving or if the driving environment could be considered unique in its influence on phone function engagement.
- Discover the current prevalence of smartphones' 'advanced functions' usage while driving and reasons behind their use or non-use.

4.3 Study Rationale

4.3.1 Research Approach

Since the aims of the study were to explore the factors which affected willingness to engage as well as to collect data on drivers' phone usage behaviour a relatively unconstrained and in depth interview methodology was chosen. This was specifically designed not to seek or test any models, which would limit the scope of the interview, but instead it was more of an open discussion aimed at allowing maximum insight and a detailed picture of factors affecting willingness to engage to be constructed.

4.3.2 Rationale Behind Environments Chosen

The main environment of interest in the current study was usage whilst driving. However, other environments were also investigated to try and gain more informed (and possibly honest) answers about participants' in car use (by not focusing solely on their, possibly illegal, phone behaviour whilst driving). This made the intentions of the study less explicit to the participants. Investigating environments outside of the car also provided insight into how factors affecting phone usage transfer from out of the car to while driving.

For the out of car environments it was decided that places with varied characteristics but also wide spread usage (so environments every driver could identify with) were required to allow maximum insight into what factors may affect phone engagement and why. It was decided the environments to be studied were while:

- Using public transport
- In a restaurant
- Shopping
- In a meeting
- Driving

These environments have diverse but contrasting characteristics which enable the identification of factors influencing willingness to engage. Below is a description of each environment and the unique characteristics they featured along with rationale for why they were included in the study and with reference to John et al. 's (2002) technology use categorisations (see literature review page for more information on these). These were also similar environments to those chosen by Turner et al. (2008), when studying phone use behaviours, only their 'on the street' environment was supplemented with 'driving' environment in the current study, which also features different aims and methodology.

Public transport can be characterised as being a standing or seated environment, where, unusually, people often have to sit very close to complete strangers. It was possible for this environment to be used for both work and social reasons and the passengers had little or no control over the length of time a journey took. It was included in the study as, similar to driving, it involved travelling from one destination to another but the people themselves could be seated and stationary (shared micro environment factors to driving). This movement from one destination to the next may also affect phone service and infrastructure availability (shared macro environment factors). It shares some aspects of the driving environment (e.g. potentially variable reception quality) but differs significantly with others (dual task and divided attention).

A restaurant can be characterised as being a seated environment where many social rules existed. The environment could be very noisy or quiet and very formal or informal. Often people would have other company with them in this environment. This environment was included in the study as it was believed to contain certain social rules and etiquette of phone use so had a stigma attached to phone behaviour which could also be argued to be present when driving (shared socio cultural environment factors). Participants were also likely to have friends or family present, as may be the case when driving, so a comparison of how people's presence affected phone use both in and out of the car would be possible (see Ling (1997) for a detailed description of social rules in restaurants which make the environment unique and patrons in the environment especially sensitive to phone usage).

In comparison shopping has few social rules, would often be a social activity and required a great deal of moving around within the environment – but with relatively little risk of significant accidents. People had a lot of control over how long the activity took and could often be conducted both alone and with company. This environment was included in the study as it offered a lot of freedom for phone use with less social rules and etiquette than other environments but similar to driving often involves a great deal of movement, though in this case the person themselves are moving, as opposed to being seated and the car moving. Therefore, similar issues with using the phone while concentrating on the changing environment around them (shared temporal environment factors) may be present for both driving and shopping.

A meeting, similar to a restaurant, has many social rules that people were often expected to abide by but, unlike a restaurant, the reason for being there was almost always work related. Therefore, the participants may have been surrounded by different types of people to the other scenarios, some of which may have authority over them so the social influence is arguably more formal rather than informal. Again the participant may have had little control over the time spent in the environment and would often be sat stationary. This environment was included as, similar to driving, there may be consequences for using the phone inappropriately. Phone use may be regarded as rude when in a meeting and appropriate usage may be enforced by superiors and may, therefore, make an interesting comparison to driving where (some mediums) of phone use were also prohibited and enforced by an authority, the law (shared socio cultural environment factors with driving).

Driving can be characterised as a seated environment but the car itself would be moving. A lot more attention may have been required than in the other environments as failure to pay attention would have far worse consequences; it was a safety critical environment. The activity could be undertaken for both work and social reasons and could be conducted alone or with company. They were less likely to be surrounded by strangers than in many of the other environments; the car is a fairly unique piece of ‘private space’ for many people offering qualities such as: personalised, defended, rarely intruded upon and often quiet. The car allows these qualities to be frequently experienced and remain stable for a defined period. Contrasting to any of the other environments there were also laws in place in an attempt to limit the usage of some phone functions.

4.3.2.1 Rationale for Scenarios

Three pilot studies were initially conducted with participants left to suggest their own scenarios which affected phone interaction in an environment. However, participants experienced difficulty in recalling scenarios which affected their phone use behaviour and often used the same or similar scenarios for each environment. Based on feedback from the pilot studies prompt cards for the scenarios affecting phone usage were created.

These prompt cards were used to help structure the interviews and give participants reminders of factors which may affect their phone use to talk around. The scenarios were based on reasons which frequently featured in the pilots for use or non-use of the phone and were supported as reasons for use or non-use by the literature. The scenarios chosen were times when participants:

- Had a perceived high workload
- Were bored
- Had other people present
- Needed information
- Expected an incoming call/ email/ text
- Had a time pressure
- Other

If the participants didn't feel the factor influenced their phone use they were not required to discuss that factor. The 'other' card allowed them to suggest and talk about any other factors not suggested which may have influenced their willingness to engage.

4.3.3 Phone Use with a Perceived High Workload

The first suggested factor was how having a perceived high workload affected phone usage in different environments. McKnight et al. (1993) found in attention demanding situations drivers might lower their accident risk by avoiding calls, particularly those involving intense conversation, they also found this was particularly true for older drivers. Liu et al. (2006) found similar findings, though driver age was not taken account of, when looking at phone use in different traffic environments discovering when faced with heavy traffic drivers restrict their phone use and lower their driving speed.

4.3.3.1 Phone Use Whilst Bored

Another factor suggested was the effect of being bored or under stimulated on phone use both in and out of the car. Emanuel (2013) in a survey of 403 students found 77% reported using their phones when bored very often to fairly often. Peters et al. (2005) found examples of phone usage '*during boring moments or moments of waiting'*. Phone usage may be used to fill what is considered to be 'dead time' whereby the task being conducted isn't very productive but is often a facilitator to achieving a goal, such as commuting to work or waiting for the adverts to finish. If driving is considered 'dead time' or 'opportunity time'; the natural state being one of communicating at will and the car being a (mostly) convenient opportunity to engage then this reasons for phone usage may apply to when out of the car and when driving.

4.3.3.2 Phone Use with People Present

Having other people present was another prompt. This was chosen as it was found by Arnett et al. (1997) that teenagers reported driving slower with their parents in the car than they did with friends in the car. This related to speeding but another risky and, therefore, possibly comparable behaviour was phone use. Lam et al. (2003) also found the number of passengers had more effect on driving speed than the age of passenger. On the basis of these findings it is possible to predict that older passengers may inhibit phone use whilst younger passengers may not. Consequently, it was noted whether participants mentioned if and how the number, characteristics or presence or absence of passengers had an effect on willingness to engage with a mobile device.

Vollrath et al. (2002) found a general positive effect of having passengers in the car; they found this is reduced for young drivers (the age of the passengers was not taken into account), in the dark, in slow traffic and at crossroads. Generally, the presence of passengers led to more cautious and thus safer driving, possibly meaning they would be less likely to interact with their phone. Rozario et al. (2010) looked at external factors affecting phone use and discovered perceived subjective norms were a positive predictor of willingness to use the phone only for the scenarios when the driver had friends in the car, suggesting drivers are influenced by the people present. Drivers may feel some normative pressures to use their phone in the car when friends were present. The current study will look into this further, gaining qualitative data that may offer more insight into if passengers affect phone use and if so, why?

These findings on passengers affecting phone usage behaviour while driving may be comparable to out of car phone usage as social settings, such as restaurants, have been shown to influence phone usage due to other people being present through socially determined acceptable behaviour for phone use. Ling (1998) found that 'sound interference', from the phone ringing or loud talking intruded on other peoples' social spaces in restaurants and so can make phone use inappropriate, it would be interesting to find if the same psycho social factors of out of car usage also influence phone use in car .

Few studies exist, both out of the car and whilst driving, on the effect of other peoples' presence on advanced functionality usage, such as email and applications usage. Verbal phone tasks are likely to be more intrusive in a social setting than text/visual activities. A quick glance at a text is likely to be more acceptable than taking/making a phone call, although an extended session on Facebook may be less acceptable.

4.3.3.3 Informational Needs

A further suggested factor was if wanting to meet informational needs affected what functions people were willing to use on their phone. Emanuel (2013) found, in a survey of college students, that 73% reported using their phone to get information they needed right away. Church et al.'s (2009) diary study found informational needs were higher on the go (e.g. when commuting or travelling abroad) than when in a familiar area such as at home or at their desk. Such needs included where to park in a certain town for example. This was also found by Sohn et al. (2008) who quoted one participant as saying '*more than 90% of my (informational) needs were (generated) in my commute going back and forth from work*'.

4.3.3.4 Time Pressure

A further suggested factor was if feeling a time pressure affected the phone functions used both in and out of the car. Rozario et al. (2010) investigated the effects of time pressure on drivers' willingness to use their phone whilst driving, and discovered drivers felt under higher stress when driving with a time pressure compared to without. Walsh et al. (2008) went further and found being under a time pressure led to an increased intention to call but not text while driving for those using the car for business purposes.

4.3.3.5 Expecting an Incoming Call/Email/Text is and if this Effects Phone Interaction

Finally the study investigated if the nature of the call such as having an expectancy of an important call, email or text affected willingness to interact with the phone and what factors dictated whether someone would interact with the expected important incoming call/ text/ email.

Nelson et al. (2009) found that people were more likely to answer a phone call if it was perceived to be important, caller ID may allow some speculation as to how important a call, text or email could be before actually deciding to engage with it.

4.4 Photo Elicitation Interview

In order to get participants to think deeply and recall as much information as possible on their previous phone use, a novel methodology involving the use of photographic prompts was used. This involved presenting the interviewees with images which could be used to help immerse them into the described environment and aid in recall of past experiences (for more information and advantages of photo elicitation interviews please see literature review and methods sections).

Figures 2-6 show the images used to represent the different environments. These images were chosen to reflect the different experiences and emotions that can be experienced in each environment and act as a reminder and prompt for participants as to the possible issues to talk about.

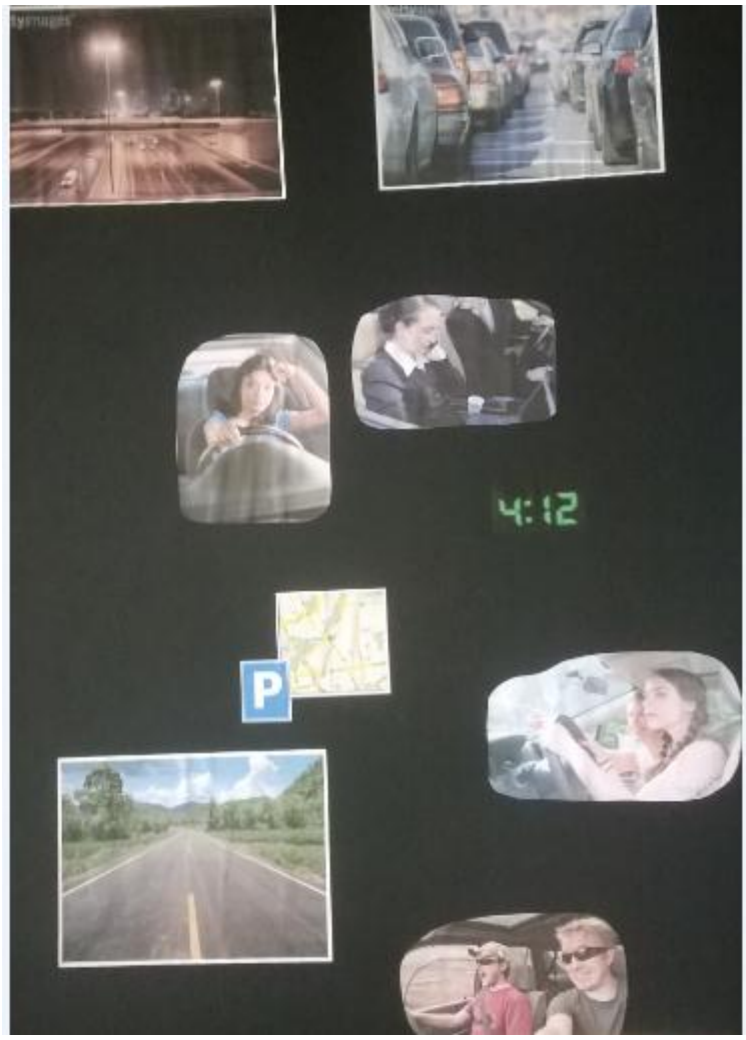

Figure 2: Images used on the photo board to represent a driving environment

Figure 3: Images used on the photo board to represent a public transport environment

Figure 4: Images used on the photo board to represent a meeting environment

Figure 5: Images used on the photo board to represent a restaurant environment.

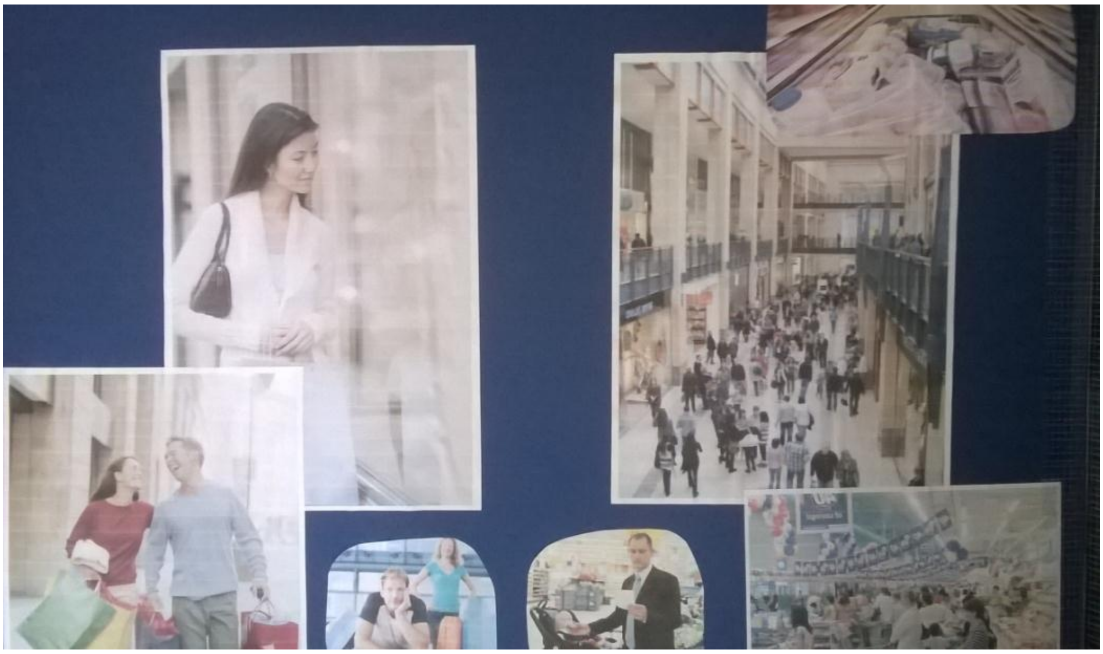

Figure 6: Images used on the photo board to represent a shopping environment.

4.5 Sample Rationale

Business professionals were sampled as this demographic have been found to be heavy users of phones in previous literature. In a study by Peters et al. (2005) it was found business users used their phones in a range of environments including: on the street, in the car, on the train, in restaurants and in shopping malls. Business users, therefore, may present interesting results for comparing phone usage when out of car and whilst driving. Business users were also considered likely to demonstrate task oriented phone usage (outlined in Leung et al. (2000)) as they try and meet their work demands using their mobile phone. This was shown by Falaki et al. (2010) finding knowledge workers were more likely to use productivity applications compared to high school students.

Students were also sampled as this demographic have been found to be early adopters of technology and so may display patterns of phone usage that the rest of the population may later also demonstrate. This was proposed by Nelson et al. (2009) who suggested undergraduate students make a excellent sample for phone use studies as they tend to be the first demographic to adopt a new technology. Lee (2010) describes '*a generation raised on augmented reality, handheld videoconferencing, and immediate access to all of the world's information'* page 2049, highlighting why it was important to include a younger generation in the sample as having been raised with more advanced technologies, they may possibly use phones differently as a result. Furthermore, students may also be more likely to be driving for personal reasons, opposed to business reasons, which may influence their phone usage habits to be more socially oriented (outlined in Leung et al. (2000)).

It should be noted that the intention of the study was not to compare or contrast the phone habits of student and business professional drivers, both groups were included to ensure a more complete picture of factors affecting phone usage could be gained.

4.6 Method

4.6.1 Participants

Twenty participants took part in the study, all of whom had been smartphone owners for at least 6 months and had held a full UK drivers licence for at least a year. Ten students (5 male, 5 female, 9 between ages of 18-25, 1 was aged 26-35) and 10 business professionals (5 male, 5 female, 7 aged 46-65, 3 aged 26-35) took part. Participants were recruited through convenience sampling through University notice boards and personal contacts, quota sampling was also used to ensure they met the demographic criteria described previously.

4.6.2 Approach

The photo elicitation methodology involved participants being presented with a mood board (Figure 7), consisting of three A1 cardboard sheets. The two outer sheets presented pictures depicting two environments (e.g. in a meeting and while shopping) whilst the middle board only depicted driving. The five environments represented on the boards acted as prompts to talk around and to remind the participants of possible variations in the environment. For example, photos of people eating in a restaurant alone, with friends, with work colleagues, looking bored or looking busy etc. were intended to help remind participants that in each environment there can be many different situations and factors affecting their behaviour. It was hoped this would aid memory recall and therefore give more insight into factors affecting willingness to engage with their phone in different environments. It was made clear that for the driving scenario participants should consider their usage based on using the phone in hands-free calling where appropriate and to imagine their phone is set up in a cradle within easy reach from their driving position.

Figure 7: Mood board for photo elicitation interviews

Participants selected environments and then considered scenarios which might be relevant to their phone use behaviour.

Figure 8: Rating scales used, this example represented phone use for when shopping bored.

Participants were presented with a five point rating scale and given prompt cards with the name of each phone function on and a picture to represent the function to make it easier to differentiate them (Figure 8). This allowed participants to give ratings on how willing they were to use certain functions in a more interactive and interesting way than simply filling in scales on a piece of paper. The physical manipulation of the functions cards was designed to encourage discussion about each function and their propensity to use it.

Many of the current studies looking at factors affecting phone use utilise the Theory of Planned Behaviour to find peoples' motivations for use. These often use either Likert (Nemme et al. (2010), Rozario et al. (2010)) or bipolar scales (Zhou et al. 2009) to measure peoples' beliefs and intentions. Many of these are seven points scales ranging from strongly disagree to strongly agree, very likely to very unlikely etc. Following pilot trials the 7 point scales were reduced to 5 point scales to simplify the rating decisions. The scale labels were defined as 'never' and 'almost always' in terms of frequency of functionality usage. Iversen et al. (2002) used a similar scale when trying to find the effects of personality on risky driving and involvement in accidents but theirs ranged from 'never' to 'very often'. In the current study 'very often' was replaced with 'almost always' as 'very often' was not sufficiently differentiated from 'often'. Pilot participants also thought 'always' was too absolute and if someone recalled a single instance when they chose not to use their phone in that situation then they couldn't select the 'always' scale point. Therefore, 'almost always' seemed to be the most apt description as it was clearly more frequent than 'often' but not as precise as 'always'.

The thematic analysis adopted a realist/ essentialist epistemology where a '*largely unidirectional relationship is assumed between meaning and experience and language (language reflects and allows us to articulate meaning and experience)*' (Braun et al. 2006), allowing motivations, experience and meaning behind codes and themes to be theorised in a straight forward way. Similarly, themes were identified at a semantic/ explicit level whereby the analysis was not looking for any meaning when coding beyond what the participant had said. This ensured data was taken at face value and no meaning was added or implied to the individual codes, only at the analysis stage were patterns in the data and their broader meanings and implications explored.

4.6.3 Procedure

Twenty in-depth semi structured interviews were carried out. An information sheet was first given to participants and informed consent collected. It was made clear all results would be kept anonymous and the participant could withdraw at any point. Each interview lasted around an hour in length and required participants to discuss their phone use in five different environments, one environment at a time.

The **environments** were while:

Driving

On public transport

In a restaurant

Shopping

In a meeting

A mood board (Figure 7) acted as a reminder and immersion tool to help participants get into the mind-set they would be in, in that particular environment. The order the environments were presented in varied each time (e.g. one participant was asked about driving then about when in a meeting, then shopping etc. whereas another was asked about shopping first then driving then on public transport etc.) in order to eliminate any order effects. Once participants were given an environment they then also specified scenarios within that environment which may have an effect on their phone usage and these were addressed one at a time.

The **scenarios** used were:

Bored

High workload

Time pressure } Expecting an incoming call/ email/ text

People present

Needed information

There was also a choice of ‘other’ if they could think of another scenario which would affect their phone usage in that environment which had not been given. For each of the scenarios listed, participants were also asked if expecting an email, call or text would make any difference and if so why. If they couldn’t think of how the scenario would apply in that environment then they didn’t make any ratings for that scenario.

Once a scenario had been chosen participants then rated their willingness to use one of a number of phone functions (place call, answer call, send text, read text, send email, read email, applications, mp3, internet, games and other) by placing a card, with the functions name on, below a point on a rating scale from one to five with one being ‘never’ use the function and five being ‘almost always’ willing to use it.

Once a participant had placed all the function cards under the rating scale for each environment and scenario a photo was taken (see Figure 8) so the results could later be turned into graphs showing phone usage prevalence for each environment and scenario.

Participants were also asked to provide verbal insight as they placed a particular function card under a frequency label in order to gain understanding as to the factors affecting willingness to engage with the phone (based on environment, scenario and phone function). This acted as a way of structuring the questions for the interview. These answers were recorded on a Dictaphone and transcribed verbatim after the interview had concluded.

The Thematic Analysis was carried out using the procedure recommended in Braun et al. (2006). Familiarity with the data was first achieved through both transcribing the interviews verbatim and then through ‘active reading’ of the transcripts allowing for patterns in the data to be observed.

Codes were next identified within the transcripts using an ‘inductive’ or ‘bottom up’ approach, whereby the data was coded without using any pre-existing coding framework from themes found in previous literature. Instead the themes were strongly linked to the data themselves, where the data was read and re-read for any themes related to willingness to engage and once identified were highlighted on a print out of the raw data and an occurrence of that code recorded in an Excel document. An example of quotes and how they were then coded is shown in Table 1 below.

Table 1: Showing an example of how quotes from the interview were coded

Quote	Code
'I would read a text, send a text and read email but I wouldn't be doing any of the other things because they would be too obvious'	Not discreet Email/text discreet
'Being bored wouldn't make any difference as I'm still limited by what is socially acceptable to be used'	Social rules/ etiquette inhibit usage
'If I'm bored then the meeting probably isn't to do with me so I might as well do something discrete that can keep me occupied'.	Relieving boredom Discreet usage
'If it was work related I would do any of those because it doesn't matter if discreet or indiscreet because to do with work'	Discretion not needed Context of function same as environment so will use
'These can help me get information so I'm likely to use them to do that'	Use functions if helpful
'Most functions wouldn't be used as it would be rude to play games, for example, in a meeting'	Social rules/ etiquette inhibit usage

The analysis then focused on collating the specific codes into broader themes, by analysing which codes were frequently mentioned in conjunction with one another or appear to be related to one another and thus could be considered to cover the same topic or reason for use or disuse. This process allowed for larger and more general theme to be formed as opposed to lots of specific themes which may only apply to this study. The initial themes identified from this stage are displayed in mind map form (Figure 9) showing both main and sub themes identified.

These initial themes were then reviewed and those that were no longer believed to be themes (were too specific or did not have enough data to support them) were removed or collapsed into each other where possible (two previously very specific separate themes combined into one more general theme which depicts the same reason for use or disuse but in a more general way). These were then reviewed against the initial coded data extracts to ensure the themes captured the meaning behind each extracts coherently. Next the same process was conducted but referring to the entire data set and ensuring the themes reflect the meaning of the data set as a whole until more refined and better defined themes were achieved. The resulting refined thematic map is shown in Figure 11.

4.7 Results

4.7.1 Rating Scales

Tables showing the ratings of willingness to engage are displayed in Appendix 2, due to the large number of tables required to fully present these findings.

4.7.2 Coding

The tables on the following pages show the frequency counts for the number of times each item was coded in the transcripts for an environment during the initial stages of the thematic analysis.

Table 2: Showing the number of times each theme was coded in each scenario as reasons for using or not using their phone

Themes	Number of times coded in each scenario				
Reason for not using the phone	**Driving**	**Meeting**	**Shopping**	**Public Transport**	**Restaurant**
Rude	1	37	6	6	28
Ineffective medium	10	7	4	6	4
No reason for use	4	7	13	7	10
Attention needed	31	5	14	0	7
More capable device	14	2	0	5	1
Noise	0	0	3	2	0
Legality	4	0	0	0	0
Reasons for using the phone					
Discreet	1	14	3	4	8
Expectancy/importance	13	15	14	0	15
Entertainment	7	6	20	18	10
Helpful to situation	12	17	15	13	5
Informal environment	4	7	19	13	7
Low attention needed	12	0	15	10	3
Save face/look busy	0	0	1	4	4
Connect with people	3	0	3	8	8
Productivity	0	0	0	4	0
Create a comfort zone	0	0	0	2	2
Habit	0	0	0	0	3

The specific codes were first represented in mind map form (Figure 9) then collated into broader themes, these are displayed in Figure 10, showing both main and sub themes. The words in circles represent what was considered to be main themes and the rectangles are sub themes which add more specific information to the main theme. For example, noise was a frequently mentioned reason for use or disuse and related to this was that a low level of noise led to discreetness and a high level of noise was considered rude. The main theme is the level of noise and the sub themes qualify how this theme influenced phone usage.

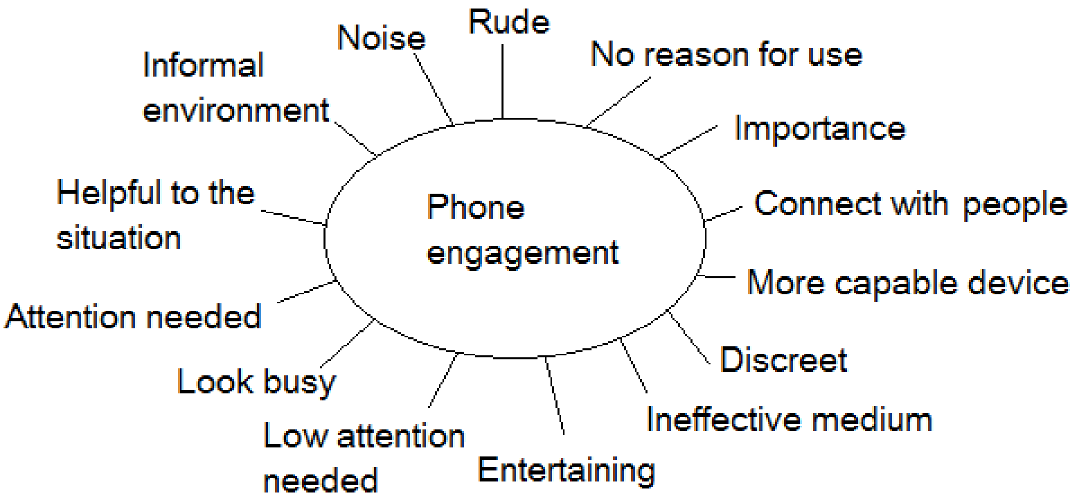

Figure 9: Initial coding displayed in mind map form

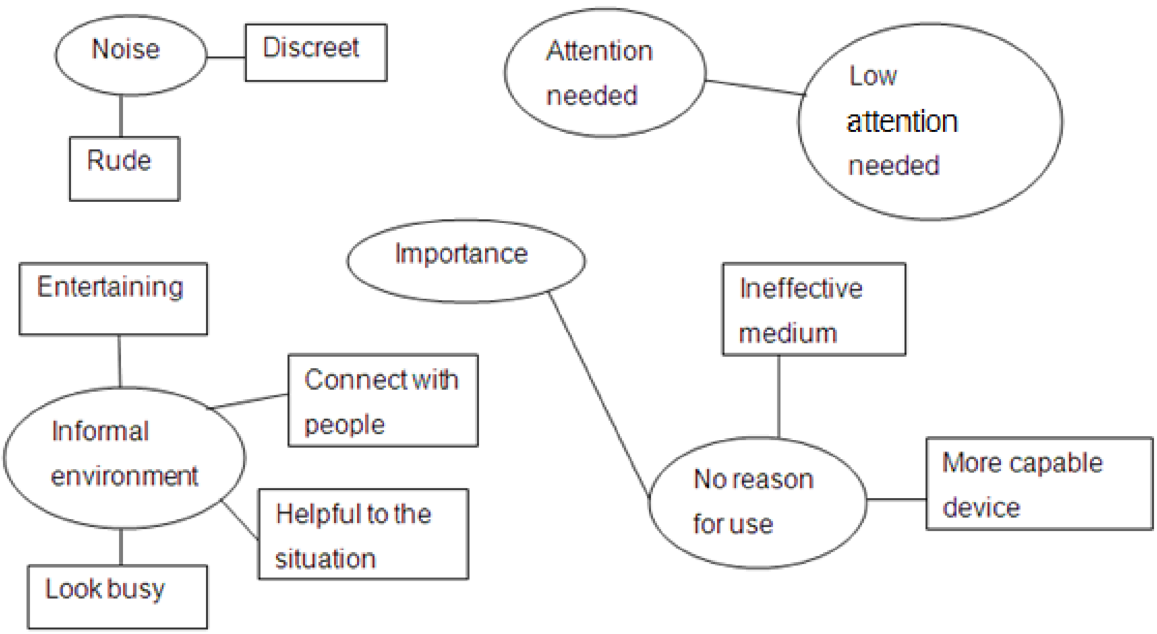

Figure 10: Initial themes with relationships mind map

These initial themes were then reviewed and those that were no longer believed to be themes (did not have enough data to support them or the data was too diverse) were removed or collapsed into each other (two previously separate themes combined into one). These were then reviewed against the initial coded data extracts to ensure the themes captured the meaning behind each extracts coherently. Next the same process was conducted but referring to the entire data set (coding and transcripts) and ensuring the themes reflect the meaning of the data set as a whole, so the themes were applicable to all environments, until more refined and better defined themes were achieved. The resulting refined thematic map is shown in Figure 11, displaying themes and sub themes (which help give structure to particularly large themes). Each theme is considered further in the discussion section.

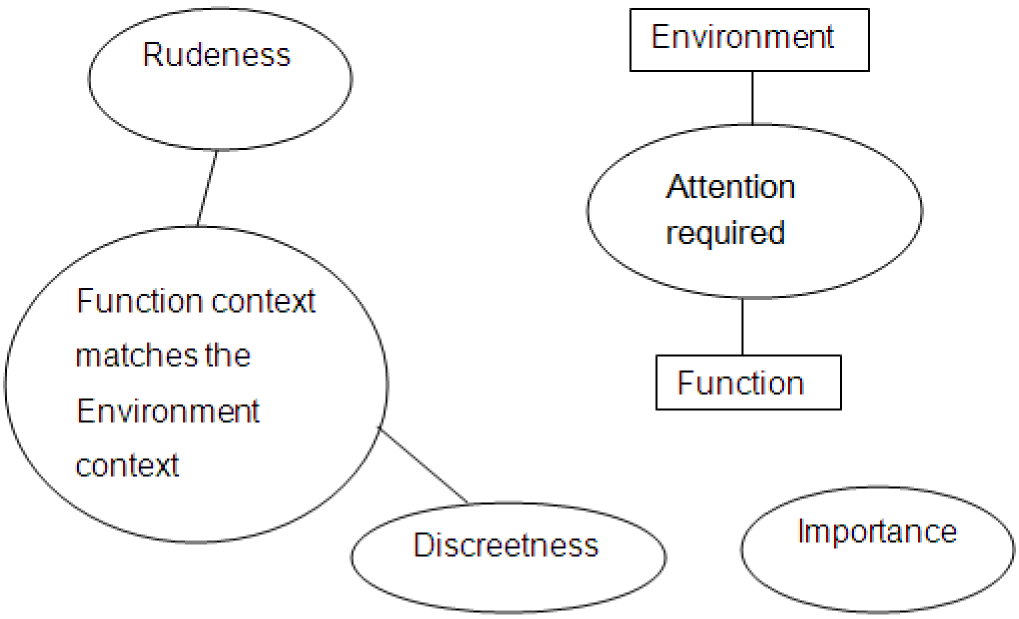

Figure 11: Developed themes mind map

4.8 Discussion

4.8.1 Differences Between Environments

Tables in Appendix 2 (Appendix 2.1 to 2.10) show the majority of participants couldn't think of examples of when they had a high workload in some of the environments (for example it was hard to have a high workload while shopping or while in a restaurant). This was often because in most environments high workload was perceived as a product of being short on time, '*time pressure would have the same effect as high workload, they're probably related to one another, the time pressure leads to me having a high workload*' Participant 2, so the effects on phone use had already been investigated in the time pressure scenario. However, high workload was applicable for (and had an effect on) phone use whilst driving with participants suggesting high workload situations (such as on an unfamiliar busy roundabout or when on an unfamiliar B-road in the rain at night). It is recognised at this point that there are a number of different concepts of what can constitute workload, such as the NASA TLX (Hart et al. (1988), Hart (2006)) which breaks workload down to its mental, physical and time pressure demand components. Participants were not given a definition of workload to judge their behaviour by so could have been referring to any one of these elements when mentioning workload. It is clear from many of the statements that they found it hard to envisage times of high mental or physical workload in any environments apart from when driving, whereas the temporal element they had often already covered when discussing their behaviour changes as a result of having a time pressure scenario. Contrary to the other environments different examples, and therefore, different findings were recalled by participants for the time pressure scenario to the high workload scenario while driving. It was considered that for the driving environment the time pressure scenario was not necessarily related to high workload as there were times when there could be low demand but still be under a time pressure (e.g. a long empty motorway but the person was under pressure to arrive at a meeting in time). Therefore, although high demand was not considered applicable by most participants in the majority of environments, making comparison between environments difficult, because of the effect it had on the driving environment it was still included in the results.

Similarly in the meeting environment the 'people present' variable was found to be rated in a different way than for the rest of the environments. Meetings by definition required the presence of other people so the effect of having different groups of people present, such as superiors (authority figure) compared to work colleagues, on willingness to engage became the focus of discussion as opposed to being alone compared to with company influencing willingness to engage. This again made comparison across scenarios more difficult but as some of the other scenarios (such as when in a restaurant) participants also said the type of person present (such as authority compared to peer) had an influence, as well as alone compared to with company, the people present variable for the meeting scenario will still be discussed.

4.8.2 Findings

4.8.2.1 Meetings

It can be seen in Appendix 2 (Appendix 2.1 to 2.10) that self-reported phone use for all functions during meetings was very low, with very few functions listed as being used more than 'sometimes' throughout the scenarios, this was in line with findings by Emanuel's (2013) survey of 403 college students. This found that the majority of college students believed it was not okay to talk on the phone in a meeting. It became clear during the analysis of the interview transcripts that the main reasons cited for not interacting with a phone in meetings, for all the scenarios and functions, was related to the perceived rudeness of using a phone in this environment. Some examples include *'being bored wouldn't really make a difference as I'm still limited by what is socially acceptable to be used,'* Participant 11 *'I wouldn't even bring my phone into the room because it isn't necessary and he would probably think I was being rude' Participant 13. 'If there are people I should behave in front of...it would be rude to do most of these things...you're trying to make an impression on them and using the phone can look rude' Participant 3*. The extent to which this factor influenced phone use can also be seen by the number of occurrences of the theme 'rude' (appearing 37 times) in Table 2, far more than any of the other themes for the meeting environment.

However, there were certain times when phone use was perceived as being acceptable in a meeting environment. The most notable of which was when the context of the phone use matched the context of the meeting, in other words the phone use was work related and/ or could help in the meeting, in these circumstances phone use increased. This can be seen in the tables in Appendix 2 (Appendix 2.1 to 2.10), showing that having an information need in a meeting led to the highest self-reported phone use for the majority of phone functions. This was also demonstrated in the interview transcripts with people saying '*if it was work related I would do any of those (referring to the list of functions) because it doesn't matter if they're discreet or indiscreet because it's to do with work' Participant 5, 'if the information is in regard to the meeting then I'd be inclined to use any means at my disposal to get it*' Participant 7. This was particularly true for functions which could help with getting information, such as the internet or phoning *'these (functions) can help me get information so I'm likely to use them' Participant 2*.

A further factor which seemed to have a large influence on whether the phone was used was the discreetness of the function. This appeared to be related to the perceived rudeness of using the phone in a meeting, if the phone function could be used discreetly (without anyone noticing) then no-one could pass judgment on the acceptability of their phone interaction. '*It's really easy to conceal you are reading a text. Reading an email is a bit longer than reading a text but you can still conceal the fact you're doing it*' Participant 19. This is why in many of the scenarios the written mediums (text and email) were reported as being used more than the verbal mediums (placing/ answering calls) as the written mediums were less conspicuous. Also relating to the points mentioned previously, the written mediums were perceived as more acceptable as other people couldn't tell the context of the phone use, '*reading a text no one knows what you're talking about so it's ok, whereas placing a call people can tell*' Participant 12. One person did, however, say they would try and make their private calls sound more work related to make them seem more acceptable in that context '*if it (the call) was social and I thought people would disapprove then I might make a call but pretend it's something it's not, be a bit cryptic, so it's less obviously private*' Participant 17.

Expecting the call, email or text message also affected the results. A high average willingness to engage was found for reading an email or text message when work colleagues were present as these functions were expected. It seemed from the comments that the expectancy of these functions made them more likely to be engaged with as that meant they were perceived as important. '*I could do that (read a text) quickly before people have noticed and worth the risk if I'm expecting it*', Participant 11 '*If I was expecting it (call/ email/text) I might check my phone every five or ten minutes. If it was something really important then yes I would answer it if it was just an informal meeting',* Participant 11. It appears that by imagining that they were expecting a call many participants also then attached an importance to it. This finding could perhaps be better termed an 'expectation of importance' whereby participants predicted that a call which they were waiting for will also be an important one. This in turn influenced their phone usage as opposed to expecting a call per se.

When in a meeting with someone of authority present (a more formal meeting) having an expected importance had far less effect on willingness to engage with the functions. It seemed the formal nature and the social rules of phone use took precedence over the importance of the call, text or email. '*It wouldn't matter how important or expected the call or text was in a formal meeting I still wouldn't be answering it …I wouldn't want to be remembered by head office as the woman who answered her phone so I wouldn't use it still'* Participant 5. '*If I did get caught the consequences would be less in an informal meeting than a formal one*' Participant 1. '*It (expecting a call email or text) wouldn't make any difference to my phone use I still can't risk using the phone in a formal meeting and appearing incredibly rude',* Participant 14*. 'If the person was important and unfamiliar then there would have to be a good reason for any phone use, such as to help the meeting progress. You're concerned about the relationship and what people think about you*', Participant 3.

Overall, in the meeting scenario, the smartphones' advanced functions usage (anything more than talk or text) was generally very low with average willingness ratings only occasionally rising above 'rarely' being willing to engage with them. As discussed previously, this was mostly due to it being considered rude to use the phone in meetings with the only exception being if there was a work related information need. The functions which could provide information (email, internet) were associated with a relatively high willingness to engage as they could help provide information, '*If I need to solve something when I'm in a meeting… I would be using the phone if it could help, placing calls or answering calls if necessary, internet if my laptop isn't in front of me or easily accessible'* Participant 5*. 'If I need to find something in one of our meetings, the sales figures for the month or the orders for the next few weeks etc. and the phone could help then yes I'd absolutely be on it. We try and keep all our meetings short and to the point, we're all busy people with places to be, so if the phone can help that then I'd be using it'* Participant 13. '*Oh that (needing information) would make it all fine then, I'm normally the one they all turn to, to look things up, they know I'm the most proficient on the phone so often get to spend half the meeting reading Wikipedia' Participant 17*.

4.8.2.2 Shopping

There was a relatively high self- reported willingness to use the phone whilst shopping. This can be observed in the tables in Appendix 2 (Appendix 2.1 to 2.10) with many functions said to be used from 'sometimes' to 'often' for all phone functions. This finding matched those of Emanuel (2013) who in a survey of college students found the majority thought it was okay some or all of the time to both talk and text message whilst in a grocery store. One of the main reasons cited for using the phone was because it is perceived to be an informal environment so there was no social etiquette prohibiting its use. '*It's quite a relaxed atmosphere, (there is) no pressure to behave in a certain way'* Participant 1*, 'shopping is less rule bound...you're out shopping you can do what you want to do'* Participant 15. Another reason cited for use was the low attention required to carry out the shopping task, it wasn't perceived as being difficult or require too much attention '*I would use Facebook... it's not hard to wander round and check status updates'* Participant 17*, 'I would answer a call because I can do that and walk no problem*' Participant 17. This was particularly true for texting and phoning but other functions seemed far more inhibited by the shopping task such as gaming '*I wouldn't use* *games...wondering around, it's difficult to concentrate on what you're doing while you're walking'* Participant 12.

Although some people saw the shopping environment as requiring low attention, many other also said they would not use their phone as they would just want to concentrate on getting the shopping task finished and then interact with the phone afterwards, this difference in opinion was also demonstrated in the coding of the interviews (Table 2) with 'low attention needed' cited as a reason for phone use 15 times and 'attention needed' cited as a reason for dis-use 14 times. '*I would be concentrating on getting my shopping done rather than sending a text'* Participant 8*. 'I would be too focused on doing the shopping in time*' Participant 9. This was particularly mentioned in the time pressure condition, as can be seen in Appendix 2 (Appendix 2.1 to 2.10) with all functions other than answer a call and read a text message having an average self-reported use of 'sometimes' or below. Answering a call might still take place as they were perceived as being more important or time critical '*I would answer a call regardless; a phone call is more immediate',* Participant 6, *'I might answer the phone if I think it's important or to do with the shopping',* Participant 18*, 'emails can wait, if it's important they'll call me',* Participant 20*. 'I would answer a call even if I had bags of shopping in my hand, but emails can wait because they're not as important'*, Participant 12.

Text messages also had a very high likelihood of being read, this was often cited as being a result of them not taking long to read, '*I would almost always read a text because if I got one it would probably be kind of important and be quick to do',* Participant 2, *'emails are more important but texts are more immediate',* Participant 11, *'I wouldn't be doing anything except maybe reading a text because that takes a matter of seconds'* Participant 8. However, it wasn't seen as essential to reply to the texts as soon as they were read, '*texts don't take any time really and no one knows you've read it or not so you can read now and answer later'* Participant 1.

Emails are a similar medium to texts but were cited as being used less whilst shopping in all scenarios. There were many reasons mentioned which may help explain why. Firstly texts were often perceived to be more related to the shopping environment than emails, '*I can't imagine many situations which make email relevant when shopping ...you are in leisure mode... most of my emails are work related so unless I'm waiting for it I wouldn't look at them'* Participant 5. This may also help explain why expecting a call, email, text (under time pressure) had quite a high willingness rating, as the expectancy meant people would have a reason to check their email while shopping. Further reasons for emails' lack of use while shopping was the extra effort required to check an email over a text, '*reading an email would mean physically having to go into my Google mail so more effort'* Participant 9. Also they were perceived by some as having less time pressure associated with them than a text '*emails aren't urgent, they might be important but wouldn't have to be done right away. I would say often emails are more important but texts more immediate'* Participant 11. The differences between perceived importance of texts and emails may relate to the occupation of the individual. If someone is in a role where high levels of email communication are relevant and they have managerial responsibilities then checking emails in non-work situations may be considered necessary. Those without such responsibilities, which applies to the majority of those sampled in this study, may see text checking as sufficient.

Many phone functions were also used while shopping for entertainment reasons. Not surprisingly this was particularly true in the bored whilst shopping condition. '*I might use mp3 if I was bored to make things more interesting'* Participant 17*; 'I would just try and do what I can to amuse myself'* Participant 17*, 'just do anything to distract you',* Participant 4. Similarly the information need scenario showed many of the functions other than just talk and text being reported as used frequently, mainly because the other functions could now help with the task, such as the internet, for finding information.

There were very few other reasons, apart from requiring too much attention, for not using the phone whilst shopping, the only other frequently cited reason was there simply being no need to use the device in these circumstances. '*there wouldn't be the delay you get when bored at a* *restaurant for example so I would just want to get on with the shopping and get out of there',* Participant 7.

4.8.2.3 Restaurant

It can be seen from the tables in Appendix 2 (Appendix 2.1 to 2.10) that self-reported phone use for some functions such as text, email and internet usage was relatively high in restaurants when bored but decreases when people are present or when under time pressure.

One reason why having family present (often referring to parents) led to a reduced willingness was found from the interviews to be because they were perceived as less tolerant of technology than friends and peers would be. '*They're less tolerant of technology and would frown at me getting my phone out'* Participant 15*, 'my friends would also take a more relaxed view to phone use and be happy to talk to me at the same time as I'm texting whereas my parents would presume it would be difficult for me to do both at once so would stop talking until the phone was away again*' Participant 9. As well as being considered rude as socialising with their parents was the real reason they were at the restaurant '*I'm there to spend time and converse with them and eating is just an activity to do really, catching up would be the real reason we're there so that would take priority*' Participant 16, '*we don't eat out very often so it would be a special event of some form so require me being in the moment and enjoying it, not using the phone'* Participant 2.

Further reasons for family being present reducing phone usage included the partner being the person the interviewee texts and phone the most, so if they are dining with them then the need to use the phone substantially reduces. Also because they want to talk to the people they are with without any distractions '*the phone would be intrusive and I find it annoying when people disengage from the table to talk to people who aren't there*' Participant 6. Though, if an email, call or text is expected then phone use increases as the expected importance attached to it means the usage was considered more urgent. '*It might be urgent it's (phone usage) more acceptable if my family understand the reasons',* Participant 9. Furthermore, some people suggested they may be more likely to go to fancier restaurants with their family or spouses than with friends so the etiquette expected would be different, '*the more formal environment demands better etiquette...than when I'm out at a pub lunch with friends',* Participant 3. This was in support of comments made by Ling (1997) who investigated inappropriate phone use in restaurants, noting '*the acceptability of the mobile telephone is somewhat place dependent. In a restaurant where higher levels of noise is part of the setting and where one is not expected to treat their setting as a particularly special occasion, a telephone is more acceptable because its use is covered by other activities'*.

Phone use in restaurants when bored was quite different to when family were present with people reporting being far more willing to engage with their devices. However, the higher willingness to engage with texts, emails and internet functions than the phoning mediums (even when bored) suggests participants still felt affected by phone use being perceived as rude in that environment. This was shown by rude being mentioned 28 times as an inhibiter to phone use in the restaurant environment (Table 2), considerably more than any of the other constraining factors. Further inhibiters included the device requiring too much attention '*sending an email takes a while and a lot of attention...a bit too distracting'* Participant 10.

The entertainment offered by the phone was a frequently mentioned reason for phone use. '*Once you've ordered the food it might take a while for food to arrive, I might surf the internet or use applications'* Participant 7*, '(if) they're all talking to each other I might...answer a phone call and read a text, I'm not involved (in the conversations)'* Participant 13*. 'Boredom has made all these things more attractive and reduced the inhibition of doing them'* Participant 7. Often if people were bored it was because they were alone and waiting for someone, so interestingly there were a few mentions of using the device to look busy as opposed to actually keeping them busy*, this usage of the phone was mentioned in* Bhatia (2008) *and referred to as* Communifaking, through pretending to be engaged with the phone when they in fact are not. '*I'd be fiddling with the phone...so you didn't feel so awkward about sitting on your own, so you don't look like Billy no mates',* Participant 5, *'If I'm on my own* *then I try and make my own comfort zone (using the phone) whereas if you're with someone then you don't really',* Participant 4.

4.8.2.4 Public Transport

Phone usage on public transport was generally reported to be very high, as tables in Appendix 2 (Appendix 2.1 to 2.10) show, the average self- reported usage was often between 'sometimes' to 'often' for most of the functions in almost all of the scenarios. On public transport when bored and when someone had an information need had the highest levels of self- reported phone usage. When bored on public transport the reason most people gave for using the function was to entertain them *'the Facebook application...I'd be using that...just seeing what other people are up to, to stop me being bored'* Participant 14*, 'I would look up random stuff the news, reviews of stuff, what's on TV, … try and be a bit productive rather than sitting there doing nothing'* Participant 20.

Further cited reasons included using the device to try and block other people out '*you're in a tiny space, crammed in like cattle half the time and I want to block everyone out'* Participant 1*, 'surrounded by strangers we've no interest in talking to so we all tend to talk to people we know on our phones instead*' Participant 8, '*I would have my headphones in so, similar to when shopping, I don't have to listen to other people's conversations, who are invariably talking too loudly on the phone'* Participant 13. Another reason frequently mentioned was simply to connect with people '*I think it's the time when I text people the most, I go through my phone book and choose people to keep in touch with while I'm travelling...I can't go anywhere...so I might as well get in contact with people'* Participant 15*. 'on a lengthy journey...it gives me an opportunity to place calls, send texts and catch up with people I haven't had much chance to talk to lately'* Participant 9*, 'I have a bit of time to relax and socialise from a phone'* Participant 9. Similar reasons for usage were given in all scenarios but in the information need scenario people were also motivated to use the device to help find information out that would help with the journey '*I might read an email to find out booked train times'* Participant

19*, 'I would definitely be using the internet because of the ease of getting information on the next bus time or delays etc.'* Participant 1.

There were not many perceived inhibitors of phone usage on public transport. A small minority listed phone use as being rude, referring specifically to the calling phone functions '*other people are around and I don't like it when people talk really loud into their phones, I don't want to annoy people'*. Others were not deterred so much by the rudeness of talking on the phone but by the lack of privacy that talking on the phone on public transport offers '*I wouldn't be placing a call...I hate talking on public transport as everyone can hear your conversation and I don't like that'*.

Having someone familiar travelling with them also affected usage as boredom was less of an issue, due to having someone to talk to, '*I'm no longer trying to relieve boredom as much. You can talk about anything to keep the boredom away'* Participant 9. Also some of the functions were then perceived as being rude to use due to having someone familiar present '*I'm unlikely to be using applications because I would be talking...and it would be rude to be messing with the phone unnecessarily'* Participant 10*, 'if I'm with people I probably wouldn't want to answer or place a phone call because it's a bit rude*' Participant 13.

A further inhibiting reason against phone use was the inefficiency of the device. In some cases this was a result of having a dedicated device with them which was perceived to do the job more effectively '*I would definitely have my mp3 player on but not the one on my phone...my phone ...doesn't work with iTunes...so I still carry my iPod with me as well*' Participant 11, '*I would listen to my dedicated mp3 player, so I would have music on but not through the phone'* Participant 5*, 'I don't like to waste my phone battery on non-phone tasks, if I want music I prefer to use something designed for that purpose...I don't want to use all my battery on music...and then when I go to phone someone... I can't',* Participant 17.

There was also some mention of the phones' limited capabilities affecting the usage on public transport '*I don't think the internet is as nice as having it on my 17 inch computer screen, so I try and delay my usage to when I get home'*

Participant 17*, ‘you can’t always get signal... so that affects how often I use some functions like calling and texting, I would use them more often if the signal was always present’, Participant 3*.

If the train was busy this was also found to have an effect on function usage for a number of different reasons ‘*it (the train being busy) would make everything less likely because I’d be hanging on (to the railings) with one hand...it might be noisy and you wouldn’t want to talk loud’* Participant 6*. ‘The poor auditory environment on public transport makes it harder to hear what people are saying to you on the phone’* Participant 11 *‘if it’s busy...it’s a lot more difficult to hear anyone on the phone whereas text and email is less affected by that’* Participant 18. However, some people mentioned that texts can also be affected by having to stand on the train ‘*texts are much easier to read than answering a call in terms of effort, unless you’re jiggling about standing on the train’* Participant 12.

4.8.2.5 Driving

It can be seen from the tables in Appendix 2 (Appendix 2.1 to 2.10), that there was very little self-reported phone use while driving. This may have been a result of using the phone in all but hands-free medium in the UK (where the study was conducted) while driving being an illegal act. It was made clear at the start of the study that participants should consider their phone use to be hands-free where possible and all information given would be anonymous to help try to avoid any effects this may have. As it was found one of the most frequently reported functions used while driving was reading a text, an illegal behaviour, this suggests the illegality of using the function had little effect on participants reporting and truthful phone usage behaviour was given.

There was also little evidence to suggest legality was a major factor in deciding whether or not to use the phone as the legality of using a phone was mentioned as a prohibitive factor only 4 times in total in all of the interviews. ‘*My insurance is already expensive so I wouldn’t even risk getting caught looking at the phone at traffic lights ...I don’t want points on my license*’, Participant 3, is one such example. It should be noted, however, that it is possible the law did influence phone engagement willingness while driving but it was such an obvious dictator of phoning behaviour while driving that many participants did not think to state it expressly. Furthermore, as it was stated that participants should imagine their phone was in a cradle and operated hands-free, where possible, this could have had further impact. It would have been legal to conduct phone conversations with the phone in this set up and so the law would be far less likely to have an impact. This was possibly another reason why the law was mentioned so infrequently.

The highest willingness rating reported for phone use while driving was an average of 3.27 on the rating scales, this was for when bored and expecting a call email or text for the answer a call function. This number still only represented an average willingness rating of ‘some times’ answering the call with the rest of the average willingness ratings for all functions and scenarios falling under the ‘rarely’ or ‘never’ use the phone ratings.

As might be anticipated, for the ‘expecting a call, email or text’ scenarios, there was a higher willingness to use the phone for the call, email or text functions than when there was no expectancy. For some functions (such as applications or sending a text message) the expected importance associated with expecting the call, email or text meant the willingness actually decreased. Interviews showed this was a result of wanting the phone to be available if the text or call came in so the participant would not risk starting a non-related task on the device. The expected importance of the incoming call email or text had the largest effect on the answer call function with a small increase in willingness to read a text and a very marginal increase on willingness to read an email. The most commonly cited reason for expecting the call, email or text leading to an increase in willingness to engage was, as seen in other environments, a presumed higher importance now placed on the function as it was expected. ‘*If I am now expecting the call it is almost certain I would be answering it as it is likely important’* Participant 7. It seems that the increased willingness did not derive from expecting a call necessarily but instead an ‘expected importance’. If the call was expected then participants mentioned it is likely to be of some important, which could influence their willingness to engage.

It was also found that other than when expecting the call the next most likely scenario where participants would engage with their phone was when bored. Being bored increased call usage because it was interpreted to mean driving in lower demand conditions. '*I'm on a motorway just straight road driving. I don't do an awful lot of driving so it will likely be an unfamiliar route but still boring'* Participant 1, '*If I'm bored then I may place calls and would certainly be answering calls to try and keep myself busy, I find sometimes I drive better when I'm on the phone or have the radio on or just something to keep my mind preoccupied',* Participant 5*' 'I'm bored means I'm probably at a fairly undemanding stretch of road*' Participant 6. Another reason frequently given for using the phone when bored was not just because of the lower workload but the boredom itself would lead them to use the phone to seek out stimulation and entertainment '*If I'm driving and I'm bored I often phone around a few people until one of them picks the phone up and then I would converse with them to keep me entertained'* Participant 18.

The higher workload from the road environment can also be seen to affect all functions, as the high workload condition had very low reported phone usage. '*I would do nothing...I would probably hear it (the phone) but ignore it because you can't risk looking at the phone when it's dark, raining and don't know the roads. You need all your attention on what you're doing'* Participant 12*. 'I might be trying to negotiate a tricky roundabout; you wouldn't be doing anything, you're concentrating on driving'* Participant 9*. 'If there was a high workload there would be too much for me to already be concentrating on for me to start using the phone, I try to use it responsibly so if I thought it would be unsafe, as in this circumstance then I wouldn't be touching it'* Participant 19. Conversely there were reports of using the phone in lower demand conditions such as when the vehicle was stationary at traffic lights '*I might answer a call in stationary traffic, I wouldn't do it in normal driving only if nothing is moving*' Participant 7. It appears from these findings that the roadway demand can have an effect on whether or not drivers engage with the phone as an assessment of the roadway demand and dangers associated were reported as being made before engaging, with a higher propensity in boring, low demand, scenarios than in high demand ones.

Having people present in the car also reduced the self- reported phone usage as shown in Appendix 2 (Appendix 2.1 to 2.10). The reasons associated with this were generally to do with people perceiving passengers to be watching and judging their driving behaviour so they ‘behaved’ more in the car. ‘*I would be concentrating on driving nicely so they (his family) were happy that I'm driving well...I'm more conscious of my driving’* Participant 16*. ‘I think my family would give me a small lecture on what it is to be a safe driver if I did try and do any of those things (use the phone's functions)*’ Participant 10. Other reasons cited including taking less risks with people in the car ‘*if I had my little sister in the car I'm not going to risk texting or anything because I don't want to crash and kill her’* Participant 3*, ‘if I killed myself while using my mobile phone (while driving) that's my own stupid fault but if I hurt somebody else by using my mobile phone I would never forgive myself’* Participant 3*. ‘If people are present then I'm even more cautious because obviously you've got someone else's life in your hands*’ Participant 8. A further frequently mentioned reason was that the passengers would be able to use the phone for the driver, reducing the need to use it ‘*my wife would answer the phone for me meaning she could do all the calling and texting’* Participant 14.

As discussed previously some scenarios showed a higher willingness to use the phone than others but the phone function intended to be used also seemed to have an effect. Answering a call frequently had the highest reported willingness to engage of all the functions in the scenarios. One reason given for this preference of answering a call over using the other functions was the perceived urgency of an incoming call, ‘*if something was urgent they would call me...I think calling is more urgent (than text or email)*’ Participant 17, as well as a perceived lower effort required to answer a call ‘*there's less effort to answering a call than placing it so it's more likely’* Participant 14. Some people also didn't perceive much risk associated with using the calling functions while driving ‘*placing and answering a call I wouldn't be too worried about while driving*’ Participant 13.

Reading a text was also reported to happen while driving '*if a text came I would certainly read it*' Participant 4, '*you can read them (texts) while driving, shouldn't but can*' Participant 4, many others pointed out they knew it was dangerous or illegal, but admitted they did it anyway. '*I might send a text; it's a bit naughty and read a text, again a bit naughty*', Participant 15. '*I would read and send a text message (when bored), even though that is really dangerous and I do appreciate that'* Participant 19.

Texting behaviour was also reported to be affected by the demands of the road which people were on. '*Very little traffic demand, and if the roads are straight then there's less inhibition especially taking calls, I might even read a text'* Participant 1*. 'I'm more likely to send a text message when I'm on a road that I know or I'm sat at traffic lights. On a motorway, because you're going so fast and things can change so fast, I wouldn't necessarily send it (the message), more likely when I'm going at lower speeds and I know the road'* Participant 12. There was a conflict with this finding as another participant said '*I would read a text message on a motorway because you can get away with it, shouldn't but do'* Participant 4.

Applications were one of the smartphones advanced functions which had a very low willingness rating in the driving environment, with an average usage rating of 'never', but was mentioned quite frequently in the interviews. One application in particular was mentioned quite frequently, the satellite navigation application, which could be used while driving to give directions. One reason for this application's low usage was because many people had a dedicated personal navigation device (PND) which they reported preferring to use if they had it with them for various reasons. '*I tried using the phone once (sat nav) but the time delay and reliability of getting GPS signal was very poor, borderline useless, so either....wait for signal or set off hoping for the best and risk getting lost'* Participant 17*. 'My separate sat nav isn't perfect but it is much more reliable...so would always opt to use that first'* Participant 15*. 'I would use the sat nav application rarely because I have a better sat nav in my car...if I didn't have that to hand I would use my phone's one more often. My separate one has a bigger screen, better information; my phone one* *came with the phone'* Participant 8. So the trust and usefulness seem to influencing in the decision to use the phone's applications or not.

Further prohibiting factors were to do with using the phone in the car '*I have no holder for the phone, no charger and the GPS eats battery like there's no tomorrow'* Participant 17. Another cited prohibiting factor was the possible costs incurred from using the phone as a satellite navigation device '*I'm worried about the data charges, if it uplinks to the internet to get the information'* Participant 5*, 'I don't really know how much it would cost me to use my... (sat nav) phone app as it uses the internet to retrieve data and I've read these...can run up big bills on data charges, which scares me a bit'* Participant 10.

4.8.3 Themes

The previous discussion highlights the main factors found to affect phone usage in different environments. As can be seen in Figure 10 all the themes which were coded in the transcripts and identified as having an effect on phone usage were then analysed and their relationship with one another considered and represented in diagram form. The proposed relationships between these themes are discussed below.

The first themes identified and believed to be interrelated were noise, discreetness and rudeness. The noise was a frequently mentioned important influence of whether or not the phone would be used. This was considered to relate to both rudeness (the noise of conversing on a phone meant it might disturb people) and also the discreetness, a text message might be used in a meeting because it was quiet and discreet and therefore the person wouldn't feel they were being rude.

Being in an informal environment was a further identified theme, this was found to allow phone use as there were fewer social rules policing the phone, this allowed phone use to be driven by a desire to connect with people, its ability to provide entertainment or if the phone could be helpful to problems encountered in the situation, with few factors limiting usage.

The environment requiring a high level of attention or the phone task requiring attention were considered to be related as both were constrained by information processing capabilities and influenced one another (the environmental demand seemed to dictate the difficulty of phone task which could be conducted) .

Finally, if there was no reason for using the phone then this further influenced willingness to engage with reasons such as the phone medium not working particularly effectively (e.g. the phone screen being very small meant using the internet was considered difficult or more effective devices existed and used instead, such as personal satellite navigation devices). Having no reason for using the phone was also considered to be linked to importance as no reason for use resulted in non-use. Whereas a high importance, and therefore strong reason for use, led to increased willingness to engage.

This initial analysis was believed to still be too specific in what affected willingness to engage and it was believed possible to further refine the codes to be more general and smaller in number and still capture the factors said to influence willingness to engage. Therefore, the initial coding was given further consideration and refinement (this process was described more thoroughly in the results section) until the believed minimum (and broader) themes which encapsulated the main findings of what participants said influenced their phone usage was attained (see Figure 11).

One theme which was developed from this further analysis was the attention required. This refers to both the attention required for the function and the environment and the interaction between the two. It appeared if there was a low amount of attention required in the environment then functions which were said to require a high attention (such as playing games or sending a text and email) were used. However, if there was a high degree of attention required by the environment (such as when driving and in the high workload/ time pressured scenarios) then only those functions which were said to be quick and easy to interact with (therefore requiring low attention) would be interacted with.

The next theme was whether the 'function context matched the environmental context'. This related firstly to having a usage for the phone. If the function context matches the environment context then it would have a reason to be used so may be engaged with (e.g. using the internet to help price check when shopping or playing games for pleasure when in an informal, pleasurable environment such as shopping). If the function did not match the environment (e.g. business email when shopping out of pleasure) then it was far less likely to be engaged with. This theme also related to rudeness whereby if the function used related to the environment (e.g. business call in a business meeting) it may be engaged with because using the phone wouldn't be considered rude, the noise and discreetness would not then matter. However, if the function did not match the context (e.g. private call in a business meeting) then the function would likely not be engaged with.

The final theme developed was the expected importance of the phone function. It seemed this could influence peoples' decisions on whether or not to engage with the phone task. When functions were expected, and therefore considered important (such as expecting an incoming call, email or text) it often lead to people being more willing to engage with the phone even in situations they reported previously having a far lower willingness for. This seemed to be influenced by both the importance placed on the function, for example it was a common perception that a call was more important than an email, based on the belief that if someone really wanted to get in touch with them they would call, whereas if it could wait an email would suffice. Also an expectancy placed on the incoming phone medium could influence importance with expected calls, emails or texts generally having a perceived higher importance and therefore higher willingness to engage with them than if they were not expected.

It was considered there may be an interplay or even hierarchy between the three themes (see Figure 12) whereby the phone user may first have a need to use the phone, such as a desire to place a call or the phone may require their attention by someone ringing them or receiving a text or email. The importance of the phone use may then be assessed (such as through looking at the caller ID or considering the medium being used such as receiving a text message compared to a phone call) (expected importance theme). If it was not perceived important it would not be used or interacted with but if it was then the environment may next be judged in terms of the attention required to use the phone function and the attention required by the environment (attention required theme). If they deem it possible to safely and effectively conduct the phone task they may then move on to assess whether it would be appropriate to use the phone (function context matches environment context theme). They may then assess if any social rules would be broken. If believed to be socially acceptable they would interact with the phone, however, if not they may reject using it.

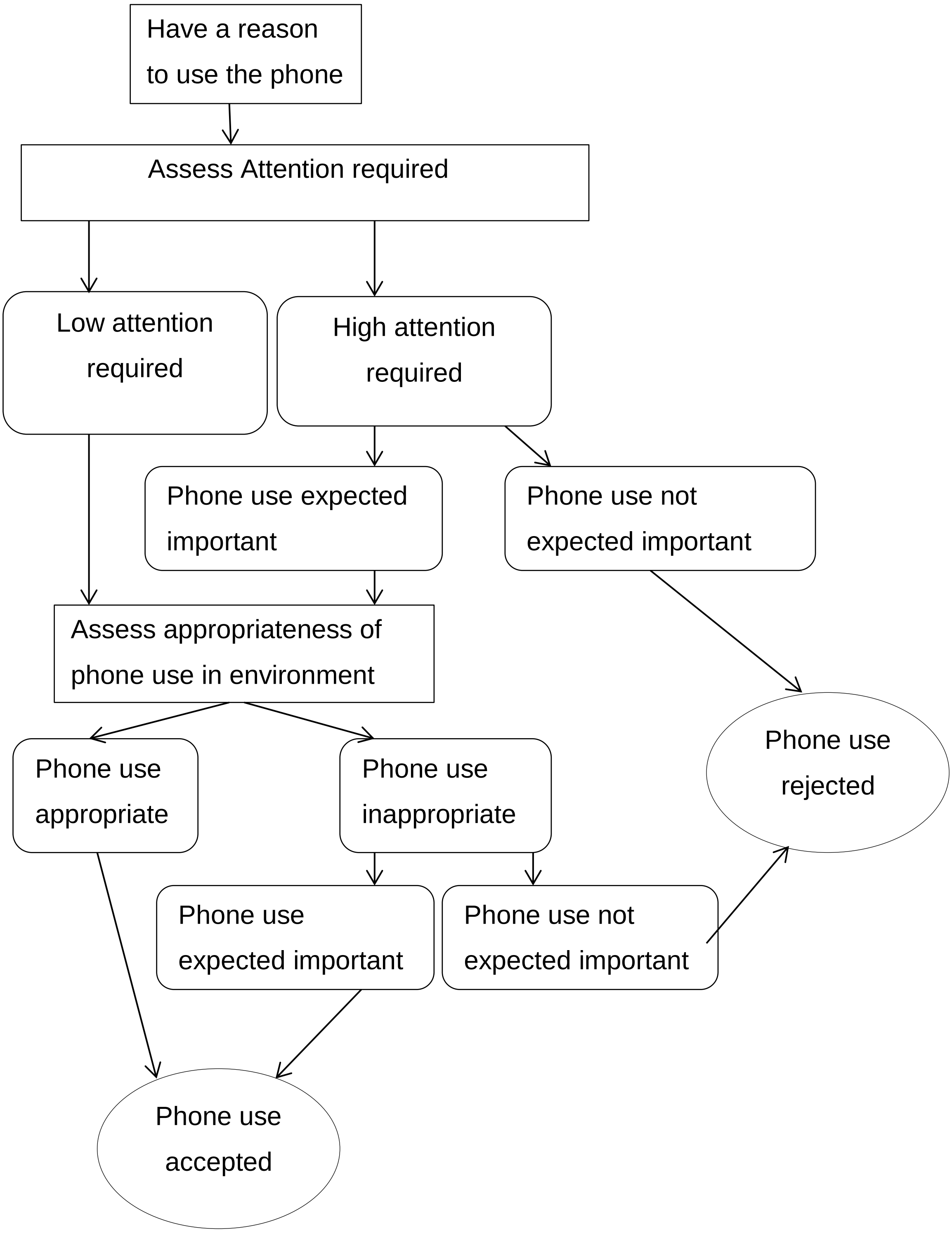

Figure 12: Possible process for deciding whether or not to engage with a phone

4.8.4 Can the Driving Environment be Considered Unique

It was found participants' reports on what affected their phone engagement when driving shared many commonalities with phone engagement outside of the car. The expected importance of the phone use was a frequently mentioned reason for engaging or not when both in and out of the car; with higher willingness to engage with the phone if the usage was expected and therefore perceived as important. Another influencing factor was the attention needed with people reporting judging the demand of the environment at the time and the demand the function required (such as sending a text requiring more attention than reading a text) before engaging with the phone.

The ‘function matching the context’ was mentioned far less as a factor influencing the decision to engage in the driving environment than in all the outside the car environments. This seemed to be because the driving environment was often quite a private, solitary environment and therefore there were less social rules to consider (for example placing a call wouldn’t disturb another driver’s conversation). However, when friends or family were present in the driving environment willingness to use the phone did reduce compared to when ‘bored’ or ‘needing information’ for higher use functions such as answering calls and texting. This was found to be less to do with social rules though and instead a result of the participants reporting they were more aware of the risks they were taking when driving and someone else was present. They reported feeling more responsible for their passengers’ wellbeing and therefore the reduced willingness to engage was considered to be related more to the ‘attention required’ theme. Another reason for having a lower willingness to engage when passengers were present was that they though the passenger may be judging, assessing and possibly pass comment on their driving. A misjudged decision, such as using the phone at an inappropriate time (a misjudgement of the attention needed) would have more severe consequences than if they misjudged it when alone. The participants seemed aware they would receive a repercussion (in terms of being judged or getting verbal feedback) on their misjudgement as opposed to when driving alone when their misjudgement would only receive repercussions if they actually crashed.

Other environments, similar to driving, such as shopping and public transport were also perceived by many participants to have few social etiquette rules affecting their usage (‘context of function matching context of environment’ theme had little influence similar to in the driving environment). However, unlike in the driving environment these environments both had a relatively high reported willingness to engage. Based on the interviews conducted it appears the 'attention required' theme had a far larger impact on willingness to engage than in the shopping and public transport environments, explaining why driving had a lower willingness to engage.

The driving environment does not, therefore, appear to be unique in terms of what influences willingness to engage with all environments seemingly influenced by the perceived importance (expected importance) of phone use. Similarly it was influenced very little by the social rules and rudeness of using the phone (similar to shopping and public transport environments). Although phone engagement while driving was found to be influenced heavily by the attention needed in the environment this was also observed in meetings, especially when under a high workload, and in other environments when there was a time pressure. Therefore, the only seemingly unique influencing factor was that the driving environment was subject to fairly high workloads in all scenarios. Even when bored (considered by participants to be the lowest workload driving condition) phone usage was still restricted with many participants commenting that some functions would require too much attention and interaction to be used or simply weren't important enough to justify using in such a demanding environment.

4.9 Conclusions

The aims of the study were to identify the phone functions used while driving and the reasons behind this. Further aims included establishing if phone use behaviour transferred from out of the car to while driving and if the reasons motivating this were similar or if factors affecting phone usage in the driving environment could be considered unique.

The results indicated that there was quite widespread usage of smartphone functions when outside of a vehicle, though factors encouraging and inhibiting their use varied greatly from environment to environment. However, this use of advanced functions did not appear to transfer to when driving with a very low reported incidence of any functions other than talk and texting on the phone. Therefore, it appears from this (admittedly) small sample that smartphones are not yet introducing any new issues in relation to driver distraction than an ordinary mobile phone, though further investigation into this issue is still warranted.

Matthews et al. (2009) suggested that the context strongly affected mobile phone use, from when users interacted with the phone to what they did with it and for how long. This was supported by findings in this study, with the ‘context’ of the environment having an impact, with some environments consistently being reported as having high phone usage and others much lower. Self-reported phone usage whilst driving was generally far lower than in other environments, the interviews suggested that this was a result of drivers being aware of the safety critical nature of the driving task. The attention required by either the driving or phone tasks was a frequently mentioned prohibiting factor to phone use while driving and was also mentioned far more times as a deterrent to phone interaction than laws prohibiting phone use. This suggests that law enforcement may have comparatively small effect on phone usage while driving, supporting Hill (2004) and McCartt et al.’s (2004) findings that phone use legislation had no significant long term effect on hand-held phone usage levels when they were sampled pre-ban and a year subsequent to the legislation being introduced.

The factor which was found most likely to encourage or inhibit self-reported phone usage whilst driving was when there was perceived to be a low workload (such as on an empty stretch of motorway) and therefore the driver was bored, leading to increased call and text usage in order to entertain the driver. This supports Peters et al.’s (2005) finding of phone use during ‘boring moments or moments of waiting’ seemingly applying to while driving also. Conversely, there was support for the suggestion made by McKnight et al. (1993) that when drivers were faced with a high workload situation, such as negotiating a roundabout or driving at night in the rain, drivers reported trying to lower demands placed on them by reducing their phone call interaction. Along with minimal self-reported interaction with phone calls there was also found to be cessation of using all other functions in high demand scenarios. From this study it is suggested that further investigation into the effects of workload on phone interaction while driving is warranted in order to find how demand from the road environment affects phone usage and the specific factors causing these changes.

In some scenarios if the driver was expecting an incoming call, text or email then reported occurrence of answering a call and reading a text message increased, as a result of the expected importance associated with this. This suggests if future studies want to investigate the worst case scenario when drivers are most likely to use their phone then simulating (or including in the scenario description) that the driver is expecting an important call or text is likely to lead to the situation with the highest incidence of phone interaction.

The main themes identified as affecting willingness to interact with a smartphone, when out of the car and while driving, were: whether the context of the function matched the context of the environment, how rude it was to use the phone in the environment, how discreet the function attempting to be used was, the level of attention required by the environment or phone function and the importance placed on using the particular function. Though the level of impact these factors had on phone usage was found to very much depend on the environment the participant was in at the time.

Overall, the study found that there doesn’t appear to be many advanced smartphone functions used while driving at this time, even though there is a relatively high adoption rate of such features in other environments. Based on the findings of what participants reported most affected their willingness to engage while driving the factor which have been highlighted as most important to research further from this study are how the drivers’ workload affects their willingness to interact with a phone. The most frequently mentioned factor affecting this workload was the road environment, such as when bored on a motorway or facing high demand from negotiating a roundabout. Therefore, the extent to which the road environment can encourage or inhibit phone usage and reasons why warrant further study.

Chapter 5- Study 2: The Extent to which the Roadway Environment and Phone Function Affects Drivers' Willingness to Engage with their Mobile Phone

5.1 Introduction

Findings from the interviews in Study 1 (Chapter 4) suggested that roadway demand may have a significant impact on willingness to engage with a mobile phone while driving. Many studies have focused on the effects on driving performance once a driver has started their phone interaction. However, few studies have investigated the factors affecting drivers' decisions on when to engage with their mobile phones in the first place. The performance decrements once engaged with the phone are only a part of the picture; the level of demand already placed on the driver at the time of phone interaction may also have an effect. Therefore, looking at the extent to which drivers delay their phone interaction based on road *demand* is important in understanding the potential for distraction. Furthermore, insight into the factors which drivers take into account when making decisions to engage or not with their phone while driving is also currently lacking in the research literature.

As Lerner (2005) highlighted '*the actual risk associated with some device will be a joint function of how the use of that device interferes with driving and the circumstances under which drivers are willing to use it*'.

As well as the road *demand* affecting the overall task demand it is proposed that the *phone function* intended to be used (e.g. *sending a text message* compared to *placing a call*) may have an effect, both on driving performance and also a drivers' *willingness to engage* with their phone. Very few studies have considered phone usage based on the function used and, as of yet, no studies appear to have investigated how willingness to engage with the device can be affected by the function intended to be used.

Fuller's (2005) TCI model suggests that drivers' behaviour is regulated by a desire to maintain an acceptable level of task difficulty which varies based on two factors: driver capability and task demand. The current study manipulated task demand in order to test whether this theory can also help explain drivers' phone use behaviour.

In the current study it was proposed that the task demand derived from phone usage whilst driving might be affected by two elements; firstly the driving task (which included both the physical and cognitive demand caused by the roadway) and secondly the phone task demand (which alters based on which function is intended to be used).

The study involved participants watching short video clips of different road scenarios, of varying road demand, and rating their willingness to engage with different phone functions should they be driving in the road scenario just witnessed.

5.2 Aims

The aims of the study were to determine if the road *demand* had an effect on *willingness to engage* with phone *functions* while driving. Specific objectives were to:

- Determine whether the road *demand* affected drivers' *willingness to engage* with their mobile phone.
- Determine whether the *phone function* intended to be used affected drivers' *willingness to engage* with their mobile phone.
- Determine whether the *perceived risk* of using a mobile phone function affected drivers' *willingness to engage* with their phone.
- Gain in-depth insight into what drivers take into consideration when deciding whether or not to engage with their mobile phone whilst driving.

5.2.1 Hypothesis

1) Drivers will have a higher willingness to engage with their phone in the less demanding (low and mid) road demand scenarios

2) Drivers will have a higher willingness to engage with phoning (place a call and answer a call) as opposed to texting (send a text message and read a text message) phone functions.

5.3 Study Rationale

5.3.1 Research Approach

Since the aims of the study were to find if road demand and phone functions affected willingness to engage it was decided a tightly controlled laboratory experimental design was required (see Rationale of Study Design section). This allowed confounding variables to be kept to a minimum (high internal validity) and make cause and effect conclusions as strong as possible.

5.3.2 Rationale of Study Design

It was decided that video clips of road environments were to be shown to participants, for testing how demand affected willingness to engage, as these were thought to be preferable to on road trials, test track trial or simulator trials for a number of reasons. Firstly, video clips ensured all participants viewed the exact same road environment, reducing confounding variables (such as traffic, weather conditions, speed travelling at etc.). These variables would have made it more difficult to ensure participants were experiencing the intended level of road demand, as opposed to a heightened or reduced demand caused by unforeseen variables in the environment. This variability in demand may have influenced willingness to engage ratings and affected the overall findings.

Secondly, viewing video clips allowed participants to talk through, and offer in depth insight into, what in the road environment was influencing their willingness to engage with their phone. This was able to be carried out safely, as a result of not actually driving at the time, and it was believed also allowed them to consider in more depth the reasons behind their actions than if they had been required to split their concentration between driving (on the road or in a simulator) and forming their considerations behind their actions at the same time.

Finally, by using video clips taken from real road driving footage a level of external validity was maintained, while still being able to keep a very high internal validity. This was required for any possible cause and effect conclusions to be strongly argued. It is, however, acknowledged that this choice of method had the drawback that participants themselves were not driving at the time of making their ratings, impacting on the external validity of the results. This methodology was believed to offer an optimal trade off to allow a high internal validity, a level of external validity, participant safety as well as enabling maximum insight into the reasons behind phone use or non-use to be gained.

5.3.3 Rationale when Rating Road Demand

It was found from the literature search that there was a great paucity of research, and suggested techniques, for how to objectively rate the demand caused by or within a roadway environment. The only suggested way found for attempting to objectively rate demand was that of Fastenmeier (1995) (as cited in Patten (2005)) who devised a way of classifying road demand into three categories based on the complexity of the road environment. A scenario was classified as *high demand* if both the vehicle handling and information processing resources were challenged (termed high/high). A scenario was classified as *mid demand* if the information processing resources were challenged, but the vehicle handling ones were not (high/low) or, conversely, the information resources were presented with little challenge but a great deal of car control was required (low/high). Finally, a scenario was deemed *low demand* if neither the information processing nor car handling resources were particularly challenged (low/low). This gives a way to classify road demand experienced at any time by looking at the demands placed on the drivers' resources. Therefore, to allow video clips to be separated as objectively as possible, based on road demand, Fastenmeier's (1995) method was used for rating the demand observed (see approach section for the exact procedure used).

5.4 Methodology

5.4.1 Approach

In order to produce a number of video clips representing *high, mid and low road demand* a pre-recorded video of a drive from Loughborough University to Leicester City Centre and back (around an hour and a half long) was analysed using Fastenmeier's (1995) classification criteria. The drive's informational and vehicle handling demand placed on the driver in the video was rated, by the author, and noted down each time an event occurred. For example a roundabout was approached, the driver overtook a vehicle, a different type of road was encountered, going from suburban road to city centre or entered onto a motorway etc. Once the whole drive had been analysed, and rated, the footage was re-reviewed and the best five examples (those that most clearly showed the desired demand as well as being different to previous video clips already chosen for that demand rating) of each of the three driving demand condition (*high, mid and low demand*) were then cut from the original video using Windows Movie Maker. Identifying and separating these video clips from the original, longer, drive video allowed the participants to see, and make willingness ratings on, a number of different demand environments in a short space of time. This also meant the videos could be presented in a different order for each participant, thereby eliminating possible order effects. Table 3 shows each of the scenarios chosen and the demand category they were rated under, for full descriptions of the road scene featured in each of the fifteen video clips please see Appendix 3.

Table 3: Showing the road scenarios in each road demand classification and the mean perceived road demand as rated by participants on a 1-5 rating scale, along with their standard deviation

High Demand	**Mid Demand**	**Low Demand**
Entering motorway	Motorway medium traffic	Motorway empty
Leaving motorway	Main arterial stopped at roundabout	Main arterial fast flowing traffic
Motorway overtake	Main arterial left turn	Main arterial through green light
Main arterial going around roundabout	City environment slow moving traffic	Main arterial stationary red light
City environment turn right	City environment approaching stationary traffic	City environment fast flowing traffic
Participants' mean road demand rating: 4.1 SD: 0.31	Participants' mean road demand rating: 3.2 SD: 0.62	Participants' mean road demand rating: 2.3 SD: 0.57

Each video's duration was around eight seconds, at five seconds in a recorded voice was embedded within the video to say 'now'. This represented the exact moment that participants were to consider their *willingness to engage* with their phone and helped ensure all participants were making their willingness ratings based on the exact same moment within the video. Therefore, all ratings were based on the exact same observed road demand. Figure 13 shows a screenshot of a *mid demand* scenario (approaching stationary traffic) giving an example of one of the road scenes viewed when the voice said 'now' and participants made their willingness ratings. Once the video had finished participants had an unlimited amount of time in which to make their ratings. The video clips were saved on a Toshiba laptop computer and played to the participants on a 32 Inch flat screen Samsung Television.

Figure 13: A Screen shot displaying the scenario ‘city environment- approaching stationary traffic’ scenario.

This study utilised a similar methodology to Lerner (2005) but using video footage rather than actual driving. This was believed to be safer and allow the driver to give more insight on their thoughts due to not having to concentrate on the driving task simultaneously to explaining their answers. The secondary tasks were all phone use related and required participants to verbally talk through why they made their ratings. Both of these study design features differentiated it from Lerner’s (2005).

Three point rating scales were chosen for participants to rate their willingness to place or answer a call and send or read a text message against (1: ‘I would absolutely not do this task now’, 2: ‘some chance of doing the task’ and 3: ‘I’m very willing to do this task now’). Due to the number of participants used (20) utilising three point rating scales ensured there would be enough participants within each cell to allow statistical testing to take place. It was believed to also still offer enough choices on the scale to clearly differentiate between when the participants were willing to engage with their phone or not.

Three pilot studies were conducted to test the procedure, and the rating scales, and to make judgements, and gain feedback from the participants, as to what could be improved. It was found from feedback in the pilot studies that, unlike for *willingness to engage*, three point scales were considered to present too big a jump between each rating point when rating the level of risk. Participants reported wanting a more gradual increase or decrease in risk ratings within the scale. Therefore, five point rating scales were used for rating *perceived risk* of using the phone in each video clip.

Five point rating scales were used to rate how risky participants thought it was to both *place and answer a call* in hands-free medium for each video clip (from 1: 'no additional risk beyond my normal driving to 5 'I'm fairly likely to be involved in an accident'). Please note although willingness to send or read a text message was collected, the risk of *sending a text* and *reading a text* were not considered here as these were considered to require hand held interaction by pilot study participants, so illegal acts. Feedback from the pilot studies showed participants taking into account the risk of getting caught, which added to the riskiness rating, thus confounding the results.

Participants also gave a rating on how demanding they perceived the road environment to be again on a 5 point rating scale (1: 'not at all demanding' and 5: 'very demanding') after the pilot studies reported three points to not offer enough flexibility or differentiation for rating an increase or decrease in *perceived demand* between each video.

It was made clear in the information sheet, provided before the experiment began, that the participants were to imagine that it was an important phone call or text that they were making or receiving, such as when a relative is in hospital and the hospital phones them, or they are running late for an important meeting. This was to ensure all drivers placed the same level of importance on the phone usage as Study 1 had found 'importance' may have quite a large effect on their willingness to engage judgements. It was also stated that participants should imagine they were the driver when watching the video clips and that they were driving alone on a weekday afternoon in dry weather. They were also informed usage of the phone referred to hands free functionality where possible i.e. for the placing and answering a phone call phone functions. This made such phone operations legal to conduct while driving.

After each video clip had been viewed participants were asked to identify the road scenario they thought the video clip had just shown them. This was to ensure all participants perceived the same scenario when making their rating, for example '*it was showing the scenario of driving along an empty motorway*'. If they had perceived the scenario incorrectly then the correct scenario was described and the video then replayed followed by asking if they now perceived the scenario differently, once the scenario was explained and video replayed all participants then reported viewing the video correctly.

Participants also gave their reasoning behind the ratings they were making in a 'think aloud' fashion. These verbal insights were collected (using a Dictaphone) to help gain insight into what factors drivers take into account when considering whether or not to engage with their phone in situations of various demands and when considering the use of differing phone functions.

To help ensure the ratings for *willingness, riskiness* and *demand* made after seeing the videos were not chosen at random, but represented accurate and considered indicators of *willingness, riskiness* and *demand*, the participants were asked to return one week later and carry out the experiment again, watching the same video clips and using the same rating criteria. This allowed comparison between week one and week two's ratings allowing tests for consistency, and therefore, reliability of the measures used.

Only two phoning functions (*place a call* and *answer a call*) and two texting functions (*send a text message* and *read a text message*) were used when testing how phone function could affect *willingness to engage*. It is noted that modern smartphones have far more functions and capabilities built into them than just phoning and texting, such as email, internet and satellite navigation capabilities to name but a few. However, the results from Study 1, in the previous chapter, indicated that these 'advanced' phone functions were not currently utilised to a great extent whilst driving and so were deemed to not be worthwhile investigating at this point in time.

5.4.2 Participants

20 participants (4 female, 16 male) aged between 33 and 47, (mean age of 32, SD= 7.312), mean annual mileage of 9850 (lowest= 2000 miles, highest 35000 miles, SD=7080) were recruited through University notice boards and convenience sampling. A questionnaire was answered by prospective participants to ensure they all held a full UK driver's license for at least two years (held on average for 14 years, SD= 7.134) and in a pre-study questionnaire reported using their phone at least 'occasionally' whilst driving, ensuring informed decisions on whether or not they would use their phone based on past driving and phone use experience could be made.

5.4.3 Procedure

An information sheet (Appendix 4) was first given to participants and informed consent collected. It was made clear all results would be kept anonymous and the participant could withdraw at any point. Demographic information was also collected at this point using a questionnaire. Participants were first shown an example of the type of video clip they would be watching throughout the experiment and asked to practice giving ratings of willingness to engage with *placing a call*, *answering a call, sending a text* and *reading a text* on three point rating scales. They also rated their *perceived risk* of *answering a call* and *placing a call* on five point rating scales and then rated the *demand* they perceived the environment placed on them on a five point rating scale. The participants were then asked if they had any questions about the procedure before a second practice clip was played and a second set of ratings given, again with a chance to ask questions afterwards.

Once participants understood, and had practiced, the procedure they were shown the first video clip that would be used in the study. When the video had finished participants were first asked to verbally describe the road environment they thought the video clip had just shown them and then participants marked down their *willingness, riskiness* and *demand* ratings as per the practice clips (see Appendix 5 for an example of the record sheet used). Participants also gave 'think aloud' verbal insight (involving participants explaining out loud why they were making the ratings they were- for example '*there are no hazards coming up that I can see and my hands aren't occupied particularly so I can concentrate on my phone if I want')* and these were recorded on a Dictaphone and later transcribed verbatim. This procedure was repeated until all fifteen video clips had been viewed and *willingness, riskiness* and *demand* ratings given.

One week later participants returned and were shown the exact same video clips (again in a random order-so different to the order they had previously viewed the clips in). They carried out the same methodology as already described, only this time without the verbal reasoning required (as the purpose for this session was only to check for consistency in the ratings made and not the reasoning behind them).

5.5 Analysis and Results

Due to rating scales being used to collect the data, along with the data being non-normally distributed, as can be seen in Figure 14, non-parametric tests were used throughout, therefore all data was ranked appropriately before carrying out the non-parametric analysis.

5.5.1 Trial One and Trial Two Differences

Participants gave their ratings of *willingness to engage, riskiness of engaging* and *road demand* twice for each video clip to ensure consistency in their ratings (rated first in trial one and again one week later in trial two). Wilcoxon signed-rank tests were used to compare the difference in results for the first trial and the repeated measures trial one week later. There were only two significant differences found between the ratings given in trial one and trial two, these were for *riskiness of answering a call* in a *high demand* scenario between the first trial and the second trial (Z= - 2.958, p=.002) and the participants' rating of *demand* in the *high demand scenario* compared to a week later (Z= - 2.841, p=.004). As there were only two significant differences, out of the seventy five tests run, all the subsequent tests and analysis were run on the first week's data only.

5.5.2 Perceived Roadway Demand Ratings

The participants rated (on a 1-5 scale) the *demand* they perceived for each road scenario (e.g. a 1-5 rating was given for 'entering motorway'). As mentioned previously five road scenarios were then grouped to represent a road demand (e.g. *High demand* featured: 'entering motorway', 'leaving motorway', 'motorway overtake', 'main arterial going around roundabout', 'city environment turn right'). All the demand scores, rated by participants, for each of these five scenarios were then averaged to give a mean demand score for *High Demand*; the same was then conducted for *Mid* and *Low demand*.

It was found that the participants' ratings corresponded with the initial classification with the *High demand* classification having the highest *perceived demand* (4.1) and the *Low demand* classification having the lowest *perceived demand* (2.3), as would be expected the *Mid demand* fell between the two (3.2), for standard deviations please refer to Table 3. A Friedman's ANOVA was run to see if the participants' *demand* ratings for the *low, mid* and *high demand* scenarios were significantly different. A significant difference was found between the *demand* ratings ($X^2(2) = 36.545$, $p<.01$). To see where these differences lay multiple post hoc Wilcoxon signed-rank tests were carried out; Bonferroni corrections meant all effects are reported at a 0.0167 level of significance. It was found that statistically significantly differences were present between participants' *demand* ratings for all demands [*high demand* and *mid demand* ($Z= -3.725$, $p<.00167$), *high demand* and *low demand* ($Z= -3.921$, $p<.00167$), *mid demand* and *low demand* ($Z= -3.784$, $p<.00167$)].

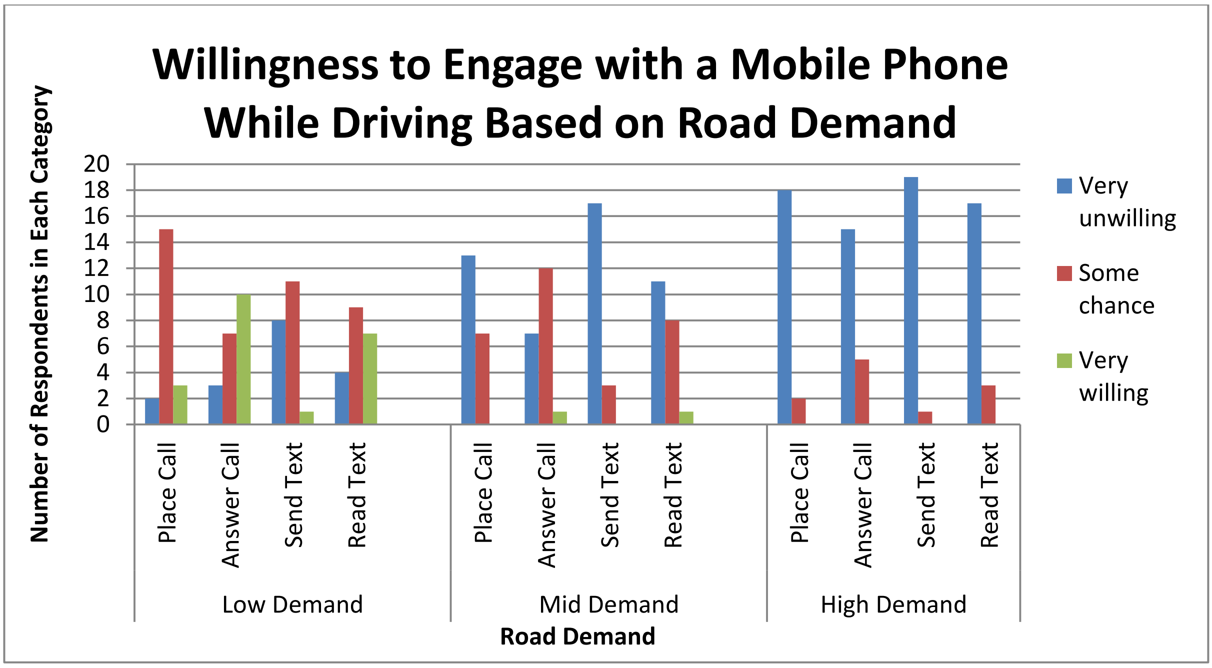

Figure 14: Showing drivers' willingness to engage with mobile phone functions based on road demand

5.5.3 Phone Function

As can be seen in Figure 14, the *functionality* intended to be used appeared to have an effect on *willingness to engage*, with *sending a text* having the lowest willingness rating in all environments and *answering a call* having the highest willingness rating in all environments. Friedman's ANOVAs were run for each of the *functionalities'* rating scores for the *low, mid* and *high demand* classifications separately.

There was a significant effect for the type of *functionality* used in the *low demand* classification $X^2(3) = 35.819$, p<.01. In order to detect where the differences lay post hoc Wilcoxon signed-rank tests were carried out, with a Bonferroni correction so all effects are reported at a .008 level of significance. It was found that statistically significantly differences were present between all *functionalities* [*answer call* and *place call* (Z= -3.774, p<.008), *send text* and *place call* (Z= -3.469, p<.008), *send text* and *answer call* (Z= -3.826, p<.008), *read text* and *send text* (Z= -3.578, p< .008)] apart from *willingness to place a call* and *read a text message* (Z= -1.08, p= .297) and *answer a call* and *read a text message* (Z= -2.25, p= .024) which were not significantly different).

A further significant effect was found for the *function* used in the *mid demand* classification $X^2(3) = 31.796$, p<.01. Post hoc paired Wilcoxon signed-rank tests showed that statistically significant differences were present between all *functionalities* at a p<.008 level [*answer call* and *place call* (Z= -2.813, p<.008), *send text* and *place call* (Z= -3.069, p<.008), *send text* and *answer call* (Z= -3.420, p<.008), *read text* and *send text* (Z= -3.301, p< .008)] apart from *willingness to place a call* and *read a text* message (Z= -1.194, p= .247) and *answer a call* and *read a text message* (Z= -2.266, p= .021) which were not significantly different.

Similarly, there was a significant effect for the type of *function* used in the *high demand* classification $X^2(3) = 17.966$, p<.01, showing participants were more likely to engage with some *functions* than others in a *high demand* classification. After running the post hoc Wilcoxon signed-rank tests with a Bonferroni correction it was found that there was a statistically significant difference between *answering a call* and *placing a call* (Z=-2.812, p=.008) and *sending a text* and *answering a call* (Z= -2.603, p<.008). No other significant differences were found [(*send text* and *place call* Z= -.816, p=.500; *read text* and *place call* Z= -1.261, p=.250; *read text* and *answer call* Z= -2.053, p=.039; *read text* and *send text* Z= -1.535, p=.156)].

5.5.4 Road Demand

As can be seen from Figure 14, the *road demand* classification also appeared to have an effect on *willingness to engage* ratings. The *low demand* classification had a higher reported *willingness to engage* rating for *placing a call*, *answer a call* and *reading a text* than seen in the other two, higher, demand classifications. To test if these differences were significant, Friedman ANOVAs were conducted on the *willingness* ratings for the same function between each *demand* classification. Post hoc Wilcoxon signed-rank tests were then carried out to see where the differences lay, a Bonferroni correction applied means effects are reported at a .0167 significance level.

For *placing a call* the roadway *demand* was found to have a significant effect $X^2(2) = 34.560$, p<.01. Post hoc tests showed there was a significant difference for *willingness to place a call* between all *demand* classifications (*mid* and *high demand* Z= -3.642, p<.0167; *low* and *high demand* Z= -3.830, p<.0167; *low* and *mid demand* Z= -3.584, p<.0167).

For *answering a call* the roadway *demand* was found to have a significant effect $X^2(2) = 38.079$, p<.01. Post hoc tests showed there was a significant difference for *willingness to answer a call* between all *demand* classifications (*mid* and *high demand* Z= -3.830, p<.0167; *low* and *high demand* Z= -3.924, p<.0167; *low* and *mid demand* Z= -3.627, p<.0167).

For *sending a text message* the roadway *demand* was found to have a significant effect $X^2(2) = 23.286$, p<.01. Post hoc tests showed there was a significant difference for *willingness to send a text message* between both *low* and *high demand* (Z= -3.36, p<.0167) and *low* and *mid demand* (Z=-3.409, p<.0167), but was not significantly different for *sending a text* in *mid* and *high demand* (Z=-2.160, p=.036).

For *reading a text message* the roadway *demand* was found to have a significant effect $X^2(2) = 31.121$, p<.01. Post hoc tests showed there was a significant difference for *willingness to read a text* between all road *demand* classifications (*mid* and *high demand* Z=-3.525, p<.0167; *low* and *high demand* Z= -3.626, p<.0167; *low* and *mid demand* Z=-3.466, p<.0167).

5.5.5 Risk Ratings

The participants' ratings of *perceived risk* when *placing* or *answering a call* were also collected to assess the influence of the *road demand* on level of *perceived risk (Figure 15)*. A Friedman ANOVA was run for the *riskiness of placing a call* in *low, mid* and *high demand* scenarios. The roadway *demand* was found to have a significant effect on ratings of the *riskiness of placing a call* $X^2(2) = 37.026$, p<.01. Post hoc Wilcoxon signed-rank tests, with Bonferroni correction (significance level of .0167) showed there was a significant difference in *perceived risk of placing a call* between all road *demand* classifications (*mid* and *high demand* Z= -3.325, p<.0167; *low* and *high demand* Z= -3.922, p<.0167; *low* and *mid demand* Z=- 3.727, p<.0167).

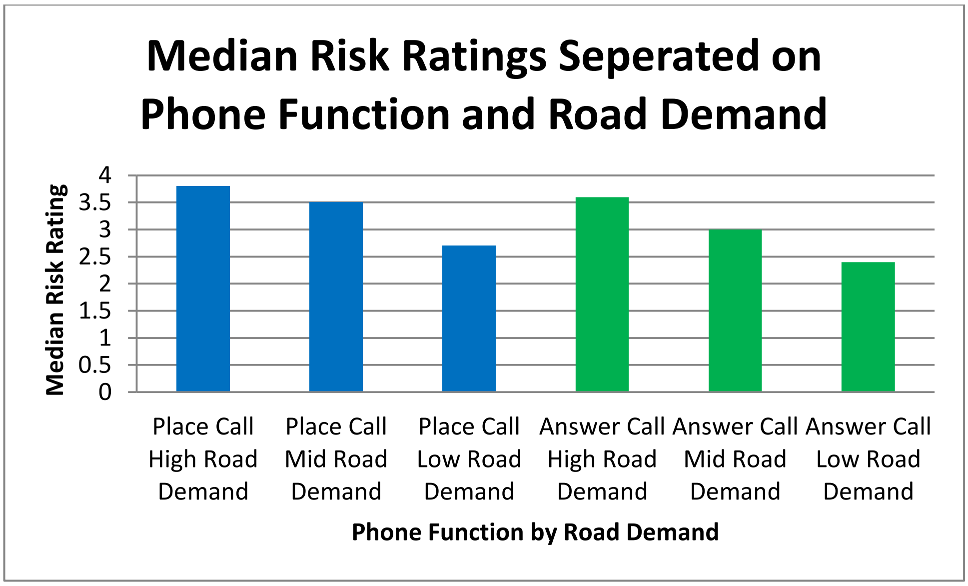

Figure 15: Showing median risk ratings separated on road demand and phone function

Similar results were found with respect to *answering a call*. The roadway *demand* was found to have a significant effect on ratings of the *riskiness of answering a call* $X^2(2) = 35.620$, p<.01. Post hoc tests showed there was a significant difference for *perceived riskiness of answering a call* between all road *demand* classifications (*mid* and *high demand* Z=-3.790, p<.0167*; low* and *high demand* Z= -3.921, p<.0167; *low* and *mid demand* Z=-3.723, p<.0167).

To compare if the *function* used affected the *riskiness* rating Wilcoxon signed-rank tests were run. It was found that the *riskiness* rating for *placing a call* and *answering a call* were significantly different in all demand scenarios (*high demand* Z= -3.222, p<.01; *mid demand* Z= -3.568, p<.01; *low demand* Z= -3.220, p<.01).

It therefore appears that both road *demand* and phone *function* can affect the level of *risk perceived* for using a phone while driving.

5.5.6 Correlations

5.5.6.1 Place Call Correlations

In the *high demand* scenario neither *perceived riskiness* nor *perceived demand* were significantly associated with *willingness to place a call* but *perceived riskiness* and *perceived demand* were found to be correlated (see Figure 16) . Similarly In the *mid-demand* scenario neither *perceived riskiness* nor *perceived demand* were significantly correlated with *willingness to place a call* but *perceived demand* and *perceived riskiness* were correlated with one another. In the *low demand* scenario both *perceived riskiness* and *perceived demand* were significantly associated with *willingness to place a call* (see Figures 17 and 18) and *riskiness* and *demand* were also correlated with one another (see Table 4 for *place a call* correlation coefficients).

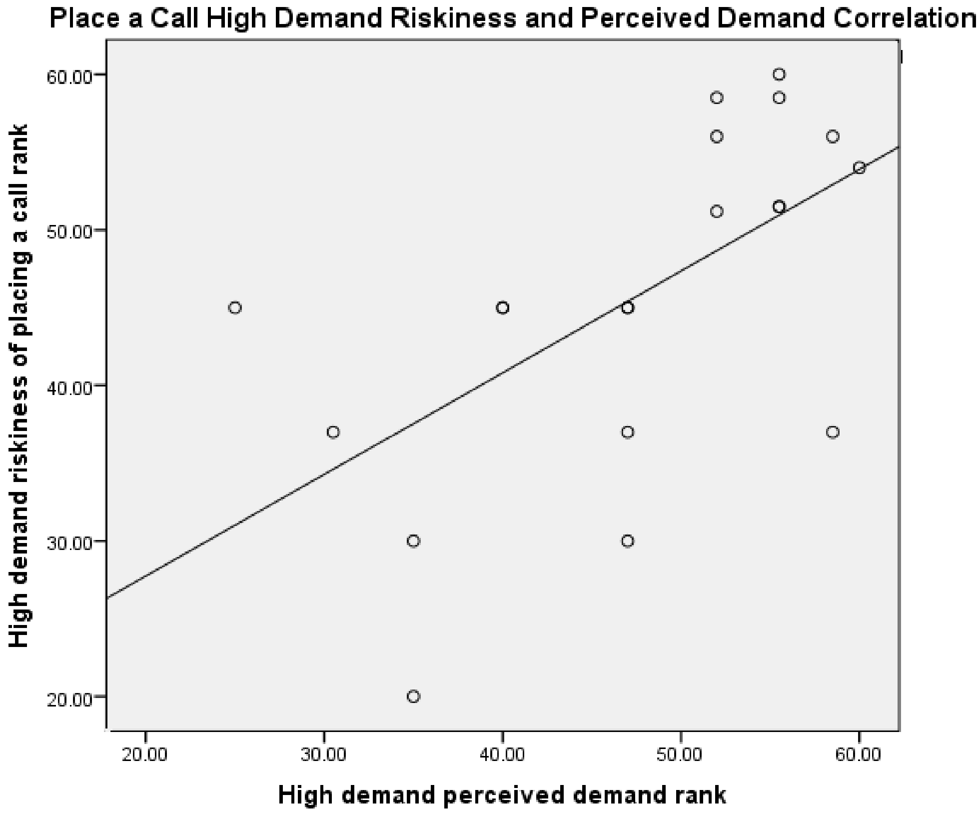

Figure 16: Showing perceived demand of placing a call rankings and perceived riskiness of placing a call rankings correlation in High Demand scenario

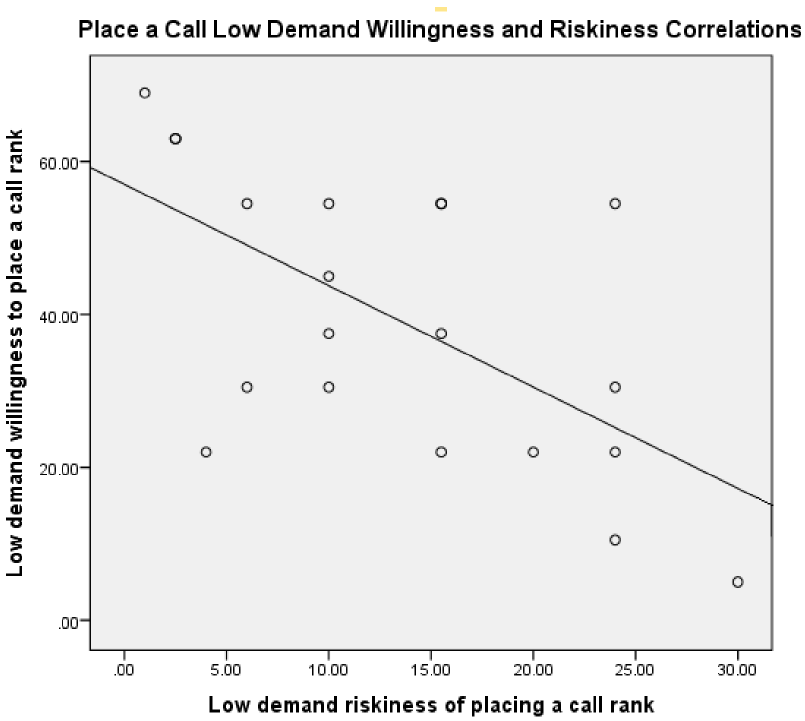

Figure 17: Showing the correlation between place a call perceived demand and willingness to engage in placing a call rankings in a low demand scenario

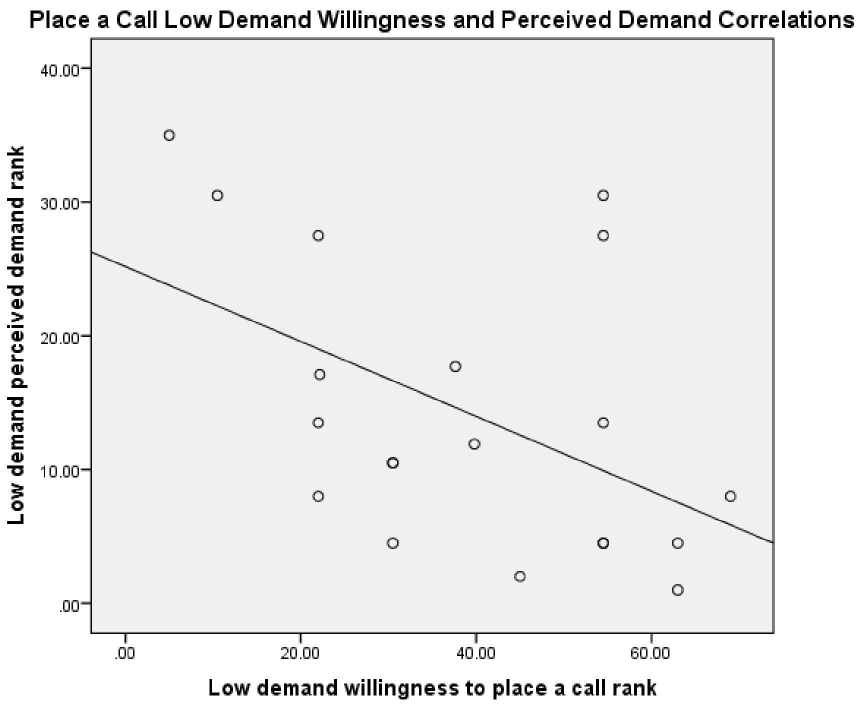

Figure 18: Showing the correlation between place a call perceived riskiness and willingness to engage in placing a call rankings in a low demand scenario

5.5.6.2 Answer Call Correlations

In the *high demand* scenarios *perceived riskiness* was significantly associated with *willingness to answer a call* (see Figure 19), *perceived demand* was not. *Perceived demand* and *perceived risk* were also found not to be correlated. Similarly in the *mid demand* scenarios only *perceived riskiness* was significantly associated with *willingness to answer a call* (see Figure 20), *perceived demand* was not. *Perceived riskiness* and *perceived demand* were also found not to be correlated. In the *low demand* scenarios neither the *perceived riskiness* nor *perceived demand* were significantly associated with *willingness to answer a call* and were not correlated with one another either (see Table 5 for *answer call* correlation coefficients).

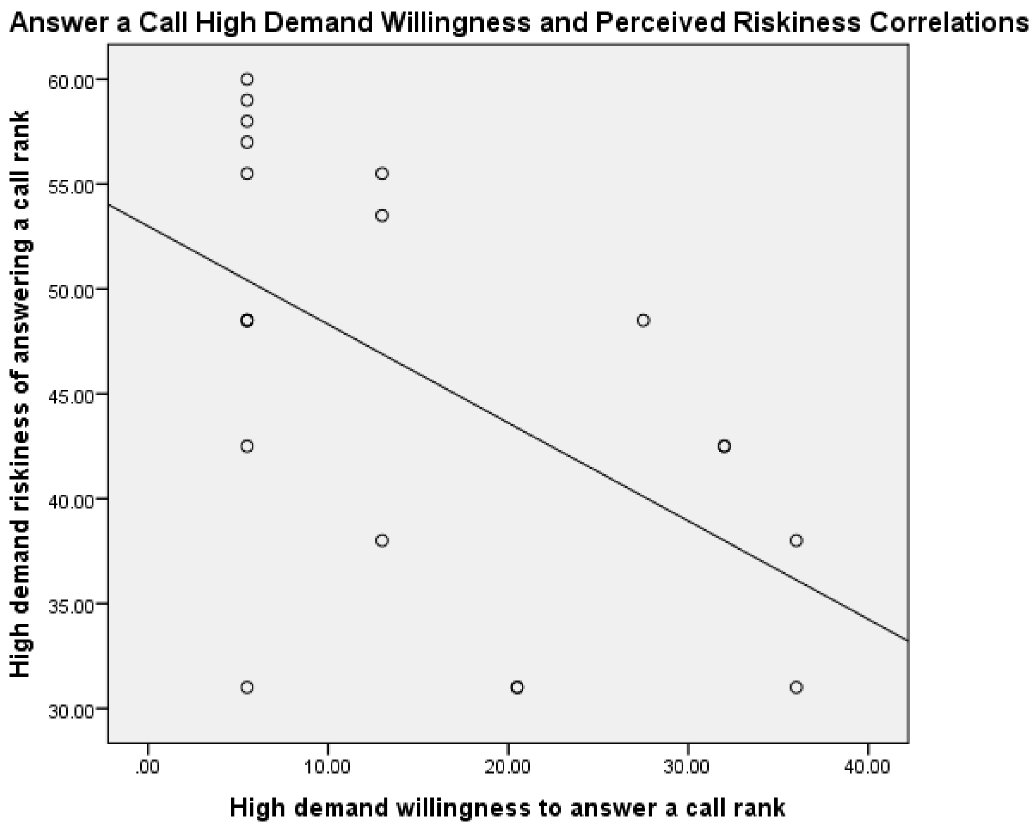

Figure 19: Showing the correlation between answer a call perceived riskiness and willingness to engage in answering a call rankings in a high demand scenario

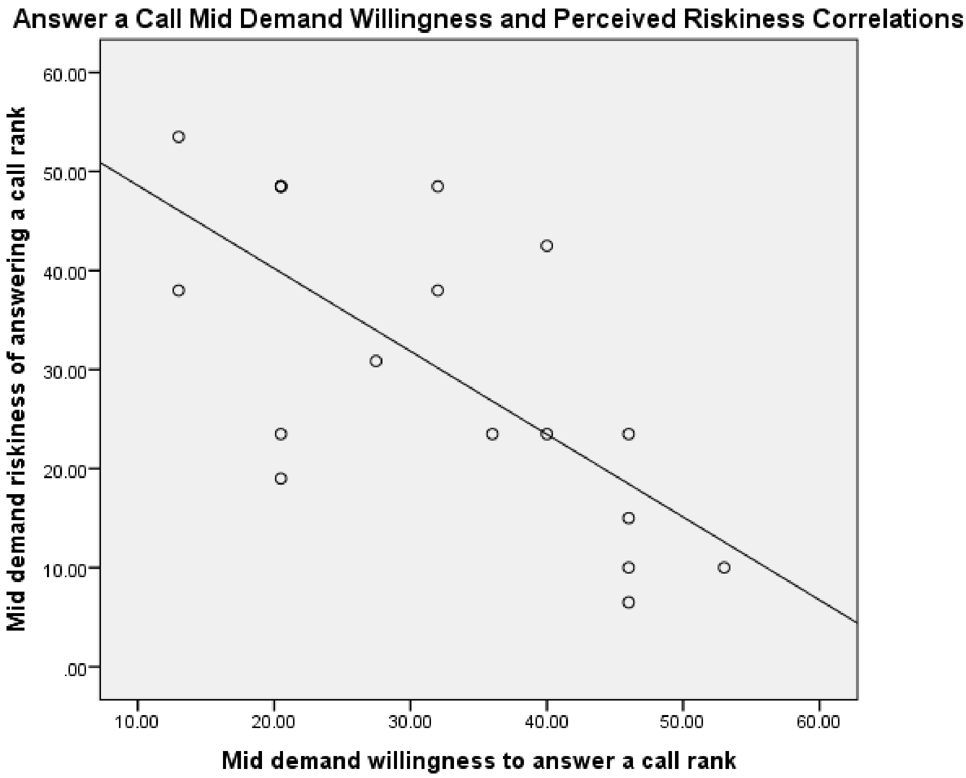

Figure 20: Showing the correlation between answer a call perceived riskiness and willingness to engage in answering a call rankings in a mid-demand scenario

Table 4: *Place call* correlation coefficients for *perceived demand* of the road environment, *perceived riskiness* of *placing a call* and *willingness to place a call* (the significant results are shown in bold)

Place Call	High		Mid		Low	
	Perceived Demand	Perceived Riskiness	Perceived Demand	Perceived Riskiness	Perceived Demand	Perceived Riskiness
Perceived Riskiness Spearman's Correlation Sig. (2 tailed)	.639 **.002**		.721 **.000**		.583 **.007**	
Willingness Spearman's Correlation Sig. (2 tailed)	-.304 .193	-.208 .378	-.260 .269	-.440 .052	-.520 **.019**	-.610 **.004**

Table 5: *Answer call* correlation coefficients for *perceived demand* of the road environment, *perceived riskiness* of *answering a call* and *willingness to answer a call* (the significant results are shown in bold)

Answer Call	High		Mid		Low	
	Perceived Demand	Perceived Riskiness	Perceived Demand	Perceived Riskiness	Perceived Demand	Perceived Riskiness
Perceived Riskiness Spearman's Correlation	.244		.383		.410	
Sig. (2 tailed)	.299		.095		.073	
Willingness Spearman's Correlation	-.029	-.574	-.087	-.678	-.312	-.351
Sig. (2 tailed)	.904	**.008**	.716	**.001**	.181	.129

5.5.7 Think aloud

The results from the 'think aloud' segment of the study offered insight as to why the previously described results were observed. These think aloud results feature in the discussion section to help illustrate the factors which affected whether a driver was willing to engage with their phone or not and why.

5.6 Discussion

The aims of the study were to establish to what extent roadway *demand* affected drivers' self-rated *willingness to engage* with their mobile phone. Along with aiming to find if the *phone function* intended to be used could also have an effect on whether or not drivers would *engage* with their phone.

Fuller (2005)'s model suggested that driver behaviour was regulated by drivers trying to maintain an acceptable level of task difficulty, which varied based on two factors: driver capability and task demand. The current study manipulated task demand in order to test whether this theory can be used to help explain drivers' phone use behaviour also.

In the current study, the task demand derived from phone usage whilst driving was theorised to be affected by two elements: firstly the driving task, which included both the physical and cognitive *demand* caused by the roadway, and secondly the phone task demand, which alters based on which *function* was intended to be used. As stated in the introduction, it was expected the results would show drivers were most willing to interact with their phone in the less demanding road scenarios. It was also predicted there would be a higher *willingness to engage* with phoning as opposed to texting phone functions. When combined the phone task and road demand was believed to affect how drivers viewed the overall task demand and if this exceed their acceptable level of demand then phone tasks would not be interacted with.

5.6.1 Driving Task Demand

In the current study each driving scenario video shown to participants was categorised under one of three *demand* classifications, *high, mid* or *low demand*. These were separated based on Fastenmeier's (1995) road demand classification which allows researchers to classify how demanding the roadway environment was based on both the vehicle handling (physical) and information processing (cognitive) resources involved in that road environment.

Evidence from the 'think aloud' verbal insights from the study indicated that participants did indeed judge how demanding they perceived the road to be when making their ratings on willingness to use their phone, and that vehicle handling and information processing capabilities were taken into account. This can be illustrated in this quote for when turning left at traffic lights (which was rated as a mid-demand scenario) '*both my hands would be used for turning the wheel so I wouldn't be able to actually touch the phone, even if I was willing to interact with it,*' showing vehicle handling being taken into consideration. Further illustrations include 'w*hen entering a motorway (rated as high demand scenario) you need to be aware of what the rest of the traffic is doing and ...you may also have to change gear, which I may not be able to do if I'm on the phone*'. For the motorway empty (rated as low demand scenario) '*just driving straight on a motorway, it's fairly undemanding. There are no hazards coming up that I can see and my hands aren't occupied particularly so I can concentrate on my phone if I want*'. These quotes suggest drivers take into account both physical and cognitive demand when deciding how demanding they perceive a roadway to be, as was suggested in Fastenmeier's (1995) classification criteria.

Table 3 shows the driving scenarios used and the *demand classification* under which they were placed subsequent to assessing them using Fastenmeier's (1995) classifications. Participants were also asked to rate how demanding they perceived each road scenario to be (on 5 point rating scales). It can be seen in Table 3 that the participants' average *perceived demand* scores for each category also corresponded with the classification given based on Fastenmeier's classifications, i.e. the *low demand* classification had the lowest *perceived demand* rating and the *high demand* classification had the highest *perceived demand* rating. The participants' average demand score for the *low, mid* and *high demand* classifications were all also found to be significantly different from one another. This may suggest that Fastenmeier's classification method is an accurate method with which to classify road *demand,* though further large scale studies would be needed in order to fully validate this finding.

5.6.2 Road Demand

It was found that the *demand* of the road environment had an effect on drivers' *willingness to engage* with their mobile phone with *low demand* situations featuring the highest *willingness* ratings for phone usage and *high demand situations* the lowest rating of *willingness to engage*.

This finding was to be expected based on Fuller's (2005) model as the low demand from the road meant the driver would have spare resources with which to interact with a secondary task without exceeding their target threshold of acceptable task difficulty.

This finding was in agreement with previous studies such as Atchley et al. (2011) who found participants rated a higher willingness to engage with any type of texting (reading, replying and initiating) as road intensity decreased. Horrey et al. (2008) also found both lower ratings of road demand and lower assessment of the relative risk of performing multiple tasks was associated with increased willingness to engage in a mobile phone conversation whilst driving. The current study used a similar methodology to that of Horrey et al. (2008) so finding similar results was not unexpected. Though, Lerner (2005) also used a similar methodology but found conflicting evidence, instead finding willingness to engage was not affected by the road demand experienced (finding Driver willingness to engage with in-vehicle tasks was related to technology type, specific task attributes, personal motivations, driving style, and decision style). Lerner (2005) asked participants to drive on a real road environment and rate their willingness to use their phone, unlike Horrey et al. (2008) and the current study, which both used pre-recorded videos of road scenarios. This may have affected the results with drivers being less affected by the roadway when rating their willingness to engage on a real roadway as opposed to a simulated one. However, Esbjörnsson et al. (2007), who observed actual phone usage on real roads, supported the findings of this study, also finding that demand of the road environment affected the timings of interaction with a secondary task.

The 'think aloud' element of the experiment also allowed interesting insight to be gained on what factors affected drivers' decisions to interact with the phone or not whilst driving. For example, the following quote mentions how the roadway *demand* can lead to reduced *willingness to engage* with a mobile phone, but also mentions that phone use can be dictated by the level of phone signal the road features. '*I wait for certain points on the motorway to place a call or send a text ... I know where there's no signal on them (his regularly driven roads) so I wouldn't make call on a certain point of the M40 because the signal drops out. I know another point on the M40 which is long and not that busy, even at rush hour. Also it isn't near any cities so I find it's a good place for having a long call. The A43 I don't tend to use the phone on because the signal's pretty appalling and there's roundabouts constantly so I try to avoid making calls and if I do then only on the dual carriage way parts of it so I'm not under too high a workload*'.

Insight into why there was a higher *willingness to engage* in the road scenarios which were categorised as *low demand* was gained through the verbal insights. For example when on an empty motorway it was said: '*I text more when I'm on a motorway, than on other types of roads because it's more of a controlled environment. You have less road furniture and everyone is travelling in the same direction, you just have changing lanes to worry about'*. *'(A motorway offers) quite a clear path with no bends, hills or anything to change or alter, just keep your foot on the pedal and shouldn't be too problematic*'. Similarly when stationary at a red light participants were found to mostly be willing to use their phone, reasons for this were: '*I'm stopped and will be there for a few seconds …I have a few seconds to do these things (phone tasks) and the situation won't be demanding*'. 'I'm a*ctually stopped and the cars ahead of me (who were also waiting for lights to change) mean you will have some extra time before you have to move off. I would feel comparatively safe to use the phone, not no concerns at all but with few concerns*'. It seemed perceiving the environment to be controlled and easier to predict in terms of how demand would increase in the near future were the main reasons for using the phone in the low demand condition.

Similarly an expected low workload ahead, not just at the time of engaging, could also lead to increased phone usage as the roadway offered little stimulation and phone use was a way of increasing this. '*The boredom factor, you're joining the motorway and I know I'm going to be there for a few hours so I would be lonely and placing calls to keep me amused*', here, as suggested in Fuller's model, a desired level of stimulation was maintained by using the phone to increase demand, so the low workload acted as a motivator for using the phone at that moment.

Both the *mid* and *high demand* conditions had far lower reported *willingness to engage* with a phone while driving, reasoning behind this were also given in the verbal insights. One such example was for the scenario of entering a motorway (high demand scenario) '*you have to match your speed to the other vehicles (who were already on the motorway), check your blind spot and the truck in front could do anything so there's much more to think about than just I must check my phone or must place a call*'. '*I would leave the* *phone use until I was at least comfortably integrated with the traffic. Very risky to take your eyes off the road and try to cut into the traffic when you have to negotiate your timing with other car's speeds*'.

Another example which had detailed reasoning for why the phone was not engaged with was for going around a roundabout (high demand scenario). '*I consider that to be a very demanding situation because it was a roundabout so requires steering around it and its quite likely cars on my right would want to come into my lane. It was likely the cars ahead of me will be slowing down quickly too so I need to be ready to react to that'*. '*I'm having to negotiate the steering to get around the roundabout and there's lots of different lanes so I may realise I'm in the wrong one or the person next to me realises they're in the wrong one and dive in next to me. That's the thing about driving is it's not just yourself, and people forget that, it's what everyone else is doing on the road which can be a hazard also'.* These examples show how participants took the demand into account when making their judgements of whether they would engage with their phone or not, often using terminology such as '*unsafe*' or '*not possible*' to use the phone when faced with mid and high demand situations.

There was also evidence to suggest having a knowledge of the roadway the driver was driving on could affect phone usage as they know if there are 'opportunities' with which to use their phone, if so they would delay their phone usage until they reached that less demanding roadway. '*I know that there are traffic lights coming up so I would be waiting until I approached them, I know from local knowledge that there is a better opportunity to use the phone then'*. '*The road is quite quick and there's plenty going on with having to turn, watch the lights etc. 'also I know there are places to pull off in a few seconds so would most likely wait until then*'.

Other quotes also highlight delayed interaction not because of local knowledge but just from an awareness that the demand would decrease in a moment for example: '*I'm going around a corner so I almost definitely wouldn't do that (use the phone), I'd just wait for the straight piece of road and then use the phone if I needed to'. 'The phone will ring for at least five* *seconds so I might answer it when I'm on the straight again but at that exact moment when turning I would not be willing*'.

This highlights how phone use may not just be regulated by the demand experienced at that exact moment in time but also by the demand that may be coming up. This was mentioned frequently as a reason for not using the phone when leaving the motorway on a slip road as the demand was not just perceived as high at that moment but was predicted to greatly increase further, as British motorway slip roads generally lead to large roundabouts that require negotiating. '*There's likely to be a roundabout or traffic light or something coming up so I know that will be ahead so not much point starting something which I would have to stop again in a few seconds'. 'You're in one lane and only have to focus in front and behind because it's a slip road but I know the demand will increase in a minute where there's traffic lights ahead and can get queues as well so I'd be preparing for that rather than using the phone'. 'I don't know what is ahead and I may have to brake, indicate I don't know, so I feel out of control of the situation and that I have to concentrate on driving*'. The effect that upcoming road demands and local road knowledge can have on willingness to engage with a mobile phone whilst driving is an area which is currently under researched and could potentially be an important area for future study.

The 'think aloud' element of the study helped to illustrate that the control the participant's felt they had in the driving environment in terms of how changeable and predictable the demand may be in the long or short term could affect their phone use decision. *Demand* of the road experienced at that moment in time as well as the predicted future road demand (whether expected to increase or decrease) were all taken into account by drivers when deciding whether or not to engage with their phone whilst driving.

5.6.3 Phone Function

The second factor affecting task demand was theorised to come from the *phone function* intended to be interacted with (*placing a call*, *answering a call, sending a text message* or *reading a text message*). The results from the study suggested that the *phone function* did indeed have an effect on *willingness to engage* with a mobile phone whilst driving. It was found that *sending a text* was the least likely functionality to be engaged with in all road demands and *answering a call* the most likely.

Answering a call and *placing a call* willingness ratings were significantly different for all road *demand* scenarios, with drivers reporting being more likely to *answer a call* in all *demand* scenarios. The verbal insights helped to explain why this difference may have been found. '*Making a call I tend to be thinking about what I'm going to say whereas taking one I obviously don't know what it's about so just have to react so takes less time and concentration to answer one for that reason as well as being easier to do, just a click of a button'.* This quote highlights the how the content of the call may be perceived to be easier when *answering a call* as it simply involves reacting to the conversation as opposed to *placing a call* which seems to be perceived to require more thought both before and during the call as a product of being required to initiate the conversation and interaction.

'*I always find answering a call easier than placing a call because on my phone you have to unlock it then look for the person to ring, whereas to answer you just press the answer button, without the need to unlock or search through menus'. 'I'm not familiar with speed dial so there (placing a call) would involve a lot of scrolling down and searching so similar to texting*'. These quotes help to illustrate a frequently mentioned reason for *answering a call* having a higher willingness to engage, it was generally perceived to be a less involving task, just a click of a button as opposed to *placing a call* which required scrolling through contacts lists in order to place the call. This highlights the issue of how the phone's interface design could possibly influence a driver's interaction with the device. If the interface is designed in such a way as to make a task easier, such as: not having to unlock the phone, recently called contacts appearing on the home screen or the user becoming proficient at speed dial or voice activation, then this may influence willingness to engage with phone tasks. Vehicle interfaces are now being developed with phone interaction and synchronisation in mind. It is possible this could make such tasks even less difficult and result in a higher propensity to engage in phone use while driving. By phone and vehicles becoming more integrated the interface could do more than just ease interaction it is possible it could increase interaction through the interface design no longer acting as a barrier to engagement.

It should be noted that the design of the study may have had an influence on willingness to engage ratings for the functions which involved holding a conversation once the engagement has taken place. The questions asked of the participants put the emphasis on rating their willingness to reach the point of conversation without mention of the conversation element itself. It is possible if the participants had been more expressly instructed to take the conversation element of the task into account as well then willingness to engage may have been reduced as this would have added to the overall workload placed on the driver. Many of the quotes used throughout this section demonstrate how the interaction with the device was talked through in depth, such as the number of button presses required to complete the task influencing willingness, but the effects of having to hold a conversation featured far less.

Willingness to read a text message and *send a text message* were also significantly different from one another in all road *demands*, apart from *high demand*. This difference appeared to come from *sending a text* requiring far more concentration and interaction than *reading a text message*, as evidenced in the quote '*When I receive a text it appears on the screen so I don't have to click anything it will just appear. I have my phone mounted high on the dashboard too so I can just turn my head and read the text when I want to', '(sending a text) will require me holding the phone and a lot more glances towards it so I would never text while driving, I just think it's too dangerous*'. This supported Atchley et al. (2011) who found undergraduate drivers were more willing to engage with reading, as opposed to sending, a text message.

A further suggested reason for a higher *willingness to read a text* than *send a text* was the difference in time each task took to conduct. '*Reading a text, it requires a quick glance is all, a very short process*', '*I can skim read a text quite quickly and get the main themes of it, so generally willing to do that',* *‘the message comes up on the screen so I can have a quick glance and get the gist of the message in the first sentence normally*’. This was in contrast to sending a text where participants reported ‘*the (traffic) lights would change and so wouldn’t have enough time to send a text, well I wouldn’t*’, ‘*It generally takes me about five minutes to send a text in my car, I have write a bit then look back up at the road then write some more*’, ‘*sending a text for me on the road means doing a few letters then looking up, do a few letters look up so it isn’t worth doing it*’.

Although there were differences, and reasons given, for a reported higher *willingness to engage* with either *sending* or *reading a text message* in *low* and *mid demand* scenarios, in the *high demand* scenarios there was no significant difference found. It is proposed this is a reflection of a perception that there were insufficient spare resources to do either task. Engaging with either *sending* or *reading a text message* would have exceeded drivers’ accepted level of demand; therefore, the perceived ease or difficulty of the text message task had no significant effect on *willingness to engage* with text messages in the *high demand* road scenarios.

It was predicted in the introduction that participants would be significantly more likely to engage with the phoning functions (*placing a call* and *answering a call*) than they were the texting phone functions (*send a text message* and *read a text message*). This was based on Wicken’s (1980) Multiple Resource Theory. *Reading a text* is predominantly a visual task so it was predicted to require longer eyes off road time than either *answering* or *placing a call*. *Sending a text message* was predicted to require both greater eyes off road time and manual interaction than either *answering* or *placing a call*, which were predominantly auditory tasks. Therefore, the texting tasks were likely to lead to a higher incidence of competing for visual resources with the driving task than phoning mediums which would be predominantly auditory. This assumption that auditory tasks are less distracting than visual (manual) entry tasks concurs with many other studies (Tsimhoni et al. (2004), Crisler et al. (2008), Drews et al. (2009), Owens et al. (2011)). It was assumed most phone users would be aware of the conflict in resources which text messaging requires and this would be taken into account by participants when deciding whether or not to engage with their phone. Furthermore, interacting with a phone in anything but a hands-free medium is illegal in the UK (where the study took place) and so it was believed the high level of manual interaction required, particularly for sending a text but also required for opening a text message, would lead to participants reporting a reduced willingness to engage with these tasks.

This prediction was found to be partially true, with significant difference in willingness to *answer a call* and *send a text message* in all *demand* scenarios and *place a call* and *send a text message* in all but the *high demand* scenario.

The reason for participants' reporting being no more likely to *place a call* than they were to *send a text* message was likely a result of the spare resources available in the *high demand* condition being insufficient to be offset by lower demand of the *placing a call* task. Therefore, *placing a call* and *sending a text* were equally as unlikely to be engaged with when faced with *high demand* roads. Conversely, *answering a call* was considered far less demanding a task than *placing a call* (as discussed earlier). This may help explain why even in the *high demand* condition participants' reported being significantly more willing to interact with *answering a call* than *sending a text message*, as *answering a call* was perceived less demanding than *sending a text message* so did not exceed acceptable task demand levels even in *high demand* scenarios.

Answer a call and *place a call willingness to engage* ratings may have been higher in the majority of *demands* than those for *sending a text message* (as predicted), however, participants' *willingness to engage* with *reading a text message* was not significantly different from either *place a call* or *answer a call willingness* ratings in any of the road *demand* scenarios.

After studying the verbal insights it is suggested that *reading a text* was just as likely to be engaged with as *placing* and *answering a call,* because reading a text message is now a far simpler task than has previously been required. Text messages on many of the participants' phones were reported as appearing open on the screen when they were received, without any need for phone interaction. '*When I receive a text it appears on the screen and I don't have to press anything so I can just scan the message without having to touch my phone, as it's mounted near my windscreen anyway*','*(I'm) likely to read a text because the texts comes up on my screen so it's just (a case of) glancing (at it)*'. If the phone was mounted high enough, as was the case in many participants' reports, reading the message only required glancing momentarily from the windscreen to the phone's screen and therefore required very little manual interaction. Similarly eyes off road time for this task was believed to be fairly short as participants perceived text messages to generally not be very lengthy and therefore did not take long to read '*I would definitely read a text because it's a short process*', '*I would have enough time to read the characters of a text message so yeah I would definitely do that*', '*I can have a quick glance and get the gist of the message in the first sentence normally*'. This stripped down process of reading a text message now also means that reading a text could also be considered a grey area in terms of its legality whilst driving as no hand-held interaction was required, which could in turn lead to more people being willing to carry out the task while driving. It should be noted, however, if an accident was to occur through the misjudged timing of reading a text message it would be a punishable act, as the driver would be considered to be driving without due care or attention.

The results of this study clearly show that the phone task can have an effect with some phone functions far more likely to be engaged with than others. This supports some previous literature in finding a difference in willingness to engage for different tasks with Lerner (2005) finding a higher likelihood towards engagement with phones as opposed to satellite navigation devices or PDA's, while others found willingness to engage to be insensitive to the secondary task (Horrey et al. (2008), Horrey et al. (2009b)). In relation to the phone use while driving literature the findings of this study were similar to those by Walsh et al. (2007) and Atchley et al. (2011) that drivers are most likely to answer a call, followed by placing a call, read a text and least likely to send a text message. In the current study the finding that answering a call was most likely to be engaged with and sending a text least likely to engage with was fully supported. The only difference in findings in the current study to previous literature was that participants' ratings indicated a greater willingness to reading a text than to place a call. As discussed earlier, the think aloud transcripts indicated this difference is likely a result of reading a text message now requiring few interactions as the message simply appears on the screen without needing any interaction, making reading a text message simpler than it previously has been.

5.6.4 Perceived Riskiness

The Friedman's ANOVAs and Wilcoxon signed-rank tests showed that the *perceived riskiness* varied according to the road *demand* experienced at the time with, as would be expected, *high demand* situations having the highest levels of *perceived risk* of using the phone while driving and *low demand* having the *lowest perceived risk*. Furthermore, correlational analysis showed for *placing a call* that *high demand* and *high riskiness* ratings were significantly associated with one another, and the same was found in the *mid* and *low demand* scenarios. This suggests that if a road environment was perceived to be demanding then it was also believed to be a risky place to place a call. However, for *answering a call riskiness* and *demand* were not associated with one another in any of the road demands.

There is currently no literature which investigates the links between demand and riskiness when driving and using a phone to compare these findings against. However, it is suggested when considered against the rest of the findings in this chapter, including the verbal insights, there is a definite rationale behind *riskiness of answer a call* not being correlated to road *demand* but *placing a call* was.

Generally, participants reported *answering a call* to require far less interaction and, therefore, less eyes off road time than did *placing a call*. Even in a *high demand* scenario the *risk of answering a call* was perceived as very low due to simply clicking one button, in some cases where hands free kits were used this was reduced to just a flick of a paddle on the steering wheel. Participants felt quite capable of doing this secondary task with very little additional risk, even when faced with a lot of demand from the environment, so as demand increased *perceived risk* did not increase in proportion. This may explain why *answering a call* risk was found to be significantly different for each *demand* classification but was not correlated with *perceived demand*, the *perceived risk* did increase as *perceived demand* increased but not to the same extent as *perceived demand* so they were not correlated.

Conversely, *placing a call* was said to involve multiple manual phone interactions and so placed far more demand on the driver than did *answering a call*. As the *demand* from the environment increased the amount of spare resources decreased. With less spare resources available to carry out a secondary task it would be risky to engage with it. *Placing a call* involved a lot of manual interaction and so faced a high likelihood, when combined with increased road *demand*, to then push the overall level of task demand past the acceptable threshold and thus as road *demand* increased so did the *perceived risk* of *placing a call*.

5.7 Conclusions

The aims of the study were to determine if road *demand* and *phone function* intended to be used had an effect on *willingness to engage* with a mobile phone while driving. Verbal insights were also used to find what drivers were taking into account when deciding whether or not to engage with a phone while driving.

It was expected the results would show drivers were most willing to interact with their phone in the less demanding situations. It was also predicted there would be a higher *willingness to engage* with phoning as opposed to texting phone functions.

The results showed both roadway *demand* and *phone functionality* affected *willingness to engage* with a mobile phone whilst driving. Finding a higher propensity to engage in road environments perceived to have a *lower demand* and lowest propensity to engage in the *highest demand* scenarios.

Researcher classification of road demand according to Fastenmeier's (1995) method corresponded with the *perceived demand* ratings given for the same scenarios by the participants. This suggests Fastenmeier's road demand classification system may be an effective measure for future researchers to use when trying to differentiate based on road demand, though further large scale testing would be needed to fully validate this.

Phone function intended to be used was also found to have an effect on *willingness to engage* with *answering a call* the most likely function to be engaged with and *sending a text message* the least likely. In both the *low* and *mid demand* scenarios all functions' willingness ratings were significantly different from one another apart from *place a call* and *read a text* and *answer a call* and *read a text*. However, for the *high demand* scenarios the *function* intended to be used had much less of an effect on *willingness to engage* with the only significant differences found to be between *answering a call* and *placing a call* and *sending a text* and *answering a call*. It seemed as the roadway became more demanding only *answering a call* had any real likelihood of being interacted with. It was also noted that *reading a text message* had a higher propensity to be engaged with, in all road *demands*, than was originally predicted. The verbal insights showed this to be a result of *reading a text* requiring no physical interaction, as most modern phones displayed the incoming text on the screen when it was received. Therefore, if the phone was mounted on the windscreen or in a hands-free holder on the dash it was tempting, possible and relatively easy to just quickly glance at the presented message. This finding from the verbal insights helped to explain why the prediction of phoning functions being engaged with more than texting functions was not found to be entirely true.

It was found that *answer a call perceived risk* and *perceived demand* ratings were not correlated but they were for *place a call.* This helps to back up the assumption that road demand and phone function interact to give a level of task demand. *Answer a call* was not perceived as very demanding so as road demand increased the risk of interacting with the function did not go up by the same amount. This was likely due to it not taking up the remainder of the drivers' spare resources. However, for *place a call, perceived demand* and *perceived risk* were correlated. It is suggested this is because placing a call was perceived as a more demanding task so as *road demand* increased there was not sufficient resources spare with which to safely engage in this phone task simultaneous to driving, thus doing so was considered a risky behaviour.

This study only focused on one part of Fuller's (2005) model of driver behaviour, task demand, investigating how two elements of the phone use while driving task: road *demand* and *phone function* intended to be used could affect *willingness to engage*. It was suggested by Fuller that overall task difficulty was a product of both task demand and driver capability, which when combined led to a certain level of task difficulty which would be aimed to be maintained. Therefore, the next chapter will still be concerned with willingness to engage. The focus will be on the second part of Fuller's model of driver behaviour, capability, and how it affects *willingness to engage* with a phone while driving.

Chapter 6- Study 3: Willingness to Engage with Mobile Phones While Driving Based on Driving Capability and Phone Capability

6.1 Introduction

It was found in Study 2 (Chapter 5) that task demand had an effect on drivers' willingness to engage with their mobile phone while driving. However Fuller (2005) suggested driver behaviour is regulated by more than just task demand, proposing drivers try to maintain an acceptable level of task difficulty which is a product of both task demand and driver capability.

It has been shown that drivers might have up to 50% 'spare' attentional capacity during 'normal' driving Hughes et al. (1986) and this may be regulated by the amount of driving experience the road user has (Patten et al. 2006). This brings into question whether more experienced drivers are able to use their phone more safely while driving, than less experienced drivers, due to having more spare resources with which to use the phone. However, the level of phone capability also needs to be taken into account.

Shinar et al. (2005) found when participants used their phone in hands-free mode over five trials, that phone practice led to greater phone use capability and also reduced the demands placed on the driver when using the phone and driving (though it should be noted Cooper et al. (2008) found practice had no effect on phone use while driving capability). Bayer et al. (2012) factored driving confidence into their model when investigating factors influencing phone engagement when driving and found it to have a significant effect, concluding '*certain individuals may feel that they can overcome the perceived risk of dangerous driving, if they are skilled (in their own opinion) at the wheel*'. However, phone experience affecting willingness to engage whilst driving has currently never been studied and provides a gap in the literature.

It may be the case that inexperienced drivers have far less spare resources with which to interact with a phone while driving as a result of the driving task taking up much of their resources (see Figure 21). However, an experienced driver may be very inexperienced at using their phone, meaning interacting with the device may place a great challenge on their cognitive resources and, therefore, exceeds the spare capacity they had gained through being experienced at the driving task. Conversely, a less experienced driver would have fewer spare resources when conducting the basic driving task but may still be more capable of using their phone while driving than an experienced driver. The inexperienced drivers' overall task difficulty (a product of task demand and capability) could be lower than that for an experienced driver who is less capable at using a phone (see Figure 22).

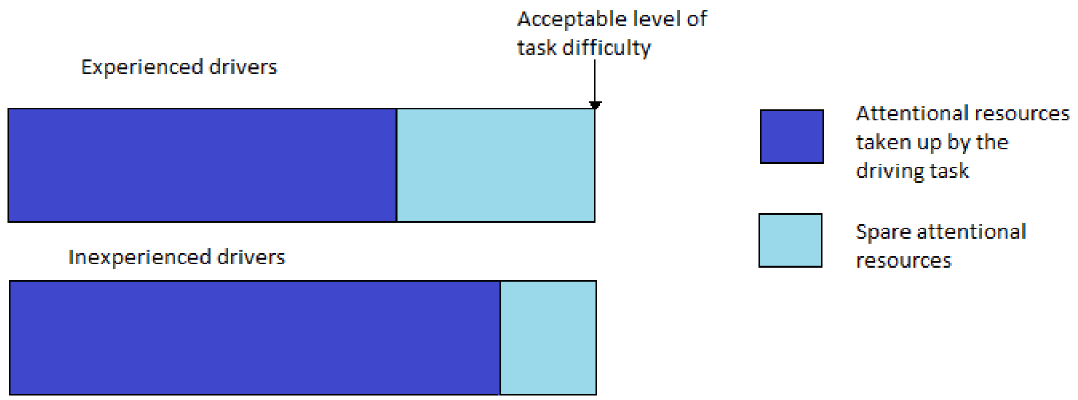

Figure 21: Diagram of possible attentional resources taken up by the driving task for experienced and inexperienced drivers

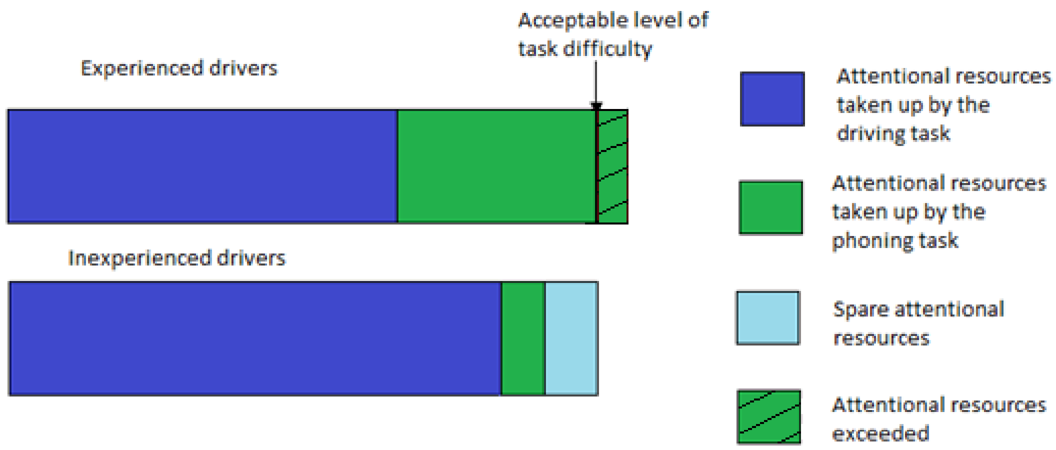

Figure 22: Diagram showing possible attentional resources taken up by both

phoning while driving for experienced drivers who are inexperienced phone users and inexperienced drivers who are experienced phone users

It is clear that the current literature has not yet fully researched, or concluded, what effect phone experience can have on driving performance when conducted concurrent to phone usage. An even less researched area is to what extent phone experience, or phone use while driving capability, can impact on a driver's willingness to engage with their phone. Are those drivers who can capably use their phone more inclined to do so while driving as a result of this capability.

Fuller (2005) suggestion that drivers try to maintain an acceptable level of task difficulty which regulates their driving behaviour could possibly have implications for drivers choosing whether or not to engage with their phone while driving. Kircher et al. (2011), after reviewing literature on how experience influences phone use, noted *'for future research it appears to be at least as important to investigate whether drivers learn to choose opportune situations for placing their calls as it is to investigate whether actual performance during a call can be improved. This would presuppose that experience in driving rather than in handling a telephone can make a difference in overall performance'.*

There is currently no research which investigates to what extent levels of driving capability or phone capability affect the decision of whether or not to engage with a mobile phone while driving. It is proposed that, as maintaining a certain level of task difficulty is said to affect drivers' behaviour, it is important to understand to what extent both of these capabilities can lead to appropriate or inappropriate phone use engagement decisions. It is also reasonable to consider whether there is an interaction effect. A more experienced driver may be more aware of the impact of phone use on their driving performance than a less experienced driver.

The current study tested the previously mentioned factors in a laboratory setting, using a driving simulator. Experienced drivers who reported having little mobile phone use experience were compared against inexperienced drivers who reported high mobile phone use experience. Both groups were faced with low and high demand simulated driving environments and their willingness to engage in the various demand situations were compared.

6.2 Aims

The aims of the study were to determine whether driving capability and/ or phone capability could affect the situations in which drivers were willing to engage with their mobile phone. Specific objectives were to:

- Determine if *self-rated driving capability* affected the road demands in which drivers were willing to engage with their phone
- Determine if *self-rated driving capability* affected the *phone functions* drivers were willing to engage with, in both low and high demand driving situations
- Determine if *actual driving capability* affected the road demands in which drivers were willing to engage with their phone
- Determine if *actual driving capability* affected the *phone functions* drivers were willing to engage with, in both low and high demand situations
- Determine if *self-rated phone capability* affected the road demands in which drivers were willing to engage with their phone
- Determine if *self-rated phone capability* affected the *phone functions* drivers were willing to engage with in both low and high demand situations
- Determine if *actual phone capability* affected the road demands in which drivers were willing to engage with their phone
- Determine if *actual phone capability* affected the *phone functions* drivers were willing to engage with in both low and high demand situations

6.2.1 Hypothesis

The higher the (self-rated) capability to use their phone while driving the more likely the participant is to engage with their phone while driving. This effect will be larger in the high demand than the low demand environment.

The higher the (actual) capability to use their phone while driving the more likely the participant is to engage with their phone while driving. This effect will be larger in high demand environment than low demand environment.

The higher the (self-rated) driving ability the more likely the participant is to engage with their phone while driving. This effect will be larger in high demand environment than low demand environment.

The higher the (actual) driving ability the more likely the participant is to engage with their phone while driving. This effect will be larger in high demand environment than low demand environment.

6.3 Study Rationale

6.3.1 Pilot studies

The research methodology was first tested in a series of five pilot studies, the feedback and lessons learned from these pilots informed and refined the methodology, the final rationale is outlined next.

6.3.2 Research Approach

Since the aims of the study were to determine whether driving capability or phone capability while driving affected willingness to engage with phone functions in low and high demand scenarios it was decided a tightly controlled laboratory experimental design was required. This allowed confounding variables to be kept to a minimum (high internal validity) and make cause and effect conclusion as strong as possible.

6.3.3 Rationale of Study Design

It was decided that a driving simulator would be used in the study for testing drivers' willingness to engage with their phone, in low and high demand scenarios, as this offered advantages over on road or test track trials. On road studies were not feasible due to testing drivers' willingness to engage with their phone for text messaging functions, which are illegal to conduct in the United Kingdom where the study took place, meaning it would not have been ethical to encourage engaging in the illegal activity. On road trials also had the possibility of having too many confounding variables, such as weather and traffic, which would have made comparison between participants difficult as they would all have experienced slightly different driving environments. Test track studies were also rejected as it was believed they didn't offer advantages over simulator driving but would have incurred a far greater cost to set up and run.

The simulator allowed all participants to drive the exact same road scenarios, controlling the road demand they were faced with and limited the confounding variables, which would have otherwise made cause and effect conclusions more difficult. If the drivers opted to engage with their phone in the high or low demand scenarios then using the simulator also meant they were able to interact with their phone without compromising their safety.

The simulator method of testing offers an effective compromise between maintaining external validity, the participants were still carrying out the actions of driving in the study and the roadway was a representation of real road environments, and high internal validity, allowing strong cause and effect conclusions to be made.

6.3.4 Rationale for Task Used to Measure *Actual Phone Capability*

This study aimed to test how phone capability affects willingness to engage whilst driving. It was believed that both actual ability and a users' self-rating of their phone capability could influence their decision as whether it would be safe to use their phone whilst driving. Accordingly, both variables were measured.

No objective ways of measuring phone capability while driving were found in the current literature. Therefore, a way of measuring how effectively participants can use their phone while driving was devised. Due to the nature of this study it was thought a task which, to some extent, simulated a driving environment would be useful to give an indication of participants' phone use while driving abilities. Therefore, it was decided a primary task that was heavily visually demanding but also comprised some demands on physical resources, meaning it shared the same resources as those used in most phone tasks would be preferable. It should therefore, prove to be challenging enough to separate those who could effectively dual task with their phone from those who could not.

Many options were considered but the Lane Change Test (LCT) (Mattes, 2003) was chosen as the primary task. The LCT involves a perceptual-motor tracking task with an event detection component in a simulated road environment (a fairly unchallenging circuit) featuring three lanes. There was no need for the participant to accelerate or change gear as the vehicle automatically moves at a constant speed of 60km/h, it was also not possible to brake to slow the car down. At regular intervals a sign appears at the side of the road informing the driver which of the three lanes to get into (using an arrow for the desired lane and two crosses representing the lanes not to be in- see Figure 23 for a print screen example). Participants were required to react to the sign the second they could perceive what it was conveying and move lanes as quickly as possible. This was believed to make an ideal primary task as it required frequent visual attention, monitoring the road side for signs, and occasional physical demand when steering into the correct lane was required. It also had the advantage of representing a simplified version of the driving task.

The LCT also had an inbuilt way of measuring performance on the task, as the programme knew the ideal path that should have been taken if the signs were responded to effectively and also the path the participants took. It therefore could calculate the participants' deviance from the set path and gives a score, the higher the score the more they deviated from the set path and the worse they performed on the task. The programme also allowed the researcher to define a section of the track for calculating deviance, which was useful as it meant rather than taking into account the whole lap it only made the rating score based on the 'markers' defined by the researcher. In this case markers indicated the start and end of each phone interaction, so participant performance was only recorded when a secondary (phone) task was taking place.

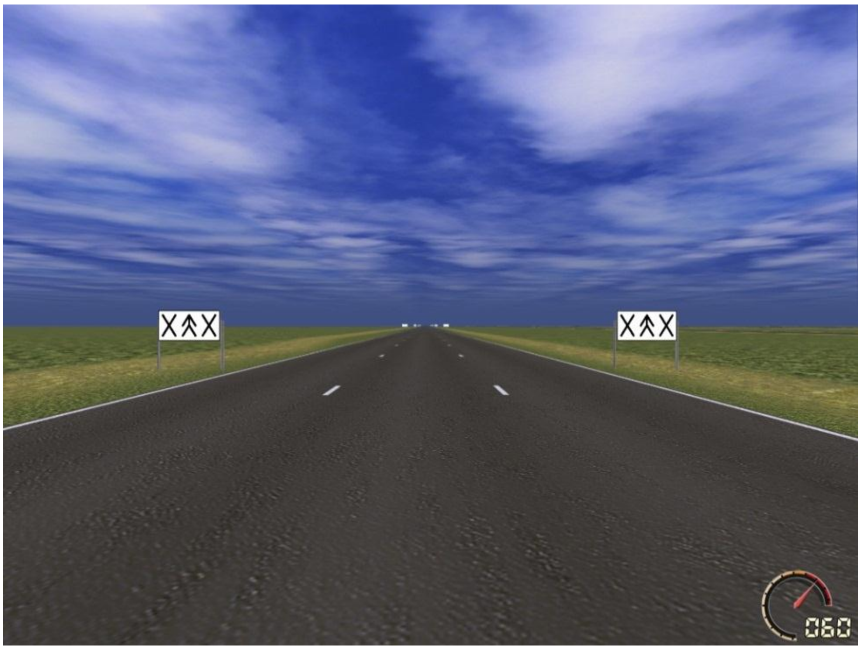

Figure 23: Print screen from LCT with signs giving instructions to stay in the middle lane

6.3.5 Rationale for Actual Driving Capability

The study also required that the participants' capability as drivers be established in order to test if driving capability could affect willingness to engage. A number of options were considered for how driving performance could be measured and defined. One example is accident history as a function of exposure. This would have allowed an objective way of measuring driving performance but had limitations by not taking into account near misses or factors such as road types and times of day, both of which have been shown to influence crash risk and might therefore have had an impact on any performance ratings made. Another possibility considered was to have participants drive in the presence of a qualified driving instructor, who would then give a rating on their driving ability in their expert opinion. This would have given an indication of their driving ability based on more than just analysing data but instead based on an actual observed ability. This method was discarded due to the difficulties of developing a reliable and valid rating system, the costs associated in both time and finance to implement such a measure and it was believed such a test might have put off many potential participants through not wanting to expose themselves to being examined.

It was decided that years of driving experience would be used as a metric for driving capability, a measure frequently used in the insurance industry. The participants would be recruited based on the amount of driving experience they had so two distinct groups could be compared: novice drivers with less than three years driving experience and experienced drivers with more than ten years driving experience. Driving experience was used as a proxy indicator for driving capability - with the more experienced drivers classed as being more capable drivers, this was based on literature findings that greater driving experience led to increased driving capability (such as greater hazard perception skills), reduced 'serious' traffic offence occurrence and reduced at-fault crash risk (Maycock et al. (1991), Waller et al. (2001), Sagberg et al. (2006)). No attempt was made to assess driving capability directly. The decision not to test driving ability objectively was informed by previous literature, such as Deery (1999) who found that although basic vehicular control was relatively easy to learn, it takes a long time to gain the higher-order perceptual and cognitive skills needed to safely interact with the road environment. Driving capability would, therefore, have been difficult to objectively test, a mixture of ability to track the road (vehicular control) and to predict hazards, both near and distant, would have needed to be ascertained, which would have been difficult to objectively measure. Years of driving experience was also noted to have been consistently used by insurance companies worldwide as a measure of accident involvement risk, of which driving capability is an intervening variable.

6.3.6 Rationale for Driving Scenarios Used

Two different demand scenarios were used to test if participants' driving or phoning capabilities affected their willingness to undertake phone tasks when faced with different levels of road demand. The choice of which road scenarios to use was made based on findings from Study 2 (Chapter 5) as well as the capabilities of the driving simulator software. Driving on an empty motorway, in the dry, and in the day time was selected as the low demand scenario (see Figure 24 for a screen capture example) as it was found from ratings of Study 2's video clips that this scenario was perceived by all participants to be of a very low demand. It was also classified as a low demand scenario based on Fastenmeier (1995) (as cited in Patten (2005)) classifications (see Chapter 5 for details), as it placed low demands on both information processing (no traffic to react to or foreseeable developing hazards to monitor) and vehicle handling resources (travelling in a straight line so required little steering input).

Figure 24: showing the graphical display which represented the low demand scenario in the study.

The scenario chosen for the high demand scenario involved overtaking a vehicle on a two lane motorway, when raining, at night. This was again based on Study 2's findings with all participants rating overtaking on a motorway to be a high demand scenario. It was also classified as high demand using Fastenmeier's (1995) classifications with a high information processing demand (caused by a requirement to ensure no vehicles were present in the right hand lane, deciding at what point to instigate the overtaking manoeuvre and ensuring the vehicle intended to be overtook will not deviate from its lane). As well as placing a demand on the driver's vehicle handling resources (requiring a steering input sufficient to move the vehicle into the right hand lane then back to the left lane again). Further demand was added to the scenario by having it take place in the dark, while raining. This decision was informed by Study 1's findings (Chapter 4) where in the 'high workload while driving' scenario the interviewed drivers frequently suggested that the dark and inclement weather would add to their driving demand, this helped to ensure the high demand scenario presented a substantial increase in demand over the low demand scenario.

6.3.7 Rationale for Rating Scales Used

Rating scales were used in order to collect information on how capable the participants thought they were at driving and at using a phone while driving. Five point rating scales were used (1 being very incompetent, 5 being very competent) as research, such as that by Preston et al. (2000), has shown five to seven point scales to be optimum number of response categories with feedback from the pilot studies finding participants expressed a preference for the five point scale for this study. There were four questions asked, one for each phone function, to collect information on self-rated phone capability while driving, for example 'how competent are you at placing a call while driving', then the same was asked for answer a call etc. A further question was asked for assessing self-rated driving capability, again on a five point rating scale. A pilot study found the optimum scale-based question was 'how competent a driver are you?' with 1 being unskilled and 5 being very skilled.

6.3.8 Rationale for Choice of Phones Used in the Study

It was decided that participants would use their own mobile phones in the study, as opposed to a single standardised phone being provided to all participants by the experimenter. It was believed that if the participants had been provided with a phone to use it was unlikely they would be familiar with the device's interface, which would have added a confounding variable of how capable they were at adapting to an unfamiliar phone. A familiarisation period with the unfamiliar phone would also have added significantly to the duration of the experiment.

It was acknowledged that in requiring participants to use their own phone there was a drawback in that each device featured a different user interface, and therefore required differing amounts of interaction to complete a task. However, it was believed that as it was ensured all participants had owned their current phone for at least six months and only commonly occurring phone tasks were being tested any limitations and idiosyncrasies associated with a device would likely have been adapted to or worked around by this point so the differences were likely to be minimal.

Every effort was also made to standardise the interactions which were required to complete the phoning tasks by asking participants to turn off the ‘auto locking’ function (so the phone would not lock itself after a set period of inactivity) before attending the experiment. This meant all users could start the phoning task without the requirement of unlocking the phone, the process of which could vary between phone makes and models (such as some requiring a pre-set sequence of button presses and others requiring numerical or alphabetical passwords to be entered) which could have further confounded results. Furthermore, all participants entered the experimenter’s phone number under the name ‘AAA’. This ensured the number was at the top of all participants’ ‘phone books’ (which were all ordered alphabetically) eliminating any variance that may have resulted result from participants having different lengths of ‘phone book’ and reducing the effects of differences in interaction required to search through the ‘phone book’ for different phone interfaces.

6.3.9 Rationale for Questions Used in the Study

As the literature review section 2.8.1.3 highlighted there have been many different ways of simulating phone conversation. There is also a mature body of literature finding that conducting a conversation simultaneous to driving results in impaired driving performance. This study was only interested in whether or not participants engaged with their phone and not the effects of performance in doing so. Therefore, it could be considered the study had a greater focus on drivers’ willingness to get to the point of attaining a conversation as opposed to their willingness to actually conducting a conversation. For these reasons very basic questions were generated for respondents to answer if they decided to engage with their phone. This was more a way of ensuring participants were willing to engage in the task of interacting with their phone, as opposed to testing their willingness, ability or performance effects of holding a conversation while driving.

6.4 Methodology

6.4.1 Approach

The simulator that was used in the study was of low fidelity with participants sitting in a Ford Fiesta car (which had been altered to allow the car's controls to input acceleration, braking and steering commands to the simulator's software). Although the participants were sat in a real car for the willingness to engage stage of the study only forward vision was displayed and no side or rear views were available, which limited the fidelity. Similarly the simulator was fixed based so no sense of motion feedback was provided so again this limited the fidelity. Although, engine noise, road noise and weather noise (for the rain) was played to participants through speakers fitted in the rear of the vehicle. The road scene was displayed via an overhead projector onto a screen in front of the car (see Figure 25) and, therefore, showed the forward view of the road only. The software had been made specifically for Loughborough University Sleep Research Centre. It allowed manipulation of the amount of bends in the road, whether there were trees present, whether it was day or night time, raining or sun shine and to what extent fog was present. It was also possible to select whether there was another vehicle on the road, always a slower vehicle travelling in the same lane as the 'driven' vehicle, and how frequently this vehicle occurred (with the option of how many minutes passed before another car was presented). There were no cars present to in the low demand scenario, in the high demand scenario a car was set to be presented every minute.

Figure 25: Showing the low fidelity simulator used in the study

The participants were given an information sheet (see Appendix 6) which explained that they were to imagine they were in a real driving environment (as opposed to a simulated one) and to drive and interact with the phone exactly as they would do in a real road environment. They were further informed when considering whether or not they would engage with their phone to consider the phone calls/ texts to be personally important. Examples of important situations included: ‘*Your line manager calling. You have a relative in hospital and the hospital phones. You've forgotten your house keys and you need to ask someone not to leave the house. Someone is expecting you at a certain time but you're running very late'.* This aimed to ensure that all participants placed the same importance on the phone tasks, helping to make sure this wasn't a confounding variable in the experiment.

The participants' phones were set up in a phone cradle which was stuck (via a suction pad) to the windshield of the car. Participants had control over the location of the cradle on the windshield to ensure they could comfortably reach their phone while it was mounted in the cradle. This allowed the height of mounting to be dictated as well as which hand would be used to operate the phone, as the cradle could be mounted to the right or left of the steering wheel depending on the participants' preference. The participants' willingness to engage with their phone while driving was tested by placing them under simulated high and low demand environments and giving them a number of phone tasks. The phoning tasks presented to the participants were: placing a call, answering a call, sending a text message and reading a text message. They chose to either complete or reject the tasks depending on whether they felt comfortable to carry out the phone task and would normally do so in that road environment, it was stressed that their judgements were to be based on how they would behave in a real, as opposed to simulated, road environment. The participants were told the phone task they were to choose to engage with, or ignore, before the scenario started (for example '*this time I would like you to place a call to me*'). Whether or not the participant had engaged with the phone when prompted was recorded by the experimenter for later analysis.

For the 'place a call' tasks the participant made their decision to engage with the task or not when the experimenter said 'now'. If they felt comfortable to, and felt they would do so in a real life road setting, they engaged with the phone task, placing a call to the experimenter, if not they just carried on driving. If the participant phoned the experimenter then they were faced with a randomly selected, common knowledge, question to answer from a short selection of: What day of the week is it today? What month are we in? How many days are there in a week? How many minutes are there in an hour? How many hours are there in a day? How many seconds are there in a minute? These questions were asked to make the participants' decision to place the call or not as realistic as possible. In a real road environment it wouldn't just be the ability to place the call that would need to be taken into account but the ability to take part in the conversation that would follow, the questions aimed to simulate this.

For the 'send a text' tasks the participants were told before the scenario started what the message they were required to send should say. This message was chosen at random from a short selection of similar length messages: I am running late, I will meet you there, I will be back soon, I will call you soon, I am in a meeting, and I am busy now. When the experimenter said 'now' the participant decided whether or not they felt comfortable to, and normally would, engage with sending a text message in the environment. If they felt comfortable they composed the text message and sent it to the experimenter, if not they just kept on driving.

For the ‘answer a call’ tasks the participants made their decisions to engage or not with the tasks when they received a phone call from the experimenter. If they decided to answer the call they were faced with a simple question to answer, as per the ‘place a call’ scenario, if not they just kept on driving.

For the ‘read a text message’ tasks the participants made their decision to engage or not when they received a text message from the experimenter. The message contained a question randomly selected from the same options as listed in the ‘place a call’ scenario. If the participants engaged with the task they were required to answer the question out loud so the experimenter knew they had read and comprehended the message.

In both the low and high demand conditions the text message was sent, or the call placed, to participants after fifty seconds of driving the particular scenario. In the high demand condition this led to the text or call being received at around one minute into the trial, this coincided with when the participant was required to overtake a vehicle (as it was set to appear at one minute intervals). For the ‘placing a call’ or ‘sending a text’ message the experimenter gave the cue to decide whether to engage or not one minute into the scenario (again coinciding with overtaking the vehicle). If the participant engaged with the phone at any point from when they moved into the right hand lane and before they returned to the left hand lane (they had been instructed to move back into the left hand lane as soon as they had passed the vehicle, and had practiced this) then this was recorded as having engaged with the phone in a high demand condition. If they engaged with the phone once they were back in the left hand lane (having delayed their interaction until after they had passed the vehicle and were faced with less demand) then this was recorded as having not engaged in a high demand condition.

The low demand scenario featured a constant, two lane, straight road. As there was no ‘event’ (such as overtaking) to mark the start or end of the engagement opportunity participants were given twenty seconds to engage with the task (the experimenter kept time but did not inform the participants of how long they had left, they were only aware the event was over when the experimenter closed the simulator programme to load the next scenario). If they had not engaged with their phone in the time period it was apparent they were not willing to engage and their unwillingness was recorded correspondingly.

6.4.2 Participants

40 participants (24 male, 16 female) were separated into two groups, experienced and inexperienced drivers. The inexperienced group comprised 19 younger, inexperienced drivers with ages ranging from 18 to 20 years old (mean 20 years of age). They were recruited based on having less than 3 years driving experience (an average of 2.2 years) and there was a 14 male to 5 female split. The experienced driving group comprised 21 older drivers, recruited based on having at least 10 years driving experience (an average of 30.9 years). They were aged between 35-63 years of age (mean 50 years of age) with a 10 male to 11 females split. They were also recruited based on how experienced they were at using their phone with all of the experienced drivers reporting, in a pre-study questionnaire, using their phone for talking or texting less than once a week (low phone experience) and the novice drivers reporting using their mobile phone for talking and texting at least once a day (high phone experience). The participants were recruited through University notice boards and convenience sampling. Average (mean) annual mileage for participants was 7687 miles (lowest= 1000 miles, highest= 20,000, SD= 4767). 24 of the participants owned a smartphone and 16 owned a more traditional non-smartphone. Participants had owned their current phone for an average (mean) of 15 months (lowest= 3 months, highest= 48 months, SD= 10 months).

6.4.3 Procedure

An information sheet was first given to participants and informed consent collected. It was made clear all results would be kept anonymous and the participant could withdraw at any point. Demographic information was also collected at this point, using a questionnaire, along with ratings of their ability to place a call, answer a call, send a text message and read a text message while driving and a rating of their driving ability, using a series of 5 point rating scales.

Participants were requested to enter the experimenter's phone number under the title 'AAA', so that it would be at the top of all the participants' phone books, thereby eliminating the need to scroll through the contacts list which would vary in size for each participant. They then rang the experimenter, so the participant's phone number was received and this number was saved in the experimenter's phonebook. Participants were also asked at this point to disable the auto locking function (which locks the phone's keypad disabling it from being used) on their phone, as different makes and models of phones required varying amounts of interaction to unlock, this thereby eliminated unlocking the phone as a confounding variable.

To ensure all participants were capable of using their phone in the required manner they were requested to conduct a number of basic phone tasks including placing a call to the experimenter and answering a call from the experimenter. They also sent a text message to the experimenter, from one of a number of short messages chosen at random from either 'I will be back soon', 'I am busy now' 'I am running late' 'I will meet you there' or 'I will call you soon'. Participants were also asked to read a text message, sent by the experimenter, and answer the question out loud to prove they had read the message, the questions sent were selected at random from a number of options including 'how many hours are there in a day?, how many months are there in a year?, how many seconds are there in a minute? And how many minutes are there in an hour?'

6.4.3.1 Simulated Car Task

Participants were, at this stage, asked to move into the simulated (Ford Fiesta) car. Each participant was given time to practice and adapt to the simulated vehicle and asked to practice overtaking vehicles, and returning to the left hand lane once the manoeuvre had been completed. Participants were allowed to practice for as long as it took for them to be able to adequately control, and feel comfortable with, the simulated vehicle.

Participants were reminded they were to imagine they were driving in a real road environment, as opposed to being in a simulated vehicle, and to consider, based on the road environment they were faced with at the time, if they would engage with their phone. If they deemed that they would engage then they were to go ahead and use the phone for the designated task, if not they were asked to simply carry on driving and ignore the phone.

The participants experienced one demand scenario at a time (so all low demand or all high demand). Which demand was experienced first by each participant was dictated by a counterbalanced design, ensuring no order effects took place. Similarly, the order in which the four phone functions were tested was decided based on a matrix which ensured a counterbalanced order between all participants.

The participant was informed which phone function would be tested in that particular run and asked to start driving. In the low demand condition the participants were given the opportunity to engage with the task after one minute of driving and had a twenty second window in which to use their phone. Once the twenty seconds had passed, or their phone engagement had finished, the experimenter noted whether or not the participant had engaged with their phone.

In the high demand scenario participants were once again informed which phone function would be used in that particular run and asked to start driving. After one minute a slower car would appear in their lane and available to be overtaken. It was at this point that the participants were faced with a choice to engage or not with their phone. Once the driver had completed the manoeuvre and were back in the left hand lane whether or not they had engaged with the phone task was noted down by the experimenter.

In both the low and high demand scenario once a phone task run had been completed (whether they engaged or not) the simulation was stopped and the next run loaded.

Once all phone functions in both simulated road demands had been tested participants were asked to leave the car and join the experimenter at a computer (situated in the same room as the simulated car) to take part in the LCT.

6.4.3.2 Lane Change Task

Each participant drove round the LCT test track twice (each lap was around three minutes in duration) to get used to the task.

On the third lap recordings were taken to get a baseline measure of their performance.

Participants were told they would next carry out the LCT again but simultaneously with conducting the phone tasks. It was made clear that, unlike in the simulated driving environment, this was not a test of whether or not they engaged with the task but how capable they were at carrying it out. Therefore, they were to engage with the phone task when instructed, whether or not they believed they would do so on a real road environment.

The participants were to engage with the phone task once they had crossed the start line. The participant then conducted the secondary task as many times as possible until the end of the lap had been reached. The experimenter informed the computer when a secondary task was being conducted, and therefore when to take recordings of their performance, by pressing ‘M’ on the keyboard at the start of each task and ‘N’ each time it was finished.

A lap was completed for each phone task (four in total) and each lap was started at a different point on the track (by the experimenter pressing a number between one and nine on the keyboard at the start of each lap) to ensure familiarity with the track was not a confounding variable.

The phone tasks were the same as those used in the simulated car part of the trial (using the same list of questions and messages as well), with questions being asked to participants when they answered the phone, had placed a phone call or read a text message and instructions given on the text message that was required to be typed. The order in which the participants carried out the phone tasks was counterbalanced across participants to ensure there were no order effects.

The participants were then asked to ‘drive’ the LCT for one more lap, without any phone tasks, in order to get a final baseline measure of their primary task performance. They were then thanked and compensated with a £10 high street voucher for their time.

6.5 Results

As the majority of results were taken from either (ordinal) rating scale responses or (nominal) dichotomous (yes or no) answers, non-parametric tests were used throughout. All data were therefore ranked first before statistical testing was carried out.

6.5.1 Driving Capability

In order to test if there was any difference between novice and experienced drivers’ *self-rated driving capability,* the data was first ranked as a whole and then separated back into novice and experienced categories, with a Mann Whitney U test undertaken to compare the groups’ scores to see if a significant difference was present.

It was found that there was no significant difference for the *self-rated driving capability* of novice (median= 17.00) and experienced (median= 17.00) drivers (Z= -.853, U= 172.500, P= .433).

As there was no significant difference between the groups it was not possible to test if self-rated driving capability affected willingness to engage (nothing to distinguish groups by).

6.5.1.1 Did Driving Experience (*Actual Driving Capability*) Affect Willingness to Engage?

6.5.1.1.1 Low Demand Road Scenario

In order to test if driving experience (also referred to as *actual driving capability* in this chapter) affected willingness to engage in low demand situations Chi square tests were carried out. As can be seen in Figure 26, it was found that there was no significant difference in willingness to engage in a low demand road environment between novice and experienced drivers for all phone functions. *Place a call* low demand engagement was not found to be significant (X(1)=.186, p=.666), with 68.4% of novice drivers willing to engage compared to 61.9% of experienced drivers. The same was true for ans*wer a call* (X(1)=.033, p=.855) with 73.7% of novices engaging compared to 76.2% of experienced drivers, *send a text* (X(1)=.351, p=.554) with 47.4% of novices as opposed to 38.1% of experienced drivers engaging or *read a text* (X(1)=.186, p=.666) with 68.4% of novice drivers engaging as opposed to 61.9% of experienced .

6.5.1.1.2 High Road Demand Scenario

In order to test if driving experience affected willingness to engage in high demand situations Fishers exact tests were carried in the place of Chi square tests as a result of the low number of counts in each cell. As can be seen in Figure 26, it was found that the driving experience of the participant did have an effect on willingness to engage in a high demand driving scenario for *placing a call* (p<.01) with 31.6% of novices willing to engage as opposed to 0% of experienced drivers, *sending a text message* (p<.05) with 21.1% of novices willing to engage as opposed to 0% of experienced drivers, and *reading a text message* (p<.05) with 21% of novice drivers willing to engage as opposed to 0% of experienced drivers.

However, for *answering a call* in a high road demand scenario a higher cell count was observed so a Chi square test could be run. It was found that driving experience had no significant effect on willingness to engage with (X(1)=.043, p=.836), 31.6% of novice drivers were willing to engage compared to 28.6% of experienced drivers.

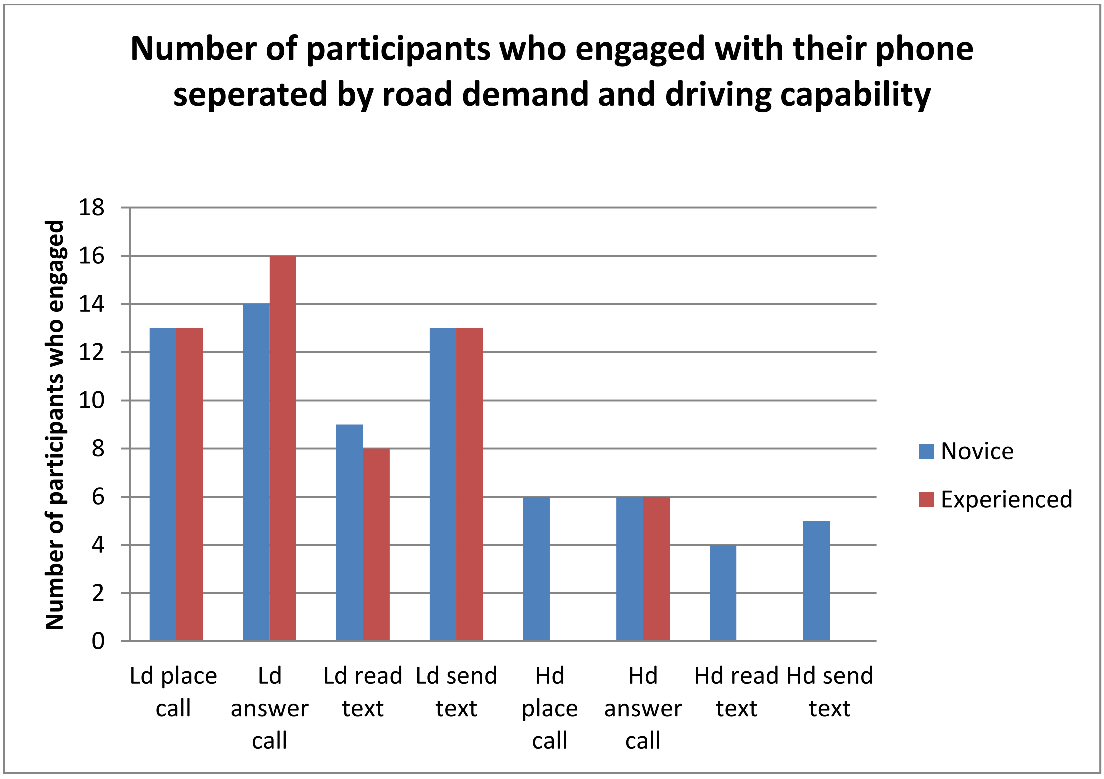

Figure 26: Showing phone engagement behaviour separated by road demand and driving capability

6.5.2 Phone Capability

6.5.2.1 Did Self-Assessed Phone Capability While Driving Vary According to Phone Function?

In order to test if there was a difference between self-rated ability to use each phone function while driving the data was ranked as a whole, separated back into phone function groupings and then a Friedman ANOVA was carried out to test if there was a significant difference.

It was found that there was a significant difference in self-rated ability to use each phone function while driving ($X^2(3) = 32.545$, $p<.01$). In order to test where these differences lay post hoc Wilcoxon tests were run with Bonferroni correction (0.05/6=.008) meaning .008 or less was required for significance.

There was no significant difference between self-rated ability to *place a call* (median= 85.2) and *answer a call* (median= 93.85) while driving (Z= -2.376, p=.014), *read a text* (median= 83.15) and *place a call* (Z= -.391, p=.707) or *read a text* and *answer a call* (Z= -1.620, p=.105).

There was, however, a significant difference in self-rated ability to *place a call* and *send a text* (median=57.30), (Z= -3.358, p<.008) with participants rating themselves as significantly better at *placing a call* while driving than they were at *sending a text message* while driving.

There was also a significant difference between self-rated ability to *send a text message* and *answer a call* while driving (Z= -4.234, p<.008) with participants rating themselves as significantly better at *answering a call* while driving than they were at *sending a text* while driving.

Finally there was a significant difference between self-rated ability to *send a text* and *read a text* while driving (Z= -4.237, p<.008) with participants rating themselves as being significantly better at *reading a text* while driving than they were at *sending a text message* while driving.

6.5.2.2 Did Self-Assessed Phone Capability While Driving Vary Based On Driving Experience?

To test if driving experience affected how capable the participants rated themselves at using the phone while driving multiple Mann Whitney U tests were carried out, split based on driving experience.

It was found that, apart from for *placing a call* (U= 136.50, Z= -1.841, p=.074), there was a significant difference in *self-rated capability* for using all phone functions while driving between novice and experienced drivers [answer a call (U= 116.00, Z= -2.457, p=<.05), send a text (U= 84.00, Z= -3.257, p<.01), read a text (U= 65.50, Z= -3.815, p<.05)]. The novice drivers believed themselves to be significantly more capable of *answering a call* (novice median=126.00, mean=111.21; experienced median=80.00, mean=78.14), *sending a text message* (novice median= 80.00, mean= 74.79; experienced median= 17.00, mean= 41.48) and *reading a text message* (novice median= 126.00, mean=110.58; experienced median=51.00, mean=58.33) while driving than the experienced drivers. Although, novice drivers and experienced drivers showed no significant difference in self-rated *place a call* abilities (novice median=126.00, mean= 99.37; experienced median= 80.00, mean= 72.38).

A further Mann-Whitney U was carried out on an average of all the phone functions ranks, in order to test if there was a difference in self-rated ability to use the phone while driving in general rather than for a specific function. It was found that there was a significant difference (U=86.50, Z= -3.068, p<0.05) with novice drivers rating themselves as significantly better at using their phone while driving (median rank of 103.00) than did more experienced drivers (median rank of 61.250).

6.5.2.3 Did LCT Performance (*Actual Phone Capability While Driving*) Vary Based on Driving Experience?

It was found the LCT score data was not normally distributed so the scores were ranked and non-parametric tests carried out. [(place call skewness=.703, standard error=.374, kurtosis= -.331, standard error= .733), (answer call skewness=2.185, standard error=.374, kurtosis=6.208, standard error=.733), (send text skewness=2.232, standard error= .374, kurtosis=5.596, standard error=.733), (read text skewness=.663, standard error=.374, kurtosis= -1.78, standard error=.733)].

First the difference between experienced (median= 16.5, mean=19.286) and novice (median=23.00, mean=21.842) drivers' *baseline LCT performance* (when conducting the LCT on its own without any phone tasks) were established using a Mann Whitney U test. It was found there was no significant difference between the two groups rankings (U=174.00, Z= -.691, p=.498).

It was found, using multiple Mann Whitney U tests, that when LCT performance rankings for each phone function were separated based on driving experience that there was a significant difference for all the phone functions. Novice drivers had significantly better performance than the more experienced drivers for all functions [place a call (U= 67.50, Z= -3.576, p<.01) (novice median=43.5, experienced=107.00), answer a call (U=116.00, Z= -2.262, $p<.05$) (novice median=36.00, experienced=66.00), send a text (U=73.00, Z= -3.426, $p<.01$) (novice median=72.00, experienced=133.00), read a text (U= 94.50, Z= -2.854, $p<.05$) (novice median=46.00, experienced= 113.00)].

6.5.2.4 Did LCT Performance (Phone Capability While Driving) Vary Depending on Phone Function Used?

The Friedman ANOVA showed that there was a significant difference in LCT scores based on the phone function used ($X^2(3) = 93.330$, $p<.01$). Post hoc Wilcoxon signed rank tests, with Bonferroni correction (meaning .008 was required for significance), showed that all functions, apart from place a call and read a text message (Z= -1.990, p=.046), had significantly different LCT scores [place a call and answer a call (Z= -5.331, $p<.008$), place a call and send a text (Z= -5.514, $p<.008$), send a text and answer a call (Z= -5.511, $p<.008$), read text and answer call (Z= -4.960, $p<.008$), read a text and send a text (Z= -5.512, $p<.008$)].

Answer a call had the lowest deviation from the desired path (median =60.537), followed by reading a text (78.825), then placing a call (81.313) and finally sending a text message (101.325).

6.5.2.5 Was Self-Assessed Phone Capability and Actual Phone Capability Related?

In order to determine whether *self-assessed phone capability* was related to *actual phone capability* Spearman's correlations were conducted for each of the phone functions.

It was found that there was no significant relationship for *place a call self-assessed* and *actual capability* ($r_s = -.242$, p=.132). There was also no significant relationship for *answer a call self-assessed* and *actual capability* ($r_s = -.190$, p=.239). However, there was found to be a significant correlation between *send a text message self-assessed capability* and *send a text* *message actual capability* (r_s = -.353, p<.05) as well as a significant correlation between *self-assessed read a text capability* and *actual capability* (r_s = -.480, p<.01).

6.5.2.6 Did *Actual Phone Capability* Affect Willingness to Engage?

In order to test whether the drivers' *actual phone capability* (LCT score) affected their willingness to engage with their phone in low demand road scenarios Mann-Whitney U tests were carried out. It was found that for *placing a call* there was a significant difference in LCT scores between those who did (mean= 16.83) compared to did not (mean= 27.32) *place a call* (U=86.5, Z= -2.709, p<.05), with those willing to engage having lower LCT scores (indicating higher driving capability) and were therefore more capable at *placing a call* while carrying out a complex primary task (see Figure 27). The same was found for *sending a text message* (U=101.0, Z= -2.586, p<.05) (did engage mean= 14.94, did not mean=24.61) (see Figure 28). However, there was no significant difference in LCT scores between those who did (mean= 19.16) and did not (mean=24.05) engage in *answering a call* (U=120.5, Z- 1.182, p=.244) (see Figure 29) or *read a text message* (U=135.5, Z= -1.319, p=.192) (did engage mean= 18.71, did not mean= 23.82) (see Figure 30).

In the high demand environment LCT scores were not significantly different for *placing a call* (U=60.5, Z= -1.572, p=.120) between those who did engage (mean =13.58) and did not (mean= 21.72). *Answering a call* (U=166.5, Z= -0.44, p= .971) between those who did (mean= 20.63) and did not engage (mean=20.45). *Sending a text* (U=37, Z= -1.578, p=.122) between those who did (mean= 11.75,) and did not engage (mean= 21.47). *Reading a text* (U=85.5, Z= -.625, p=.546) between those who did (mean= 23.25) and did not engage (mean= 20.01).

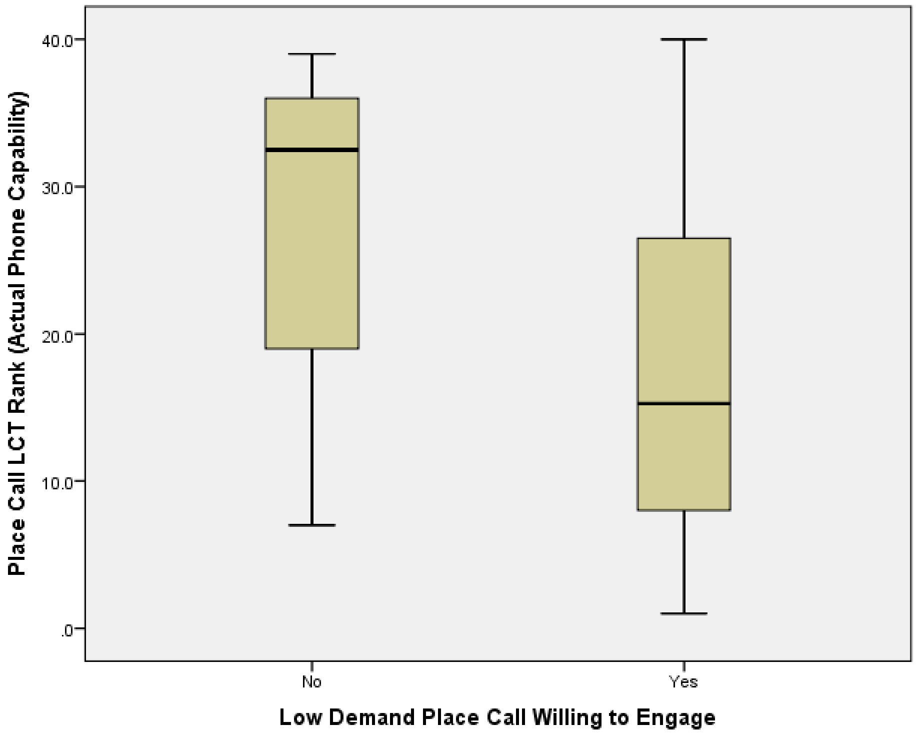

Figure 27: LCT ranking (low ranking represents higher place a call capability) separated by phone engagement decision in a low demand road scenario

Figure 28: LCT ranking (low ranking represents higher send a text capability) separated by phone engagement decision in a low demand road scenario

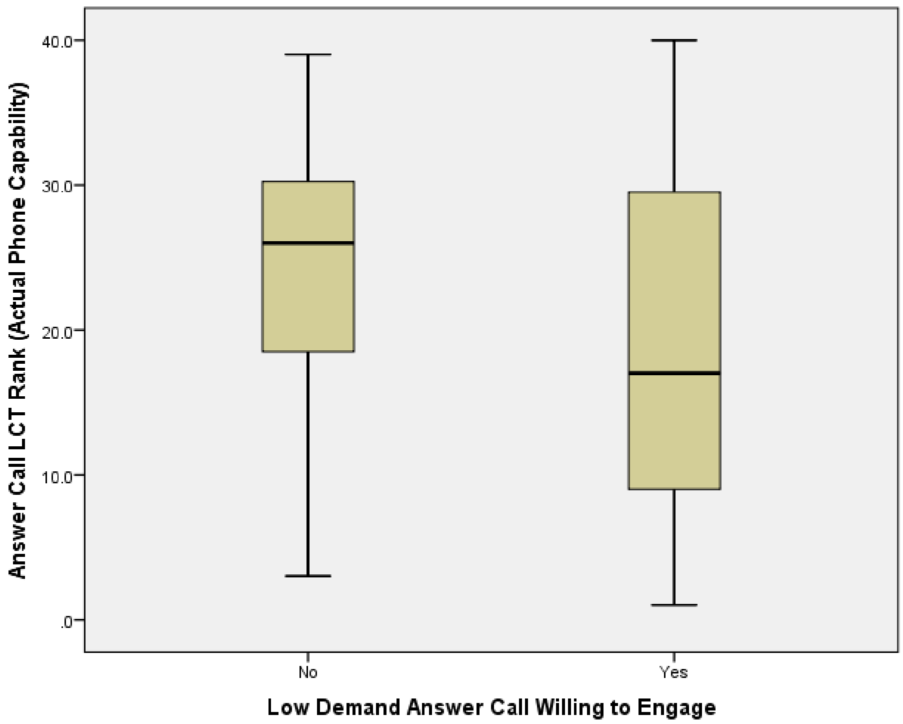

Figure 29: LCT ranking (low ranking represents higher answer a call capability) separated by phone engagement decision in a low demand road scenario

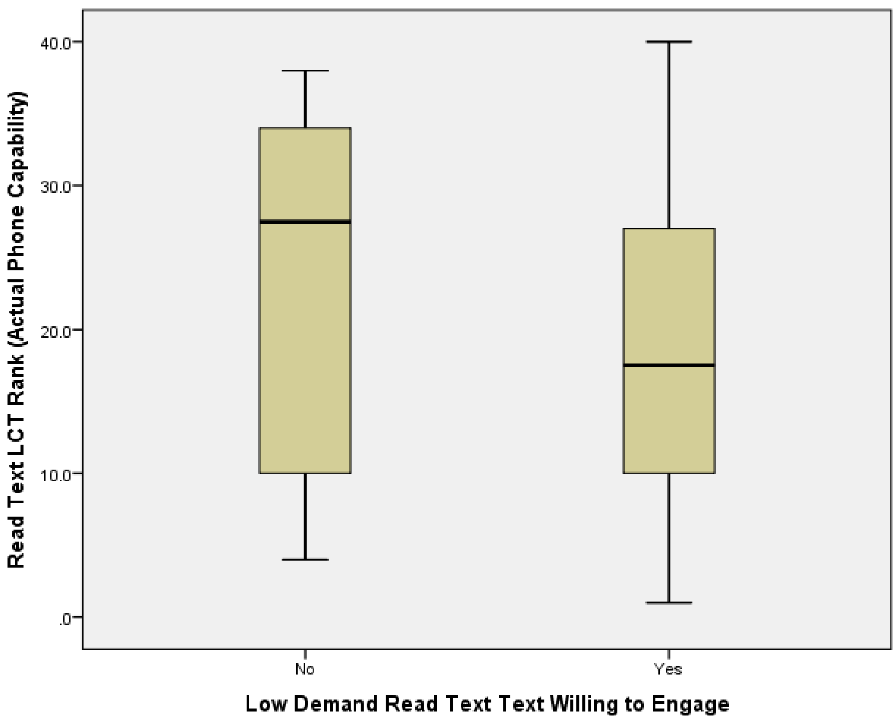

Figure 30: LCT ranking (low ranking represents higher read a text capability) separated by phone engagement decision in a low demand road scenario

6.5.3 Phone Function

6.5.3.1 Did Phone Function Affect Willingness to Engage?

Whether or not a participant engaged with their phone was recorded with a dichotomous scale of yes or no. The median scores, therefore, would only be a value of 0 or 1, thus only informing on the direction of any difference found and not the extent of the difference. For this reason the mean scores, which give an indication of the number of participants who did and did not engage, will be reported for willingness to engage tests to quantify the differences in willingness to engage between the factors being compared.

6.5.3.1.1 Low Road Demand

In order to test if there was a difference between the dichotomous answers (yes or no) for willingness to engage with different phone functions while driving in the simulator, in a low demand environment, a Cochran's Q test was run. It showed that there was a significant difference between all phone functions ($Q= 23.143$, $p<.05$). Looking at the mean scores it was clear that participants were most willing to engage in *answering a call* (mean=.73) and least willing to *send a text* (mean=.42) and were equally likely to *place a call* or *read a text message* (both means=. 65) (see Table 6).

Post Hoc McNemar tests were carried out (with Bonferroni correction meaning $p< .008$) to establish where these differences lay. It was found there were no significant differences between *place a call* and *answer a call* willingness to engage in a low demand environment ($p=.250$), *place a call* and *read a text* willingness to engage ($p=1.0$) or *read a text* and *answer a call* willingness to engage ($p=.375$).

However, there was found to be a significant difference in willingness to engage, in a low demand environment, for *place a call* and *send a text message* ($p<.008$) with participants being significantly more willing to *place a call* than send a text. There was also a significant difference between *answer a call* and *send a text message* ($p<.008$) with participants more willing to *answer a call* than *send a text* and also a significant difference in willingness to *send a text message* and *read a text message* (p<.008) with participants significantly more willing to *read a text message*.

6.5.3.1.2 High Demand Road Environment

A Cochran's Q test was also run on the willingness to engage rating (yes or no) for the four phone function when in a high demand road environment. It was found that there was a significant difference in willingness to engage between the phone functions (Q= 14.400, p<.01). Looking at the means it was clear that participants were most willing to engage in *answering a call* (mean=.30) and least *willing to send a text* (mean=.10) and were equally likely to *place a call* or *read a text message* (both means=. 15) (see Table 6).

Post hoc McNemar tests were run with Bonferroni correction (p< .008) to see where these differences lay. It was found that there was no significant difference in willingness to engage in a high demand road environment for *placing a call* and *answering a call* (p=.031), *placing a call* and *sending a text message* (p=.50), *placing a call* and *reading a text* (p=1.0), *answering a call* and *reading a text message* (p=.070) or *sending a text* and *reading a text* (p=.625).

However, it was found that there was a significant difference between willingness to engage in *answering a call* and *sending a text message* in a high demand road environment (p<.008) with participants significantly more willing to *answer a call* than to *read a text*.

6.5.4 Did Road Demand Affect Willingness to Engage

Table 6: Number of people who engaged in each demand scenario

Phone function	Number of people who engaged in low demand scenario	Number of people who engaged in high demand scenario
Place call	26	6
Answer call	29	12
Send text	17	4
Read text	26	6

In order to test if road demand affected willingness to engage McNemar tests (with Bonferroni correction p <.0125) were carried out, comparing the willingness to engage with each phone function in low compared to high demand scenarios (see Table 6). It was found that for all phone functions the road demand affected willingness to engage (p<.0125) with participants found to engage with their phone significantly more in the simulated low demand environment than the high demand road environment [(low demand place call mean rank= .65, high demand place call mean rank= .15), (low demand answer call mean rank=.73, high demand answer call mean rank= .30), (low demand send text mean rank= .42, high demand send text mean rank= .10), (low demand read text mean rank= .65, high demand read text mean rank= .15)].

6.6 Discussion

The aims of the study were to establish to what extent *phone capability* while driving and *driving capability* affected willingness to engage with various phone functions while driving.

Fuller's (2005) model suggested that driver behaviour was regulated by drivers trying to maintain an acceptable level of task difficulty, which varied based on two factors: driver capability and task demand.

In the current study the capability element of the model was seen as comprising two parts: the drivers' ability to use their phone while driving (*phone capability*) and their driving ability (*driving capability*). *Actual* phone *capability* was measured by testing participants' performance when using the phone (as a secondary task) simultaneously to conducting a simulated driving task (LCT). However, *driving capability* was not measured directly, instead 'years of driving experience' was used as an indicator of *actual driving capability*.

Two different sampling criteria were, therefore, used in the study: younger, inexperienced drivers who were also experienced phone users and older, experienced, drivers who were also inexperienced phone users. In an ideal world the sampling would have consisted of experienced drivers who were also experienced phone users as well as inexperienced drivers who were also inexperienced phone users. However, these samples proved difficult to recruit due to almost all young drivers having grown up with mobile phones from an early age, making younger, inexperienced phone users difficult to find. Experienced drivers who were also as experienced (and as capable) at using their phone as the younger generation were difficult to find as people possessing these characteristics were generally in the business sector, meaning their working hours, and limited free time, led to it being impractical to recruit (and encourage) them to take part in the study.

An ideal sample would also have consisted of older, inexperienced, drivers and younger, experienced, drivers. Finding such demographics proved to be difficult in the case of the former and impossible in the case of the latter (seventeen is the legal driving age in the UK so finding participants who were of the same age as the novice drivers but highly experienced at driving on the roadway would not have been possible- by the criteria set in this study 27 year olds would have been the youngest experienced drivers possible to recruit). Similar sampling difficulties have been highlighted in previous studies such as Deery (1999) noting *'researchers have typically failed to partial-out the relative effects of age and driving experience when examining the driving skill of novice drivers…this is, perhaps, not surprising given that the large majority of novice drivers are young and obtain their licence in their late teens'.*

The conflicts arising from only having older, experienced, drivers who were inexperienced phone users and younger, novice, drivers who were only experienced phone users leads to some difficulties in confidently concluding cause and effect relationships due to the interaction of these factors. These limitations are acknowledged but nevertheless the findings from the study still add significant new insight to this under researched area.

6.6.1 Self-Rated Driving Capability

Although the groups were recruited, and separated, based on their *actual driving capability*, the participants' rating of their driving capability was also collected out of interest. It was found that there was no significant difference between the experienced drivers (with an average of 30.9 years of driving experience) and the novice drivers (average of 2.2 years of driving experience) *self-rated driving capability*. The vast majority of participants in each group reported themselves to be either 'skilled' or 'very skilled' drivers. This is not surprising based on findings from previous studies. For example De Craen et al. (2011) investigated young novice drivers' self-assessed levels of driving capability using a number of different scales, comparing their self-assessed ability to their actual driving - as assessed by driving instructors observing their real-road driving behavior. They found when comparing themselves against other, more experienced, drivers the novice drivers tended to acknowledge themselves to be not as skilled yet. However, when rating their driving performance in general, as per the current study, they were shown to overestimate their driving skill. Similar 'optimism bias' for drivers rating their own driving ability has previously been found in many other studies, such as Delhomme (1991) who found sixty percent of participants rated themselves as better than the average driver, Svenson (1981), McCormick et al. (1986) and Delhomme (1996) reported similar findings.

6.6.1.1 Did Self-Rated Driving Capability Affect Willingness to Engage?

As discussed both experienced and inexperienced drivers gave equal ratings of driving ability (both demographics having the exact same median) and, therefore, self-assessed driving capability could not be measured in terms of how it affected willingness to engage, due to there being no differentiation in the groups' ratings. However, it should be noted that Bayer et al. (2012) found self-rated driving confidence affected their sample's willingness to engage with text message while driving, concluding *'certain individuals may feel that they can overcome the perceived risk of dangerous driving, if they are skilled (in their own opinion) at the wheel'.* Although, how self-rated driving capability affected willingness to engage could not be measured in the current study, due to lack of variability in participants' ratings, it was possible to test if willingness to engage varied based on actual driving capability.

6.6.1.2 Did Actual Driving Capability Affect Willingness to Engage?

It was found when participants were separated based on *actual driving experience* that there was no significant difference in willingness to engage with any of the phone functions in *low demand* road environments, novice and experienced drivers were equally likely to engage with their phones. However, in the *high demand* road scenarios novice drivers were significantly more willing to engage in *placing a call, reading a text message* and *sending a text message* than were the experienced drivers. However, both groups were equally likely to engage with *answering a call* in a *high demand* scenario.

The findings suggest that *driving capability* may have an effect on willingness to engage with a mobile phone while driving in *high demand* scenarios, with the more experienced (and therefore presumably capable) drivers being significantly less willing to engage with the phone tasks. Deery (1999) suggested that novice drivers are recognised to be inferior to experienced drivers in two ways: hazard perception (detecting and dealing with hazards) and attentional control (giving attention to the right things, for the right amount of time, at the right time).

Both of the previously mentioned factors may have influenced the experienced drivers' decisions to refrain from engaging with the phone tasks. The experienced drivers may have had better developed hazard perception abilities and, therefore, predicted that a high demand situation (having to overtake the slow moving car) was about to occur, causing them to refrain from engaging where the less experienced did not. A more likely alternatively, however, (as the situation was already developing when they were faced with the engagement choice so the upcoming hazard was easy to perceive) was that the more experienced group just made more appropriate choices of when to, and when not to, engage with their phones. It was possible that their years of driving experience had lead them to have better developed attentional control, leading to them making better judgements of which task to give their attention to (giving attention to right task, at right time, for right amount of time).

There could be a further variable accounting for the less experienced drivers having a higher willingness to engage in *high demand* situations, the drivers' age. Lerner (2005) found, in an on road study, that teen drivers rated less risk across a range of different driving situations than did other driving experience groups. They also found teen drivers *'to be quite distinct from other groups in their degree of in-vehicle technology use, their attitudes about safety, their motivations, their decision making style, and their assessment of their multi-tasking capabilities'*. Due to difficulties with recruiting novice older drivers all the novice drivers in the sample were between eighteen and twenty years of age. As highlighted in the quote above, previous literature suggests propensity to take risks is at its highest level when young so the novice drivers' increased willingness to engage with the phone in a *high demand* situation, compared to the older and more experienced drivers could be a result of them having a higher willingness to accept risks. There is a possibility the novice drivers identified the hazard equally as well as the more experienced drivers but were more accepting of the risk required to interact. The novice drivers' lower age, as opposed to more limited driving experience, or some interaction between the two factors could, therefore, have dictated their higher willingness to engage.

This interaction effect resulting from driving inexperience and characteristics associated with teenagers is cited in the literature as one of the possible reasons for overrepresentation of novice drivers in road traffic accidents, as noted by Brown et al. (1988) 'y*oung drivers are statistically overrepresented in road accident. Their elevated risk is a complex function of chronological age and driving experience, both of which are associated with acceptance and misperception of risk on the road'.* Although this interaction effect makes solid cause and effect conclusions as to why the novice drivers were more likely to engage with their mobile phone in *high demand* situation difficult, the finding that young, inexperienced, drivers were more willing to engage still adds to our knowledge in driving and willingness to engage behaviour and may be an appropriate topic for further study.

Even with this interaction of age and driving experience the finding is still considered very applicable to the real world (ecologically valid) as the majority of novice drivers out on real roads are younger. Therefore, finding younger novice drivers have a higher willingness to engage in *high demand* situations is particularly important as the sample can be considered representative of novice drivers as a whole. This shows that younger/ inexperienced drivers should be the primary target audience for safety messages about inappropriate phone use.

The interaction between age and driving experience limiting the conclusions able to be made is also a common problem in many novice driver studies. This was highlighted by Deery (1999) saying '*the results of studies where most, if not all, novice drivers are young are often inconclusive in terms of establishing the effect of driving experience on driving skills (due to its confounding with age-related factors)'.*

Although novice drivers were found to be significantly more willing to interact with the majority of phone functions compared to the experienced driver in the high demand situations it was found that *answering a call* was equally likely to be engaged with by both demographics. This is possibly a result of *answering a call* being considered the least demanding phone function to use while driving, as found in Study 2, and thus even some of the experienced drivers were willing to conduct the task in a *high demand* situation. *Answering a call* also had the highest median value for both the novice and experienced driving group, showing participants were more willing to interact with the *answer a call* function than any other functions. This finding supported that of previous literature with Ferreira et al. (2012) also finding answering a call to be the phone function that drivers most frequently interacted with.

6.6.2 Self-Rated Phone Capability

The results showed that participants believed themselves to be significantly better at *placing a call, answering a call and reading a text message* while driving than they were at *sending a text message* whilst driving. However, apart from for *sending a text messa*ge, there was no significant difference in *self-rated capability* between any of the other phone tasks, meaning they believed themselves to be equally capable at *placing a call* as they were at *answering a call* or *reading a text* whilst driving.

When these self-rated results were split based on phone experience (and therefore age and driving experience also) it was found the more experienced phone users (the novice drivers) had higher self-rated scores for *answer a call, send a text and read a text* than those of the less experienced phone users. However, there was found to be no significant difference between either groups' *place a call* ratings.

Looking at the median scores it is clear the more experienced phone users believed themselves to be most capable of *answering a call* then *reading a text* and then *placing a call*, with *sending a text* the function they rated themselves least capable of carrying out while driving. In contrast, the less experienced phone users believed themselves most capable of *answering a call* then *placing a call*, then *reading a text message* and finally *sending a text message* whilst driving. It is interesting to note how although both groups rated *answering a call* as the easiest task and *sending a text* the most difficult task to carry out while driving, the more experienced phone users believed *reading a text message* to be easier to carry out than *placing a call*, whereas the less experienced phone users instead rated *placing a call* as the next least demanding task. This difference suggests that the more experienced phone users do not find reading a message very taxing which may make interacting with the received message whilst driving particularly tempting to this demographic.

6.6.2.1 Did *Self-Rated Phone Capability* Affect Willingness to Engage?

Whether or not *self-rated phone capability* actually influenced the participants' decision to engage with their phone was also tested. It was found that only *place a call* and *read a text message* capability levels were a predictor of engagement with the respective phone functions while driving in a *low demand* scenario. It was further found that in the *high demand* scenario *self-rated phone capability* did not significantly help predict willingness to engage for any of the phone functions.

These findings suggest that, for the most part, participants did not take into account how capably they thought they could carry out the phone task before deciding whether or not to engage with their phone. The participants' capability ratings may not have had much influence on their willingness to *answer a call* in a *low demand* scenario as *answering a call* has been shown to generally be regarded as the easiest phone function to interact with whilst driving (as also found in studies one and two). Therefore, capability may have had far less effect, as even those who did not consider themselves capable may have believed they could answer their phone on a straight, empty, road without impairing their driving too much. Conversely *sending a text message* requires a great deal of interaction and was rated by both groups as the function they were least capable at using so even those who thought themselves capable may still not have been willing to engage due to the impairment interacting for such a long time could bring.

It is possible that *reading a text message* and *placing a call self-rated capability* were the only factors found to have an effect on willingness to engage in the low demand environment because these functions could be considered the two middle functions in terms of difficulty, both requiring a medium amount of interaction to read the message or searching through a contacts list to place a call. The decision of whether to engage or not may have been less definitive as it was less obvious how safe it was to engage. It is possible that capability was, therefore, the deciding factor that participants referred to when trying to decide if they could safely engage with the phone or not, with the more capable users then opting to engage and less capable opting not to.

6.6.3 Actual Phone Capability

The LCT was used as a measure of *actual phone capability* while driving in order to separate those who could proficiently use their phone as a secondary task and those who could not. It was found that *actual phone capability* varied based on phone experience, with the more experienced phone users, who had reported using their phone for talking and texting at least once a day in a pre-study questionnaire (who were also all novice, young, drivers) performing significantly better on the LCT for all phone functions than those with less phone experience, who in a pre-study questionnaire reported using their phone for talk and text functions less than once a week (who were also all more experienced, older, drivers). Those who were more experienced phone users were shown to have better performance on the LCT. Future research might expand on this finding by seeing if the same is found on a task more representative of driving, exploring the extent to which phone capability can affect real driving performance whilst using the phone.

6.6.3.1 LCT as Measure of Actual Phone Capability

The participants were not recruited based on their experience of using the phone while driving, just experience of using their phone in general. The LCT was then used in this study as a way to separate those who were and were not capable at using their phone while driving, with the LCT acting as a surrogate driving task.

As previously mentioned, the literature has shown that gaining basic car control skills does not take a long time. As the LCT requires only simple steering inputs the novice drivers could be considered to be equal with the more experienced drivers in terms of driving skill in this test. The perceptual skills developed with driving experience would also not have proved particularly advantageous as the only perception required was detecting and reacting to the signs' instructions, informing them which lane to be in, with no other visual distractions or judgements to be made, so driving experience should have had little effect on LCT performance. This was shown to be the case with there being no significant difference between the novice and experienced drivers baseline LCT performance (their performance when conducting just the LCT with no secondary tasks).

The only factor which was expected to influence performance on the LCT was the drivers' ability to carry out the secondary task. This was shown to be the case when the younger, novice drivers, who were far more familiar with carrying out the phoning tasks, performed significantly better than did the older, experienced, drivers who were less experienced phone users. The LCT was, therefore, deemed to be an appropriate task for differentiating those who were capable at using their phone from those who were not. From these findings it is believed the LCT may represent a good task for future studies to use if they need to explore the participants' levels of phone capability while driving, so long as the limitations such as lack of ecological validity are kept in mind.

The current study sampled forty participants, with strong significant differences found between the two groups, in terms of LCT performance when carrying out the secondary tasks. This provides a strong base on which to assess these initial conclusions of its effectiveness as a measure of phone capability while driving. Although, a larger scale study may still be required to fully validate the LCT for usage as a measure of phone capability while driving.

6.6.3.2 How Accurate Were Participants at Rating their Phoning Ability?

Correlations were calculated between the ratings the participants gave for how capable they were at using their phone (*self-rated capability*) and how proficiently they could actually use their phone (*actual phone capability* based on LCT scores). It was found participants were only able to accurately predict their ability to *send a text* and *read a text message*, no correlation was found between *self-rated place a call* ability and *actual place a call ability*, nor *actual answer a call* ability and *self-rated answer a call* ability. This suggests that the participants were far better at predicting their text messaging ability than the other phone function abilities that were assessed. This is an especially interesting finding as answering and placing calls are the only functions that can be legally undertaken while driving in many countries. If phone users are not good at estimating their ability to use these functions as a secondary task, then this could have a knock on effect for road safety, with people who are incapable at carrying out such functions concurrent to another task, attempting to do so due to this misjudgement in ability.

6.6.3.3 Did *Actual Phone Capability* Affect Willingness to Engage

It was found that, in the *low demand* scenario, *actual phone capability* had an effect on willingness to engage with *placing a call* and *sending a text message*. The participants who engaged with these phone mediums while driving had significantly lower LCT scores for the respective phone functions (were more capable at *placing a call* and *sending a text*) than those who did not engage. There was, however, no significant difference in willingness to engage in *answering a call* or *reading a text message* while driving when LCT rankings of those who did and did not engage with their phone were compared. Similarly in the *high demand* driving environment no significant differences in LCT scores were found between those who did or did not engage with any of the phone functions.

These findings suggest that the phone users' *actual capability* in using a phone function can have an effect on their willingness to engage for some functions. The participants' willingness to engage with *placing a call* being affected by *actual capability* is also in line with the finding for *self-rated phone capability* (as self-rated place a call capability also had an effect on willingness to engage). Although it was found that *self-assessed send a text capability* did not affect willingness to engage, it was found participants' *actual send a text capability* did influence their engagement behaviour. This seems to suggest that participants' *actual ability*, as opposed to their *self-*

rated ability to *send a text message* influences their willingness to engage with the phoning task. Perhaps, this is an indication that participants who were capable at *sending a text* were a little reserved with their *self-rated send a text ratings* but knew themselves to be more capable. The finding that *actual* and *self-rated send a text* abilities were correlated may suggest otherwise however.

Read a text message self-rated ability was also found to affect willingness to engage, whereas their *actual ability* to *read a text* did not have an effect. A correlation between *actual* and *self-rated read a text ability* suggests lack of awareness of texting ability was not the cause of this discrepancy, although the reasons why *self-rated* but not *actual read a text ability* would influence willingness to engage is difficult to explain at this time.

Neither *self-rated* nor *actual answer a call capability* were found to influence willingness to answer a call while driving, suggesting *capability* has no bearing on willingness to engage with this function.

6.7 Conclusions

The aims of the study were to establish to what extent *phone capability* and *driving capability* affected willingness to engage with various phone functions while driving.

It was found that *driving capability* did have an effect on willingness to engage in *high demand* scenarios with the less capable, novice, drivers having a higher propensity to engage with *placing a call* and *reading a text message* than the more experienced drivers. As this meant they were attempting to *read a text* or *place a call* whilst overtaking a vehicle, in the dark, while it was raining, it is argued that this shows the novice drivers were willing to engage with some functions on their phone at very inappropriate times. This was possibly due to having less well developed attentional control (giving attention to right task, at right time, for right amount of time) (Deery 1999) than the experienced drivers demonstrated. Age could also have been a confounding variable which influenced this finding, a common problem among novice driver studies.

It was further found that there was no significant difference in *self-rated driving capability* between the experienced drivers (who had an average of 30.9 years driving experience) and the novice drivers (who had an average of 2.2 years driving experience). The finding that participants demonstrated an optimism bias towards their own driving skill was in line with findings from previous literature.

As well as *driving capability*, the study also aimed to see if *phone capability* could affect willingness to engage with a mobile phone while driving. As there was currently no suggested way to measure *phone capability while driving* in the literature a methodology for testing this was devised. The LCT proved to be an effective way of differentiating participants based on phone use capabilities and was also found not to be sensitive to driving experience or age with no significant difference between the (younger) novice and (older) experienced drivers' scores, when carrying out the task in baseline form (LCT only with no phone tasks required). This suggests the differences in performance between the two groups, when conducting the LCT simultaneously with the phone tasks, were due to the differences in phone capabilities alone, as the phone task was the only variable added. Further studies to validate this finding are still required.

It was found that the younger, more experienced, phone users demonstrated greater *actual phone capability* performance for all of the phone tasks (*place a call, answer a call, send a text and read a text*) when conducted simultaneous to the LCT. It was further found, in the simulated *low demand* road environment, that the drivers who were willing to engage with placing a call and sending a text message had significantly lower LCT scores than those who did not engage, suggesting *actual phone capability* influenced willingness to engage for these functions. However, there was no difference in LCT scores for *answering a call* or *reading a text message* between those who did and did not engage with the task. There was also no difference in

LCT scores between those who did and did not engage with any of the phone functions in the simulated *high demand* road scenario.

Self-rated phone capability was also found to be a predictor of willingness to engage, with those rating themselves as more capable at *placing a call* and *reading a text message* having a higher willingness to engage with these functions in the simulated *low demand* road environment. However, *self-rated phone capability* was not found to influence willingness to engage with any of the phone functions in the simulated *high demand* road environment.

Fuller's (2005) model suggested that driver behaviour was regulated by drivers trying to maintain an acceptable level of task difficulty, which varied based on two factors: driver capability and task demand. The current study manipulated capability in order to test whether this theory can be used to help explain drivers' phone use behaviour also. The study expanded on the suggestion that *driving capability* could affect behaviour by also testing if *phone capability* could further affect willingness to engage.

Overall, it was found both *driving capability* and *phone capability* can affect willingness to engage with a mobile phone whilst driving. With the less capable drivers found to be more likely to engage with their phone at an inappropriate time. *Self-rated* and *actual phone capability* abilities of the participants were also found to influence their willingness to engage decision in a *low demand* road scenario for some phone functions.

Overall, the results from this study suggest that *driving capability* can affect driving behaviour but not in the way Fuller's model predicted. The model suggested the drivers who were more capable would have more spare resources available before they exceeded their acceptable level of task difficulty leading them to be more inclined to engage in distracting behaviours. However, the findings from this study found the opposite, as younger, less capable, drivers were more likely to engage in distracting activities in a *high demand* scenario. This is a possible indication of their less developed attentional control leading to inappropriate engagement decisions. Although, a higher capability for using some phone functions was also found to lead to increased willingness to engage. This suggests that as capability to use the phone increases, leading to a decreased demand on resources, using such functions while driving may become more tempting.

Chapter 7- General Discussion and Future Work

7.1 Introduction

The previous chapters in this thesis have described and discussed the findings from a literature review, possible methodologies that could have been used and three studies employing both quantitative and qualitative methodologies. These all addressed specific aims, namely:

1. To identify the factors which influence smart phone usage when outside of the car and the extent to which these transfer to the driving context
2. To determine if task demand has an effect on willingness to engage with phone functions while driving
3. To determine whether *driving capability* or *phone capability* affect the situations in which drivers are willing to engage with their mobile phone

This chapter will begin by considering how each chapter has addressed the aims of the thesis as outlined above. This will be followed by proposals for future research concerning willingness to engage with mobile phones while driving which follow on from this thesis. A final statement will briefly summarise how the thesis has addressed its aims and the results found.

7.2 Aim One

Identify the factors which influence smart phone usage when outside of the car and the extent to which these transfer to the driving context

Because of a relative paucity of studies in the current literature addressing factors which influence phone engagement while driving it was decided that it was important to first attempt to investigate these factors in an exploratory and open way. Of particular interest was a topic shown in the literature review to be surprisingly under investigated, namely, the extent to which factors which influence phone use out of the car can be considered to also influence phone use when a user is behind the wheel. Furthermore, this issue is becoming increasingly significant as smartphones, with their more diverse functionality, rapidly replace more basic phones that are limited to speech and text applications.

The results from the rating scales indicated that there was quite widespread use of smartphone functions when outside of a vehicle, though the thematic analysis results revealed factors encouraging and inhibiting usage varied from environment to environment. However, the use of smartphone advanced functions did not appear to transfer to driving situations, with a very low reported use of any functions other than talk and texting on the phone. Therefore, it appeared that smartphones were not yet introducing any issues in relation to driver distraction more than an ordinary mobile phone. For this reason smartphone advanced functions (such as email, internet usage etc.) were not investigated further within the thesis, thus allowing more detailed investigation of traditional talk and text functions to be conducted. This finding also suggested that the driving environment could be considered different to some of the other environments studied (such as shopping and public transport) in terms of what influences willingness to engage, as these environments saw high reported interaction rates with the advanced functions.

The main reason found to encourage or inhibit phone interaction in many of the environments, from the think aloud insights in the study, was the context of function matching the context of the environment. For example a work related phone call was likely to be answered in a meeting because the context matched the environment in which it was received. However, a call for social reasons was far less likely. Similarly participants reported being happy to read an informal text message while out shopping but reading a work email would be less likely as they were engaged in a leisure activity and would not want work related phone use to affect their mood. Related to this was the social acceptability, or perceived rudeness, of the action. The work call would be accepted in the work context because it was considered to be socially acceptable to do so, whereas to answer a social call in the middle of a business meeting was considered far less acceptable so this acted as a limiting factor to interaction. This social acceptability factor was regarded as both encouraging and inhibiting phone use in other environments too, including when in a restaurant and out shopping.

Driving was the exception to both the context and social acceptableness factors frequently influencing phone use. Driving can be considered a private space, with people often driving alone- 61% of car driver journeys were ‘single occupancy’ in 2012 (Department for Transport, 2013c). The privacy offered when alone in a vehicle may demonstrate why the social acceptability of carrying out a call, reading an email etc. had far less of an effect for this environment. It could be argued that laws prohibiting the use of some phone functions while driving dictate what is considered acceptable or unacceptable phoning behaviour. However, similar to Hill (2004) and McCartt et al. (2004)’s findings that phone use legislation had no significant long term effect on hand held phone usage levels, laws which prohibited phone usage while driving (Department for Transport 2003) were not mentioned very often as a factor limiting phone engagement behaviour. However, this may partly be a result of the setup of the study as the methodology used may have biased their thoughts more towards phone tasks and how these affected willingness to engage as opposed to rules of the road or laws which could prohibit behaviour.

Drivers did, however, seem very aware of the safety critical nature of the driving task and this limited their interaction with a phone more generally. The attention required by either the driving or phone tasks was a frequently mentioned prohibiting factor to phone use while driving. This suggests drivers were aware of the possible risks associated with phone use while driving as they were less inclined to engage if a high perceived attention level was required in conducting the task. Anderson’s (1982) framework for skill acquisition (see literature review) shows how, with practice, the attention required to conduct a task can be reduced as interactions become more automated. This brings into question the extent to which phone interaction may increase as individuals become more proficient drivers or phone users, leading to lower attention required and possibly therefore greater willingness to engage with such tasks simultaneously. This was taken into account in the capability element of Fuller's (2005) TCI model of driver behaviour. Fuller suggested that driver behaviour was dictated by trying to maintain a desired level of task difficulty and this was influenced by two factors: task demand and capability.

A factor related to task demand and capability which was found most likely to encourage or inhibit self-reported phone usage whilst driving was workload. Situations of low perceived workload (such as on an empty stretch of motorway), and consequent driver boredom, was when the highest reported call and text interaction occurred. Similarly higher workloads led to lower reported phone interaction. This supports McKnight et al.'s (1993) finding that when drivers were faced with a high workload situation, such as negotiating a roundabout or driving at night in the rain, drivers reported trying to lower demands placed on them by reducing their phone call interaction. This again relates to Fuller's (2005) TCI model, this time covering the task demand element, as task demand increases it appears from this exploratory study that willingness to engage decreases. However, as noted previously, the literature is not in agreement on the extent to which the roadway demand influences willingness to engage and it was deemed that this area was in need of further research.

In some scenarios if the driver was expecting an incoming call, text or email then reported occurrence of answering a call and reading a text message increased. This was attributable to an importance being attached to the phone use if it was expected, suggesting it was the expected importance as opposed to just the expectancy which made interaction increase. This suggests for future studies investigating worst case scenarios in which drivers are most likely to use their phone then simulating expecting an important call or text is likely to lead to the highest incidence of phone interaction.

From this study it appeared that having either a high workload, or being bored while driving, was when willingness to engage was at its lowest and highest levels respectively for this environment. The think aloud part of the study helped to explain why, with the level of attention required said to be influenced by either the driving or the phoning task. Therefore, how workload or experience can influence willingness to engage were established as requiring study in the remainder of the thesis.

As Fuller's model on what influences driver behaviour took into account both capability and task demand it was believed it may provide a particularly useful theoretical framework for the thesis. Fuller (2005) proposed that drivers try to maintain a constant level of task difficulty. It was also suggested that task difficulty was determined by two factors: driver capability and driving task demand. '*Where capability exceeds demand, the task is easy; where capability equals demand the driver is operating at the limits of his/her capability and the task is very difficult. Where demand exceeds capability, then the task is by definition just too difficult and the driver fails at the task, loss of control occurs…for instance, the use of a mobile phone can be an additional task, which pushes demand beyond driver capability'.*

It was further identified in Study 1 that the expected importance of the phone function intended to be used may influence an individual's willingness to engage with their phone both when out of the car and while driving. When discussing the results of this study in Chapter 4, a decision making model for how factors may interact to influence willingness to engage, applicable to both in and out of the car, was proposed (see Figure 31). In Chapter 4 the first part of the model was a judgement on the level of attention required. With further studies now conducted and reported in the current thesis this construct has evolved to become *task difficulty* so that both *task demand* and *capability*, both of which will influence the level of attention required by the task, are taken into account. This is more in line with Fuller's (2005) previous model of driver behaviour, the rest of the model remains the same.

User perception of the appropriateness and expected importance of phone use before someone engaged with their phone were then considered. Unfortunately the scope of the thesis did not allow for these factors to be tested. The results in Study 1 suggested that the social acceptability element of the appropriateness of phone use was not a significant influence on willingness to engage with a phone in the driving environment, possibly due to vehicles being such a private space. However, this factor did appear to have a far larger effect in other more public environments, such as when in meetings or restaurants. It was acknowledged that that the laws of the road and social norms for phone use while driving were considered to fall under the appropriateness theme but results from both Study 1 and the literature suggest that phone use being illegal does not have a very large influence on someone's decision to engage or not with their phone while driving.

Previous literature suggests appropriateness does not have a large effect on willingness to engage with mobile phones while driving. Therefore, as a result of the need to limit the scope of the thesis, it was decided that appropriateness of phone use while driving would not be studied any further but instead kept in mind for future work. The scope of the thesis did also not allow for the effect that perceived importance of phone use had on willingness to engage to be studied. As Study 1 had highlighted this may have an impact on willingness to engage it was ensured that this factor was held constant between participants. In the rest of the studies in the thesis participants were always asked to consider phone use importance to be high, to ensure its potentially confounding effects on results were limited. Deciding to reject further study of these two factors allowed for more detailed study of the remaining variable, namely task difficulty, which itself encompasses task demand and capability. Figure 32 shows the factors which were tested in the remainder of the thesis. Phone use importance was included in the model as it was expected to influence willingness to engage with a phone while driving but was not explicitly tested; instead it was held at a constant level between participants to ensure it did not act as a confounding variable. Task difficulty was based on Fuller's (2005) definition and therefore comprised both task demand and capability. The combination of these two factors led to a perceived high or low task difficulty which in turn was predicted to lead to an acceptance or rejection of phone engagement.

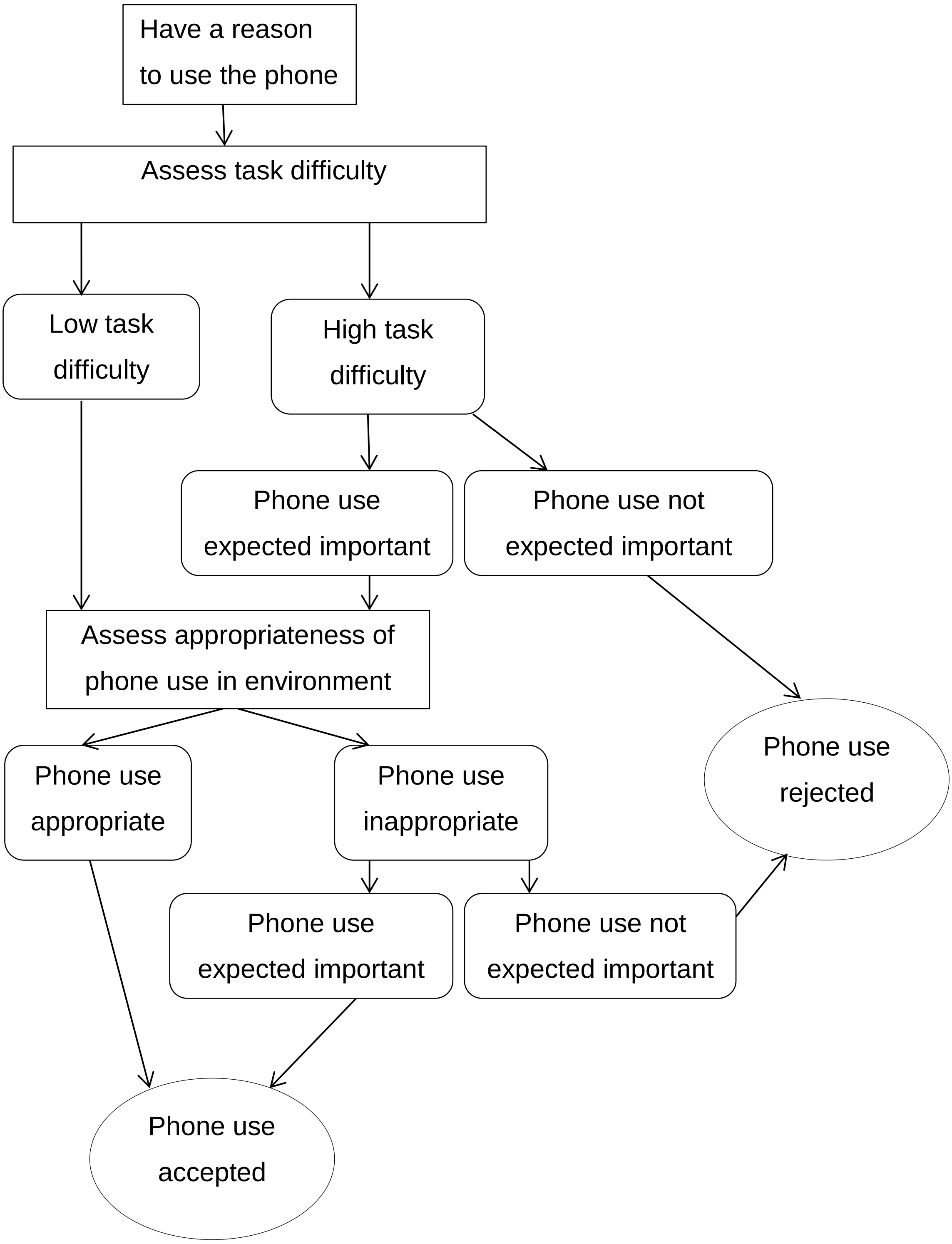

Figure 31: Proposed decision making model of factors influencing willingness to engage based on findings from Study 1

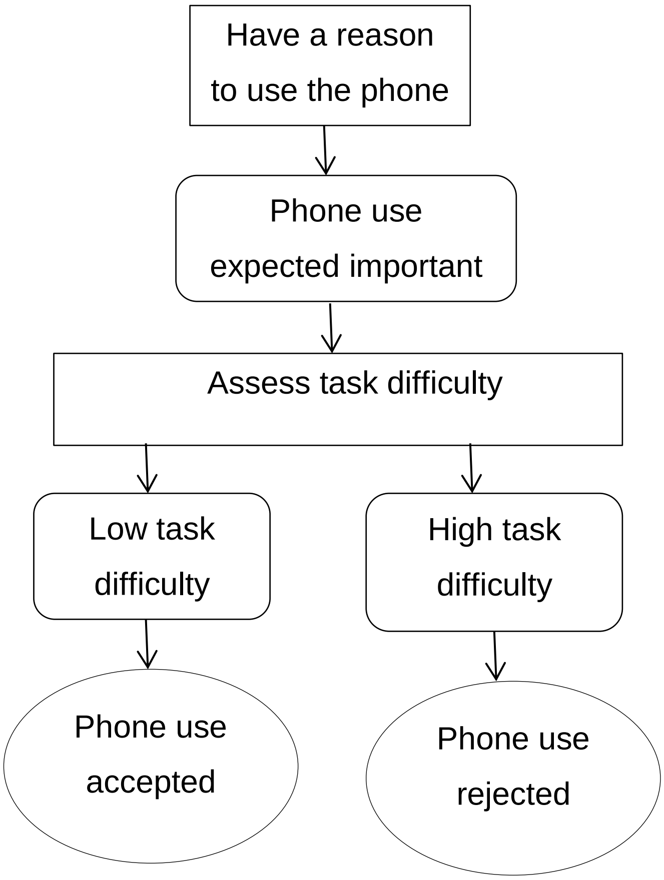

Figure 32: Decision making model tested in studies 2 and 3 based on Fuller's (2005) model of driver behaviour. Phone use importance was held constant but not directly tested.

Ultimately, conclusions from Study 1 were that driving shares many of the same factors influencing phone engagement that apply when out of the car, but specific factors predominate. The main differences found were that the social acceptability or perceived rudeness of phone use played a very small part in influencing phone behaviour when driving. This factor had far larger impact in environments such as meetings and restaurants.

The high demands placed on the driver by the road environment clearly distinguished it from the other environments and reported phone use engagement propensity seemed to reflect this. Only factors which either changed the level of attention required by the task, such as a change in task demand as a result of changes in the traffic environment, had any substantial influence on willingness to engage. The only other exception was if the importance of the phone use increased. This led to participants reporting that they were slightly more willing to take a risk and use the phone as they reported that the increased importance now warranted interaction. Driving is one of the few activities that people undertake every day that is safety critical. It seems from Study 1 that drivers were aware of this when making engagement decisions, with the attention required having a far larger impact on engagement than in any of the other environments. Driving may not be unique in terms of the overall factors influencing phone use but it is unique in the extent to which this particular factor seems to have such a strong bearing on interaction.

7.2.1 Limitations of the Study

Study 1 had a number of limitations to its findings. Firstly due to using an interview methodology the sample size (N =20) was limited, making it difficult to apply findings to the population as a whole. Interviews are time consuming, compared to, for example, questionnaires. However, due to how under researched the area of interest was it was deemed necessary to conduct a very open and exploratory first study to gain the necessary insight into the motivations and factors which may influence willingness to engage. The typically more targeted nature of questionnaires, which would have enabled a higher sample number, was therefore considered inappropriate.

As the environments to be discussed (e.g. restaurant, meetings etc.) had been decided before the interviews were conducted this may have limited some insight into phone use behaviour that other environments may have enabled if participants were free to talk about phone use in locations of their choice. This narrowing of environments was deemed necessary to provide a common basis for making comparisons between participants, as otherwise the number of possible environments would simply have been too large.

A further limitation of Study 1 was that it relied on participants being honest about their phone engagement behaviour; only covert observation would provide such a perspective. However, it would not have been possible to observe all the participants' phoning behaviours in different environments and scenarios. Furthermore, this would not have led to any insight into *why* they behaved as they did. Therefore, an acknowledged limitation of Study 1 was participants possibly trying to please the experimenter with their answers, thereby giving socially acceptable, as opposed to realistic, accounts of their phoning behaviour.

7.3 Aim Two

To determine if task demand has an effect on willingness to engage with phone functions while driving

The effects the two elements of task difficulty (capability and task demand) had on willingness to engage with mobile phones while driving were tested separately in the two remaining studies in the thesis. Study 2 (Chapter 5) focussed on meeting Aim 2 by experimentally testing the extent to which road *demand* and *phone function* intended to be used influenced drivers' decisions to engage with their phone.

The results showed both roadway *demand* and *phone functionality* affected *willingness to engage* with a mobile phone whilst driving. It was found that there was a higher propensity to engage in phone use in road environments perceived to have a *lower demand* and lower propensity to engage in phone use in the *highest demand* scenarios. *Answering a call* was the most likely function to be engaged with by the participants and *sending a text message* the least likely, supporting current literature findings (Walsh et al. (2007), Atchley et al. (2011)). Significant differences were found in willingness to *answer a call* and *send a text message* in all *demand* scenarios and *place a call* and *send a text message* in all but the *high demand* scenario. In both the *low* and *mid demand* scenarios, all functions' willingness ratings were significantly different from one another apart from *place a call* and *read a text* and *answer a call* and *read a text*. However, for the *high demand* scenarios the *phone function* intended to be used had much less of an effect on *willingness to engage* with the only significant differences found between *answering a call* and *placing a call* and *sending a text* and *answering a call*. As the roadway became more demanding *answering a call* was the only activity that participants had any real likelihood of interacting with. The influence of road demand on phone function engagement has not previously been studied so comparison to findings in the literature cannot be made.

This interaction (the decrease in the willingness to use phone functions as the roadway demand increased) indicates that task demand for phone use while driving is the product of an interaction between the demand from the road environment itself and from the intended phone function. The correlations between perceived risk and perceived demand ratings also support this assertion. As, for the *answer a call* function, *perceived risk* and *perceived demand* were found not to be correlated, however, for *placing a call* they were. This is a possible result of, even in a *high demand* scenario, the *risk of answering a call* being perceived as very low due to simply requiring the press of a button. Participants felt quite capable of doing this secondary task with very little additional risk, even when faced with high demand from the road environment, so as demand increased *perceived risk* did not increase in proportion. This could be taken as evidence that *function* and *road demand* interact to make up *task demand.* The combination of a simple to interact with phone function and the demand from the roadway never combined to exceed the acceptable level of task demand, resulting in low influence on perceived risk and higher willingness to engage. Conversely, *placing a call* involved a lot of manual interaction and so faced a high likelihood, when combined with increased road *demand*, of putting the overall level of task demand above the acceptance threshold. Thus, as road *demand* increased so did the *perceived risk* of *placing a call* which may explain why, for *place a call, perceived risk* and *perceived demand* were correlated. In combination, road demand and phone function influenced overall task demand which in turn influenced the level of risk perceived in carrying out the task and the subsequent willingness of the drivers to engage in the phoning task.

There is no current view in the literature as to whether phone function and roadway demand interact to give a level of task demand. Therefore, the findings in Study 2 give a strong foundation for future work to expand upon.

The finding that task demand can influence willingness to engage with a phone while driving is of importance. This is because it may help to explain why the number of accidents where phone use is a contributing factor is not as high as might be expected in current accident statistics i.e. drivers take into account how demanding they think the function they intend to use may be before engaging. This suggestion is further supported by the finding that drivers also attempt to time their engagement with a phone to coincide with lower demand road scenarios. Therefore, by refraining from use at inappropriate and excessively demanding times, and with excessively demanding tasks, adequate car control, attention and safety are maintained. Whether drivers are proficient and sufficiently capable of estimating task demand to avoid accidents occurring was however not an aim of this study and further conclusions on this cannot be made based on work conducted. However, the findings of this study go some way to suggest that task demand can dictate drivers' willingness to engage with their phone. Both the specific task and road demand, at the time of the engagement decision, are taken into account when considering the amount of demand the task will pose. Ultimately, this may help dictate whether to engage in the phoning task or not.

7.3.1 Limitations of the Study

The main limitation to Study 2 was that it only tests what people say they would do with their mobile phone based on viewing video clips of road environments; participants were not actually driving at the time and were also not actually expected to use their phone. Although the method chosen was justified on the basis of experimental control and ethical considerations (participant safety) this limitation needs to be kept in mind when making any conclusions based on the study's findings.

The sample size (N=20) was considered an adequate size for an experimental study but was still small relative to the driving population, making the findings somewhat tenuous. The findings were true for this sample but when making conclusions for the population the conclusions based on this study have to be stated with caution.

As the study investigated whether drivers delayed their phone interaction in response to road demand a way of classifying road demand was required. However, no studies were found in the literature that had used or suggested ways of classifying road demand. As a result, the video clips were categorised according to the demand the scenario was expected to place on the driver using Fastenmeier's (1995) classification criteria. This method gave a suggestion for classifying demand based on subjective measures of several criteria, but no evidence was found that this method had been validated. However, once the clips had been assigned demand ratings by the experimenter using this classification system, the participants' scores for perceived demand were found to be consistent with the experimenter's categorisations. It therefore appears that this offered an effective way of differentiating road demand.

7.4 Aim Three

To determine whether *driving capability* or *phone capability* affect the situations in which drivers are willing to engage with their mobile phone

Study 2 concluded that *task demand* influences willingness to engage decisions when driving. Study 3 aimed to test the second part of (Fuller 2005)'s model of driver behaviour, namely capability, in terms of whether it can also influence phone use while driving. To test this, a study was conducted whereby participants (N=40) were required to drive in a driving simulator under two conditions, simulated *low* and *high* road demand. Their willingness to engage with their phone was tested as they received *phone calls* and *text messages* from the experimenter and they were also invited to *send text messages* or *place phone calls* to the experimenter at certain times while driving. The participants' level of *phone capability* while driving was also tested using the Lane Change Task and their *driving capability* was estimated based on the number of years they had been driving.

It was found that actual *driving capability* did have an effect on willingness to engage in *high demand* scenarios with the less capable, novice, drivers having a higher propensity to engage with *placing a call, sending a text message* and *reading a text message* than the more experienced drivers. However, no differences were found for answering a call or in the *low demand* environment; novice drivers were willing to engage with some functions on their phone at possibly inappropriate times. However, it was also found that younger drivers were better at using their phones while driving.

It was found that the younger, more experienced, phone users demonstrated greater *actual phone capability* performance for all of the phone tasks (*place a call, answer a call, send a text and read a text*) when these tasks were conducted simultaneous to the LCT. It was further found, in the simulated *low demand* road environment, that the drivers who were willing to engage with *placing a call* and *sending a text message* had significantly lower LCT scores (performed better at the task) than those who did not engage, suggesting *actual phone capability* influenced willingness to engage for these functions. However, there was no difference in LCT scores for *answering a call* or *reading a text message* between those who did and did not engage with the task. There was also no difference in LCT scores between those who did and did not engage with any of the phone functions in the simulated *high demand* road scenario.

Self-rated phone capability was also found to be a predictor of willingness to engage, with those rating themselves as more capable at *placing a call* and *reading a text message* having a higher willingness to engage with these functions in the simulated *low demand* road environment. However, *self-rated phone capability* was not found to influence willingness to engage with any of the phone functions in the simulated *high demand* road environment.

It seems from the findings in Study 3 that *driving capability* influences willingness to engage but not in the way Fuller's (2005) model would predict. It was not the case that a greater level of *driving capability*, meaning the driving task placed less demand on resources, lead to a higher willingness to engage. In fact the exact opposite was found, the less experienced, novice drivers, had a higher willingness to engage than the more experienced drivers in *high demand* situations. This could be due to a number of factors; firstly it could be that novice drivers misjudge their driving capability (as backed up by both groups having very similar self-rated driving capability scores). It is important to remember that there was a probable confounding variable between driving experience and phone experience for the sample in this study. Therefore, the novice drivers' misjudgement in driving ability combined with their greater ability to use the phone while driving means they likely do not exceed their personal demand threshold which, once exceeded leads to refraining from engaging. However, the more experienced drivers, who were not as capable at using their phone, exceed this threshold as a result of the phone task which was predicted to utilise (and actually took up) far more mental resource, as shown in Figure 33.

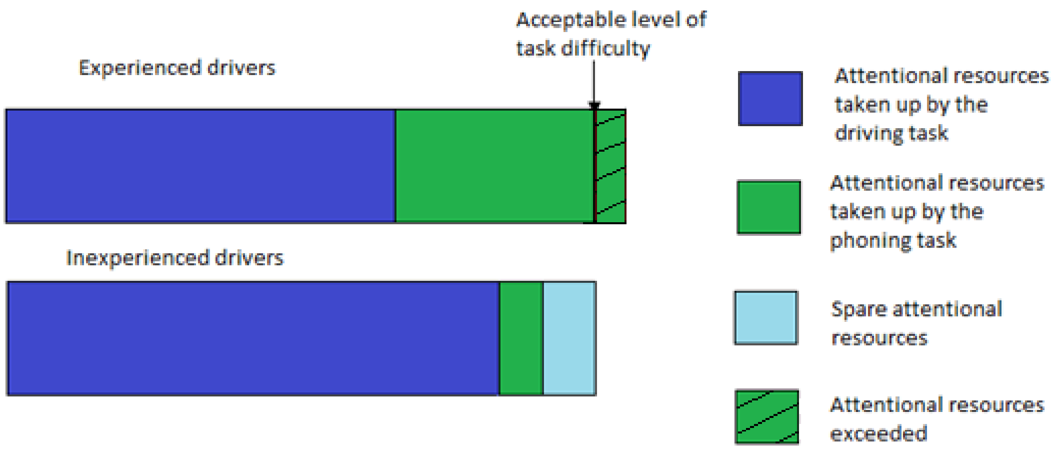

Figure 33: Diagram of attentional resources taken up by each task for each driving experience group.

It seems from the findings in Study 3 that the left hand (darker blue) box in Figure 33 (above), which represents participants' attentional resources taken up by the driving task should be equivalent for the two driving experience groups. This is due to the inexperienced drivers' having the same *self-rated driving capability* as the experienced drivers (as represented in Figure 34).

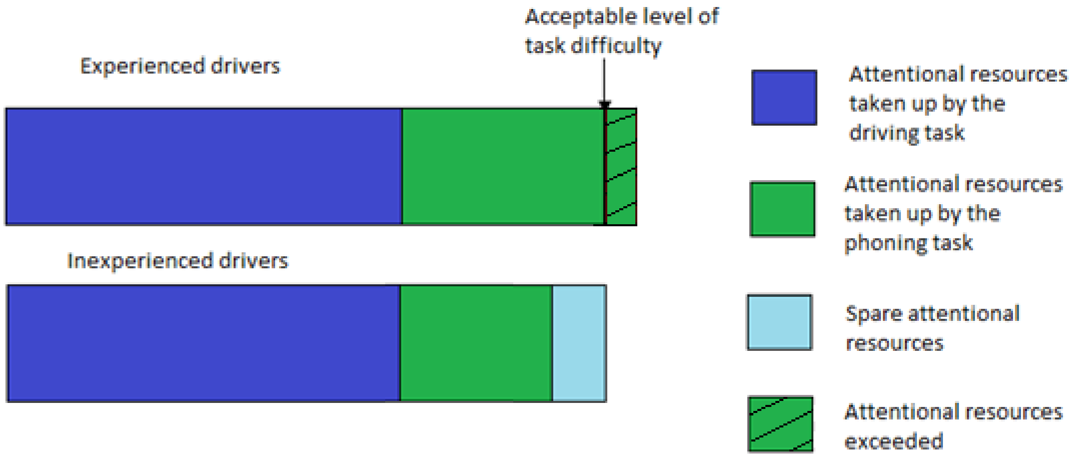

Figure 34: Study 3's finding for perceived attentional resources of both groups of drivers

The finding that even the older, experienced drives, were willing to engage with *answering a call* (shown to be perceived as lowest demand function in Study 1 and Study 2) supports this theory. The older, experienced, drivers perceived the same amount of demand taken up by the driving task as the inexperienced drivers. Their lower level of *phone capability* while driving led to them being unwilling to engage with all functions apart from *answering a call*, when the demand was *high*. As *answer a call* is often perceived as the least demanding phone function it may be that due to the low level of demand it placed on them, they perceived themselves as more capable at using this function. This in turn left some perceived spare resources with which to interact with a secondary task and therefore they were more willing to engage even when in the *high demand* situation.

Another explanation for this higher willingness to engage for the younger, less experienced, drivers is that because of their age, they have a higher willingness to take risks and therefore actually have a larger threshold to exceed before they deem it too risky to engage with a task (as shown in Figure 35). However, as mentioned previously, because the two groups differed in age, driving experience and phoning experience were partially confounded making 'cause and effect' conclusions difficult to corroborate. This is one of the major limitations of the study. The effect of age on phone use has been previously reported with Sullman (2012) observing a greater number of young drivers, as opposed to older, using their phone while driving. Lansdown (2012) also found, through a survey methodology, that younger drivers were more likely to engage in distracting activities. However, no reasoning behind young drivers' higher distraction engagement was deduced from these studies and neither phoning capability nor driving capability were controlled for, making it difficult to conclude that age was the factor causing this difference.

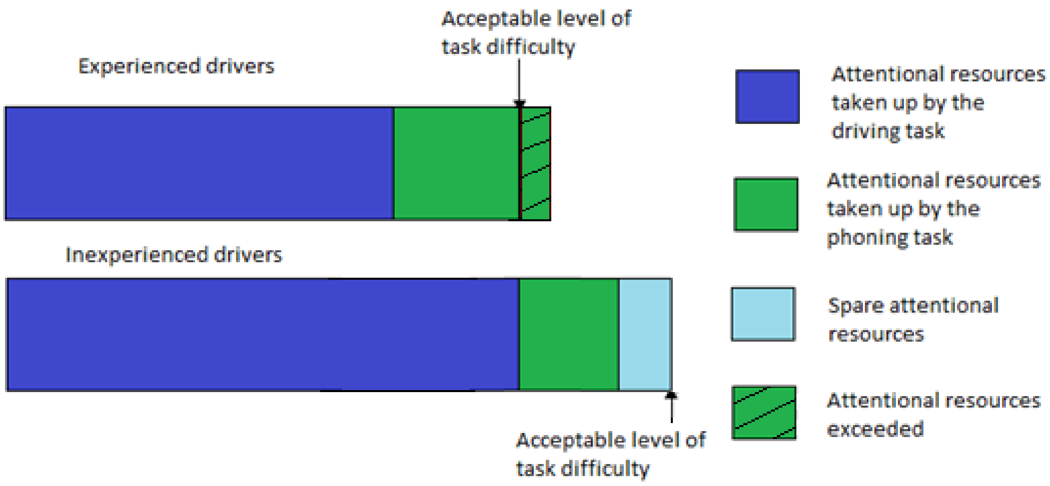

Figure 35: Illustrating younger drivers' possible larger risk threshold

7.4.1 Limitations of the Study

As mentioned previously, the major limitation to Study 3 was the sample chosen for the experiment. Although the sample was considered to be of a good size (N=40) for an experimental study the sampling criteria were difficult to achieve. It was not possible to recruit equivalent numbers of participants with the required levels of contrasting driving and phone experience.

Table 7: Young driver and phone user sample that would have ideally been used

Ideal young sample	**Experienced Driver**	**Inexperienced Driver**
Inexperienced Phone user	Young	Young
Experienced Phone user	Young	Young

Table 8: Older driver and phone user sample that would have ideally been used

Ideal older sample	**Experienced Driver**	**Inexperienced Driver**
Inexperienced Phone user	Older	Older
Experienced Phone user	Older	Older

Table 9: The actual sample of drivers and phone users that featured in Study 3

Sample used in Study 3	**Experienced Driver**	**Inexperienced Driver**
Inexperienced Phone user	Older	Not feasible
Experienced Phone user	Not feasible	Young

Ideally, to test if driving capability affected willingness to engage with a phone the sample would have comprised young experienced drivers for comparison against older, experienced drivers (see Table 7 and Table 8). However, as the legal driving age in the UK is 17 years old it would be very difficult to recruit anyone who is young and very experienced at on-road driving. The sample would then have also ideally comprised older, inexperienced drivers. This again would have made recruitment difficult as the majority of people learn to drive in their younger years so the number of older drivers who are still relatively novice is low in the UK population. Therefore, finding and getting access to these individuals is very difficult.

Similarly in order to test if phone capability affected willingness to engage with phones while driving it would have been ideal to have both young and older proficient phone users and young and older inexperienced phone users (Table 7 and Table 8). This sample again would make recruitment difficult as the younger generation (18-20 years of age) have grown up with technology from an early age, with technology in every part of their life. Therefore, to find people who were not capable phone users at this age would have been difficult and would have introduced new issues as these individuals would probably have been raised in unusual circumstances and therefore have brought unknown confounding variables with them. Without a younger, inexperienced, phone-user group for comparison purposes, recruitment of older, experienced, phone users was not deemed worthwhile. Recruiting this group would also have proven difficult for similar reasons as this demographic had not grown up with these technologies so adoption was likely to have happened later and led to lower levels of experience and capability. Furthermore, the older experienced phone users who do exist are likely to have learned through necessity such as for work purposes and as these users would be in the business sector- a demographic that is notoriously difficult to recruit for study participation.

The final samples chosen were younger, inexperienced drivers who were also experienced phone users, compared against older, experienced drivers who were also inexperienced phone users (Table 9). This sample choice inevitably led to some limitations and made concluding cause and effect a significant challenge. However, the samples employed were representative of major groupings within the driving population; young but inexperienced drivers who are good at using their phone versus older experienced driver who are not as capable phone users. Limitations this sample brought to the study have been kept in mind when conclusions about findings were made and these limitations were also repeatedly mentioned throughout the thesis, where necessary, to ensure the reader is aware of them.

A further limitation of Study 3 was the use of a driving simulator. Whether or not participants engaged with their phone whilst driving was recorded but the driving and phone usage took place in a controlled environment where the participant will have been aware they could not place themselves, or others, in any real harm which may have influenced their phoning behaviour. Compared with direct observations in a real-road environment, this method had major advantages in terms of cost, time, participant safety and ethics. However, it made generalising findings to the real world more difficult. Due to the illegality of some of the phoning tasks and the possible dangers of such behaviour it was believed the approach was justified and every attempt was made to ensure the driving environment was as real as practicably possible. Nevertheless, the limitations posed by the use of a simulator must of course be kept in mind when making any conclusions based on the findings of the study.

7.5 Factors Affecting Willingness to Engage With a Mobile Phone While Driving

The previous sections have individually addressed the findings from the three studies conducted and how these helped to meet the aims of the thesis. This section looks at the thesis findings as a whole and makes conclusions in terms of factors affecting willingness to engage with a mobile phone while driving.

In order to assess how generalisable the results in this thesis are to the driving population as a whole it is important to analyse the distribution of ages of drivers in the UK and compare this to the samples used throughout the thesis. Only around 3% of UK drivers are aged between 17 and 20, 13% are between 21 and 29, 17% 30-39, 23% 40-49, 18% 50-59, 16% 60 to 69 and 10% are 70+. Around 54% of the UK driving population are male and 46% female (DVLA, 2012).

The sample in Study 1 consisted of a mix of 10 students (9 aged between 18-25, 1 aged between 26-35 with an equal number of males and females) and 10 business professionals (3 aged between 26-35 and 7 aged between 46-65 with an equal number of males and females). 17-65 year olds equate to around 90% of the UK driving population so the sample used is considered to be fairly representative of the population as a whole. Also, with a 50/50 gender split in the sample this is again a good approximation of UK driver population by gender divide.

In Study 2, 20 participants (4 female, 16 male) were recruited aged between 33 and 47. As 30-39 year olds equate to around 17% of the UK driving population and 40-49 year olds equate to around 23% Study 2's sample is only representative of about 40% of the UK driving population. This limits the extent to which the findings can be generalised. This is compounded further more by the gender split in Study 2 being 20% female and 80% male when the proportion of UK drivers is 46% female and 54% male, again limiting generalisability. This needs to be taken into account when drawing conclusions from the findings.

In Study 3, 40 participants (24 male, 16 female) were recruited, aged between 18 to 20 years of age (mean 20 years of age) and 35-63 years of age (mean 50 years of age). As 3% of UK drivers are aged between 17 and 20 and 74% of the UK driving population is aged between 30 and 69 Study 3 is representative of around 77% of the UK driving population. Although, the 60% to 40% male to female divide is not quite representative of the UK driving population which has an almost even ratio of male to female drivers.

Overall, throughout the studies in the thesis a fairly diverse set of age groups were covered and are considered to be quite representative of the UK population as a whole. Although, some issues of generalisability of findings, as a result of the age and gender split sampled, means these limitations need to be kept in mind when applying findings.

Overall, based on the findings from studies in this thesis, it appears a number of factors influence drivers' decisions on whether or not to engage with their phone while driving. Firstly, task demand seems to have an influence with both the selected phone function and the demand of the roadway interacting to influence willingness to engage. The phone tasks that were perceived as particularly undemanding (especially answering a call) were selected in high road demand conditions, in both studies two and three, when other higher demand phone functions were not. This can be seen as a result of the overall task demand being deemed as acceptable for the phone interactions which were considered to be easy. In contrast, the more challenging phone tasks interacted with the roadway demand to make the overall task demand above that which was deemed acceptable by the participants, leading to low levels of willingness to engage.

The level of capability was also found to influence willingness to engage. Those who were more capable at placing a call and sending a text message (considered the most demanding of the calling and texting functions) were found to also be more likely to interact with these functions when driving in low demand environments. These functions saw a very low willingness to engage for all participants in high demand scenarios, in both Study 2 and three, and it seemed even those who were capable at using these functions thought them too demanding to use when road demand increased. Actual driving capability was found to have an effect on engagement with all functions, apart from answering a call, with those who were less capable drivers (had low levels of driving experience) found to be more willing to engage with most phone functions in high demand conditions.

The majority of these findings supported Fuller's (2005) TCI model of driver behaviour. This thesis has tested the model's applicability to drivers' phone use behaviour. It was generally found that task difficulty could indeed influence willingness to engage with a phone while driving. Task difficulty was said to be made up of task demand (proposed in this thesis to be an interaction of road demand and phone function) and capability (proposed in this thesis to be an interaction of driving capability and phone capability) and both of these factors were found to influence willingness to engage.

The only finding that did not support Fuller's (2005) model was that the less capable drivers were more willing to engage with some phone functions in high demand environments than the more experienced drivers. According to the TCI model the more capable drivers should have had more spare resources, as greater experience meant the driving task placed less demand on the experienced driver, and therefore the more experienced drivers should have had a higher willingness to engage with secondary tasks. This was not found to be the case in Study 3 and it is proposed that it may be that the experience did indeed affect willingness to engage, as would be predicted, but just not in the manner predicted. It is known from studies such as De Craen et al.'s (2011) that inexperienced drivers often overestimate their competency and underestimate the challenge of driving conditions. It is suggested that with driving experience came not just a lower demand on resources from the driving task but possibly a better judgement of appropriate secondary task engagement behaviour. With greater driving experience came a greater ability to judge when it would be appropriate or inappropriate to take their mind from the primary task, hence greater driving experience resulting in lower willingness to engage.

Alternatively, this finding could also be a result of a complex interaction between the more experienced drivers also being older and less phone capable than the less experienced drivers, all of which may have confounded results. Perhaps, as suggested previously, the novice drivers did not make less appropriate decisions about engagement timing as a result of their inexperience, but instead because the younger drivers were more capable phone users, which may have had some effect on the resources taken up by the task. Although the driving task would take up more resources than for the experienced drivers the phoning task would take up less due to this increased phone capability. This does, however, seem unlikely to have caused the difference in findings as the level of phone capability was found to have no effect on willingness to engage in the high demand scenario in Study 3. It seems more likely that the novice drivers' younger age in fact led to the finding of higher willingness to engage in the high demand scenario. They may have been just as aware of the risks of phone use as the more experienced drivers but this higher risk taking propensity may have led them to engage anyway. As all novice drivers were young and all experienced drivers were older it makes conclusions on whether it was a case that the older drivers' experience lead to better decisions or the younger drivers' higher risk taking propensity caused this difference in engagement behaviour. It is therefore difficult to conclude the extent to which this finding undermines the argument that Fuller's TCI model provides an effective model for phone engagement while driving due to the nature of these interactions.

As it was found that in the low demand scenario phone capability had an effect on willingness to engage, whereas in the high demand scenario it did not, it appears in the low demand scenario phone capability may be the best predictor of willingness to engage. This is as long as the phone tasks are considered reasonably demanding (i.e. placing a call and sending a text message). Conversely, in the high demand scenario, as phone capability did not influence willingness to engage but driving experience did, it seems that for all but the *answer a call* function, the level of driving capability (experience) may be the best predictor of willingness to engage. Answering a call was regarded as a very easy task to conduct by participants and was largely insensitive to road demand, driving capability or phoning capability. As a consequence, if an incoming call is perceived as important, it will also be answered in the majority of scenarios by the most drivers.

These findings suggest a model that is specific to willingness to engage with mobile phones while driving is needed (Figure 37). It involves considerable extension to Fullers' model (Figure 36) and is not a simple application of the model for phone usage.

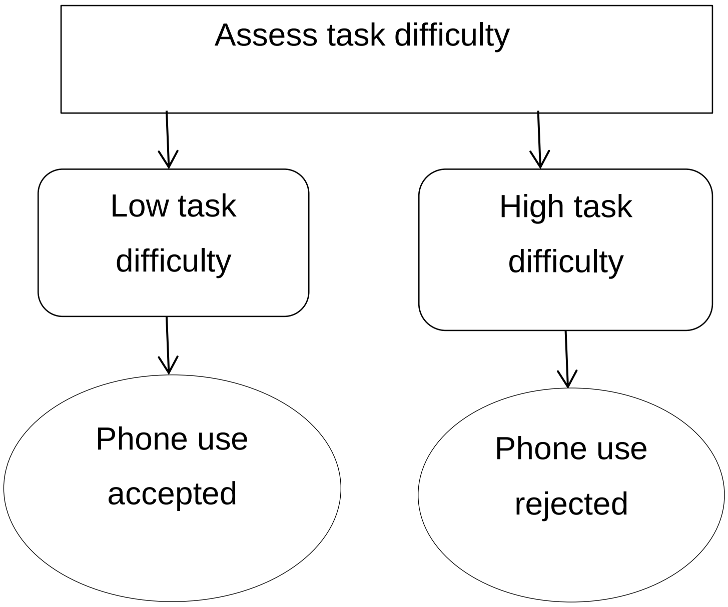

Figure 36: Fuller's (2005) TCI model of driver behaviour if adapted to apply for phone usage

As a consequence of the study designs the model (Figure 37) is only relevant to situations in which drivers rate phone usage as important; it may not be valid in situations involving functions regarded as more 'trivial'. The model goes beyond identifying task difficulty as influencing willingness to engage and attempts to predict engagement behaviour based on a number of factors including road demand, phone function, phone capability and driving capability/ age. The model shows that in low road demand conditions, for important incoming calls, the studies in the thesis did not identify any clear factors that would restrict engagement with these functions. However, for sending a text or placing a call it was found that how capably the phone user could operate these functions while driving dictated their engagement behaviour. Those who were capable engaged with the phone and those who were less capable refrained from engaging.

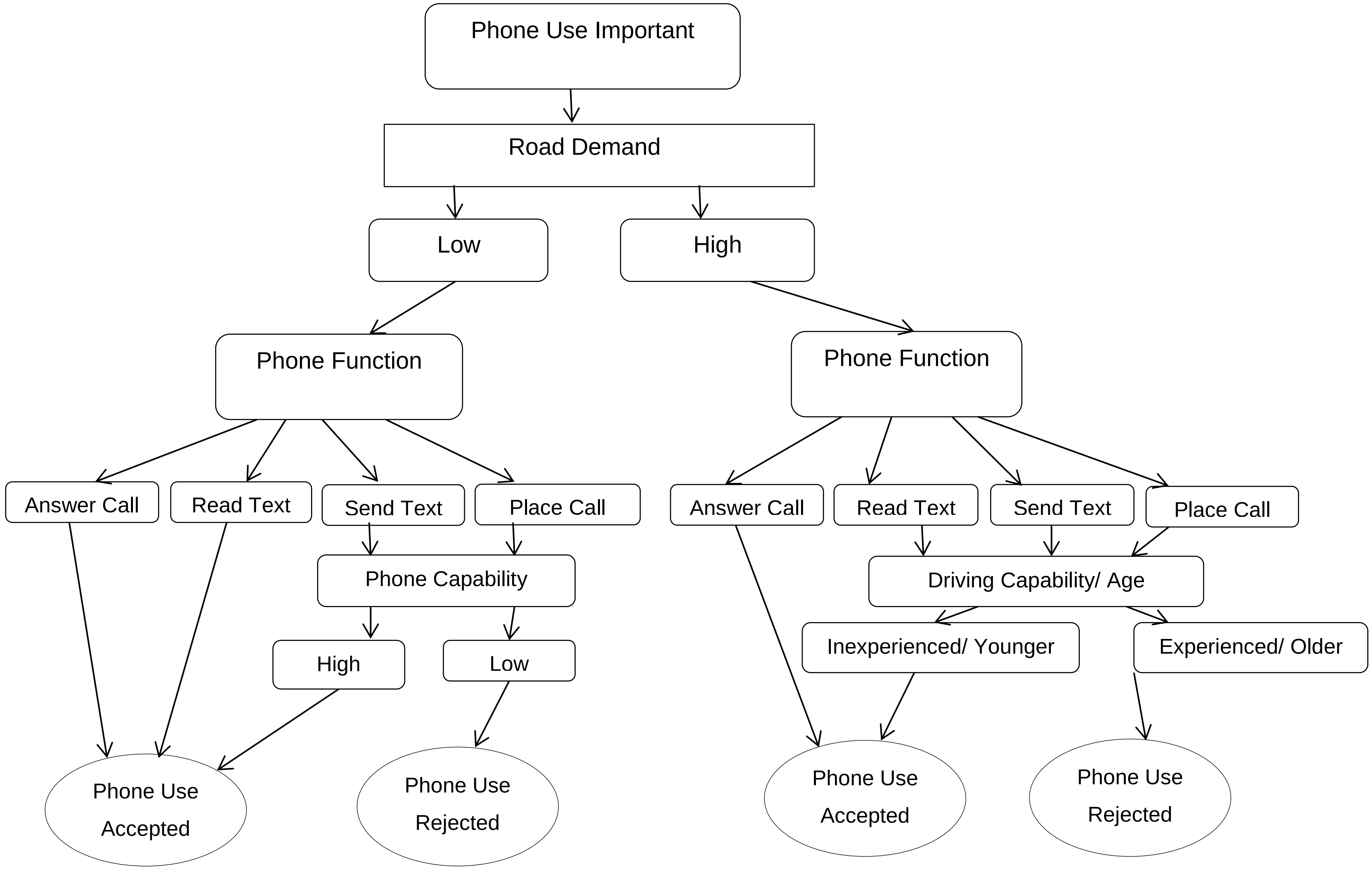

Figure 37: Proposed model for factors influencing willingness to engage with a mobile phone while driving, based on thesis findings

Similarly, in a high demand road environment there were no factors identified which clearly led to refraining from answering a call. However, for the other phone functions driving capability or age were identified as influencing engagement decisions. Unfortunately the thesis ran out of scope to follow up and identify exactly what it was about these tasks which limited engagement in high demand conditions. However, it is theorised, based on comments made by participants in Study 1 and 2, that the high level of visual demand required to read a text and the visual demand of scrolling through the contacts list to place a call had a big impact on interaction. Similarly sending a text message can be considered a task which is both visually demanding and requiring a strong biomechanical interaction as well which adds further to the distracting effect. Answering a call required far less of an interaction in order to engage in terms of eyes of road time, it can be considered a simple visual task, and this may be why this task is less sensitive to roadway demand. If the model was to be made more generalisable for other secondary tasks, or adapted for new phone tasks which emerge in the future, then replacing the exact phone tasks with descriptions of how they influence the driver's resources may be appropriate. For example, sending a text message may be replaced with 'biomechanically and visually intensive task'. Place a call and read a text may be called 'visually demanding tasks' and answering a call instead labelled 'simple visual task'. Considering how visually demanding the task is, and the biomechanical interaction required, and applying this to the decision model developed in this thesis may go some way towards helping to predict the likelihood of interaction by a driver.

As all the less experienced drivers (taken to represent capability) were young and all the experienced drivers were older it was not possible to distinguish which of these factors had the largest effect. However, the younger, less experienced drivers were more likely to place a call, send a text or read a text than the older, more experienced, drivers and this is represented in the model for phone engagement behaviour.

This thesis aimed to find the factors that could influence willingness to engage while driving. Although a comprehensive model was built as a result of this thesis it is proposed there is still room for improvement on this current theory by taking into account other variables which fell out of the scope of this work. One such variable is that of risk taking factors and finding if those with a higher propensity to risk taking may be more inclined to engage with their phone than those who are more risk averse. Further research on this and how such factors interact with those identified in the thesis would help to build a more complete profile of influencing factors. Furthermore, the literature review established there has been some research into social acceptance theories, such as those addressed using the theory of planned behaviour (TPB), and how such factors can influence intention to engage with a phone while driving. A model which could combine findings from these diverse areas would give a more complete picture of influencing factors for phone engagement whilst driving.

7.6 Thesis Relevance and Outcomes

Although it was unfortunate that age and experience could not be separated in order to identify the variable which exerted a greater influence on willingness to engage decisions it is also a problem which is applicable to real roadway environments. The majority of novice drivers are young and all young drivers will be novices because of the age-related driving limitations. Therefore, the finding that this group of drivers behave differently with their phones to the older, more experienced, driver group is considered an important one. Young drivers are already over represented in road traffic accident statistics across the world, often seen as an interaction between their inexperience and higher risk taking propensity (Lourens et al. (1999), De Craen et al. (2011)). If, as findings in Study 3 suggest, young drivers are also more willing to interact with their phone at inappropriate times on the roadway then this may be another contributory factor which explains their over-representation in accident statistics. With younger drivers more likely to be early adopters of technology and also shown to be heavy phone users when out of the car, this problem is likely to be exacerbated as phone capabilities increase and new distractions are brought inside the vehicle. Although the root cause of their higher propensity for interaction with the phone was not established in Study 3, it would seem reasonable to conclude that it is an interaction between being heavy phone users, more capable phone users and their age. Previous literature identified novice drivers as having inferior hazard perception (detecting and dealing with hazards) and attentional control (giving attention to the right things, for the right amount of time, at the right time) compared with more experienced drivers Deery (1999) and these are also predictable contributing factors to their inappropriate engagement.

This finding highlights the need for novice drivers to have specific training in timing their secondary task engagement. Ideally, this would focus on deterring engagement altogether, but it should emphasise the need to anticipate the possible demands from the roadway before engaging in a distracting secondary task. This thesis shows that currently young drivers make less appropriate secondary task engagement decisions compared with older, more experienced drivers. Education may give the novice drivers the ability to make better engagement timing choices that older drivers develop through their greater driving experience. The benefit of more sophisticated risk and awareness training for novice drivers has been demonstrated in the literature (Isler et al. (2009), Walker et al. (2009), Crundall et al. (2010)).

It also seems from the findings in this thesis that the dangers associated with answering a call while driving are largely misjudged. *Answer a call* was found to be the phone function most willing to be engaged with in all three studies and this was frequently a consequence of it being regarded as the least demanding phone function, with participants stating ‘it’s only the case of pressing a button’. This suggests that participants often made their demand ratings for phone use based on the amount of physical or visual interaction the medium requires. Most recent research into hand-held versus hands-free calling has found the hands-free medium to be equally as distracting as hand-held usage, the cognitive element of the phone call being the primary cause of the distraction (Ishigami et al. 2009). Some studies even found hands-free calling to have more of an effect on driving performance as drivers did not adapt their driving behaviour as a result of being on the phone. This may be a result of the hand-held nature of the task reminding drivers of their ‘self-imposed impediment’ whereas simply talking hands-free offers no stimulus to remind them of how demanding the conversation element can be (Patten et al. 2004). Findings in this thesis seem to suggest there may be a divergent response to the answering a call and placing a call functions- drivers often reported refraining from placing a call due to perceiving the task as too demanding but being willing to engage with answering a call in the same scenario. Both tasks result in a conversation that could cause driver distraction but drivers did not seem so concerned about the conversational element of the call.

There is currently a lack of literature concerning the issues identified. It appears this is the first time that willingness to engage for different phone functions has been investigated thoroughly and it is certainly the first time in-depth analysis on engagement decisions has taken place. It seems from these findings that drivers need to be made aware, through better training or advertising campaigns, just how dangerous the conversational element of a call can be while driving and to take this into consideration before engaging with the phone. This is as opposed to simply being made aware of how demanding the physical act of placing or answering the call may be.

In a similar vein, there was a higher rating for willingness to engage in reading text messages than was originally anticipated. It had the second highest willingness ratings in both Study 2 and three, with it often being rated more likely to be undertaken than placing a call. This firstly shows how little impact laws prohibiting phone usage seem to have, as placing a call is still legal in hands-free mode in the UK whereas taking their eyes off the road to read a text message would very probably constitute an illegal driving practice. This is in-line with previous research, which also found the law to have little long term impact on phone usage behaviour (Hill (2004), McCartt et al. 2004). The law was also mentioned very infrequently in Study 1 interviews, where factors which inhibit phone interaction were explored. It was also found in both studies 1 and 2 that participants often reported they would engage with reading a text because it no longer required the level of attentional demand with which it was previously associated. Participants often reported that text messages now appeared on the phone screen when received without requiring any interaction to ‘open’ the message, which previous phone interfaces had required. If the phone was kept in a location near the driver’s line of sight, such as a phone cradle on the dashboard, this was reported as leading to a great deal of temptation as well as being perceived as relatively easy to read while driving.

This firstly shows how important it is to educate and remind drivers about how just a few seconds of attention away from the road can lead to far higher probability of accident occurrence (Klauer et al. 2006). It also raises concerns for the future, as more and more vehicle manufacturers are now integrating ‘infotainment’ into the vehicle’s central display. Function on such systems already include internet access, applications, text messages being read aloud when received and the driver’s phones’ contact book being synchronised with the display to enable easier calling. All of these systems make carrying out a secondary task easier. As participants throughout this thesis reported the ease with which the function can be engaged with– as opposed to its overall distracting effect- as an important factor in their willingness to engage it raises the question of whether manufacturers should be making these once difficult tasks more possible when behind the wheel. The manufacturers may argue they are making driving safer, by making the tasks less distracting, but as research in this thesis suggests that task difficulty can discourage task interaction, perhaps these tasks should remain difficult. The inherent difficulty of the task may discourage usage and by making the task simpler, more people may feel capable to engage, even if doing so exceeds their capabilities. An improved interface may make interaction safer for the few who would have otherwise engaged with their phone but far more dangerous for the many who otherwise would not have engaged at all.

These findings could be taken as evidence that an adaptive system developed by vehicle manufacturers to help ‘manage’ task interaction may be of use. This system could detect factors identified in this thesis, such as road demand and the nature of the task wanting to be engaged with, and delay the information presented to the driver based on the overall task demand experienced at the time. The studies in this thesis demonstrate a possible need for such a system as currently drivers neglect to appropriately take these issues into account. One such example would be to delay the presentation of a text message or to automatically divert a call to voicemail if the system detects the driver is under high demand. As a result this 'management' by the system would thus limit drivers' temptation to initiate task interaction at inappropriate times.

In the introduction it was mentioned that phone usage is not currently reported in many accidents as a contributory factor as a possible consequence of people generally being adept at timing phone engagement until it is less distracting. There seems to be some support for this notion from the findings in this thesis. Drivers certainly seem to take task demand into account, as opposed to simply engaging with a phone whenever need or desire arises, with both road demand and the demand of phone usage taken into account when making engagement decisions. This was particularly true for older, more experienced drivers, who were adept at avoiding phone engagement when demand increased, except for when answering a call which was found to be relatively insensitive to any factors which could reduce phone usage. For this user group, this may go some way to explaining why phone usage does not contribute to a high number of accidents as may be expected from current literature findings. However, younger, less experienced drivers were found to be willing to engage with their phones at inappropriate times, such as when overtaking a car when it was also dark and raining. This age group was found to be more capable at phone usage while driving but whether this would be enough to offset such poor decisions for phone engagement timing seems doubtful.

7.7 Future Work

The field of willingness to engage with mobile phones is still largely unexplored. This thesis aimed to make a contribution to knowledge in this area, but there is still a lot that is unknown about what can influence phone engagement behaviour.

One study that would be particularly useful would be to build on the findings in Study 3 that driving capability, age or phone capability can influence willingness to engage. Due to the difficulties of sampling, separating which of these factors had the greatest effect on willingness to engage was difficult. It is suggested a better resourced study that can offer sufficient incentives to allow the recruiting of older, experienced phone users for comparison against older, inexperienced phone users would allow for further insight to be gained. By controlling age and driving experience and only varying phone capability, it would be possible to make stronger conclusions on the effects of phone capability on engagement behaviour while driving.

Similarly, a study comparing older inexperienced drivers who are capable phone users with younger, inexperienced drivers who are capable phone users would give additional insight. This study should control phone and driving capability and only vary age to allow conclusions on the effects of age on willingness to engage with phones while driving. These older, inexperienced drivers who are capable phone users would certainly be difficult to recruit but with sufficient funding for recruitment and incentivising participation it would not be impossible to assemble a sample. Testing this sample's performance on the Lane Change Task would also be interesting, as both samples would be equally inexperienced at driving and capable at phone use. Therefore, little difference in driving performance while using the phone would be expected. However, it is known that with ageing comes a reduced ability to process information in parallel which impairs dual task performance. It would be interesting to assess whether the sample was sufficiently aware of any decline in abilities to influence their engagement behaviour.

As a consequence of ethical, financial and temporal limitations none of the studies conducted in this thesis took place on real roads. However, this does make generalising findings to real life difficult as all findings were based on what participants said they would do or were observed to do in a simulated environment. A large scale trial on road observation study looking at drivers of different ages, driving experience and phone experience would add insight and help to validate findings from this thesis and add substantially to the willingness to engage with mobile phone literature. Observing drivers' phone interactions when behind the wheel of their own car and on real roads is proposed as a logical next step for phone use while driving research. This would allow for observation of whether drivers really do delay phone interaction based on road demand, along with the percentage of incoming phone calls and messages that are ignored. It would also inform if there are some functions which are engaged with more frequently than others.

It was found throughout the research reported in this thesis that participants are relatively willing to engage with reading a text message. This was mostly due to the task being seen as easy to conduct with modern phone interface designs displaying the message on the screen when received, without requiring any physical interaction by the driver. This raises the question as to whether car manufacturers making email, Facebook, internet access, text to speech text messaging and the internet accessible through the car's dashboard interface are potentially contributing to an increase in drivers engaging in distracting behaviour. It is posited that a controlled experimental study should be undertaken with two groups, one having access to features on the display screen and the other required to navigate their phone menus to access such functions, to test for a variance in willingness to engage with the tasks while driving. Many studies only look at the distracting effects of interfaces and not on the effects on user uptake of such technologies while driving- if it makes drivers feel more capable to carry out the task, are they then more likely to do so? This is a very important question as manufacturers frequently argue that they are only responding to consumer demands and have designed the interface to pose as little distraction as possible. If the manufacturer interfaces do offer less distraction compared to phone interfaces, then it may be fair to conclude that such interactions increase safety compared to drivers trying to use their phone. However, if this ease of use makes more drivers more willing to engage in distracting activity, which they would not have otherwise conducted, then this may be cause for concern.

Study 2 found that drivers based their phone interaction decision on both the phone function intended to be engaged with and the road demand at the time, aiming to maintain an acceptable level of demand. Answering a call was the most frequently engaged function, as it simply required the push of one button to complete the engagement. This does not take into account the cognitive element of the task, in terms of requiring engagement in discussion once the button had been pressed, suggesting that drivers may be underestimating the demand the task can place on their resources. A study testing drivers' internal models of estimated demand, based on function and perceived road demand at the time, compared against a more objective measure of the demand the task actually causes would be of interest. For example, findings in Study 3 comparing self-rated and actual phone use ability while driving showed participants to be accurate at predicting their phoning ability but not their texting ability. If drivers are basing engagement decisions on a mental model of how demanding the task is likely to be, it would be interesting to determine the accuracy of these internal mental models. If they are found to be significantly different from the actual level of distraction and demand caused by the task then this may raise issues of concern, with drivers needing to be made more aware of their poor judgement or trained to make better, more accurate, demand assessments.

Again, building on findings from Study 2 that drivers make engagement decisions based on the demand they perceived at the time, it was also mentioned in the "think aloud" element, by a number of participants, that the decision of whether or not to engage would be based on local knowledge. The participants reported that they might be under a low demand scenario now but if they knew that the demand would increase in a moment, from their local knowledge of the roads, they might not engage based on a predictable increase in demand. A study testing to what extent local knowledge of road demand can influence engagement behaviour could explore this possibility. A controlled experiment in which one group of participants drive a simulated environment a number of times, in order to familiarise themselves with the environment, before their engagement behaviour is observed, compared to a second group who are offered no familiarisation opportunity would allow this theory to be tested. This would allow conclusions on the extent to which drivers base their engagement decisions on their local knowledge, not just basing their decision on demand at the time but expected upcoming demand as well.

There are further factors which may influence willingness to engage that were not tested in the current thesis and which may enhance the proposed model for phone engagement decisions. Risk taking propensity may influence willingness to engage but it was beyond the scope of the current thesis to test this possibility. An initial study on this topic has recently been undertaken by Merat et al. (2013), finding those who are higher on a sensation seeking scale are more likely to perform calls and those lower on the scale more likely to perform text messages, but there is still scope for further study on this. Similarly, personality factors such as introversion and extroversion may have an impact on willingness to engage and could usefully be explored. The importance of the phone function's 'message content' was mentioned as having an impact on willingness to engage throughout Study 1 interviews. This variable was controlled for in the studies in the thesis by clearly stating that all phone use should be considered important and example scenarios were given. However, there is scope to test this factor experimentally to make more firm conclusions on its impact on engagement decisions.

7.8 Concluding Statement

This thesis contributed to current 'mobile phone use while driving' literature by focussing not on the effects of phone use whilst driving but on the under-researched topic of what can influence phone engagement behaviour in the first place. Its unique contribution was first to look at how factors which influence willingness to engage out of the car transfer also to what happens behind the wheel. In other words, to what extent driving could be considered a unique environment in terms of the factors which influence willingness to engage, this is an issue which has been very under-explored in the literature. This study also aided in highlighting factors which may influence willingness to engage with a phone when in control of a vehicle which were also largely unexplored. This led to experimental testing of the extent to which drivers delay their interaction based on road demand. In many ways the study provided evidence that was in dispute in the current literature. Most crucially the extent to which phone function could affect the decision to engage was studied. This was an entirely new contribution to the 'willingness to engage literature'. In addition, the final study also offered entirely new insight to the literature through studying the extent to which either driving or phone capability could have an impact on willingness to engage decisions. Suggestions for how the findings presented in this thesis can effectively be used, along with how future work should proceed to build on the foundations made by this thesis were proposed.

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Appendices

9.1 Appendix 1: Study 1 Participant Information Sheet

This information sheet was provided to paricipants prior to taking part in the study.

The Implications of Smartphone Usage Whilst Driving

Participant Information Sheet

Graham Hancox (g.hancox@lboro.ac.uk)

John Richardson (j.h.richardson@lboro.ac.uk)

Dr Andrew Morris (a.p.morris@lboro.ac.uk)

What is the purpose of the study?

The purpose of the study is to gain insight into how people are using their smartphones both outside of a vehicle and whilst driving. It is hoped that identifying what smartphone are used for will highlight future areas of research that warrant study.

Who is doing this research and why?

The study is being conducted by Graham Hancox from the department of Design at Loughborough University, as part fulfilment of his PhD thesis. It is supervised by John Richardson and Dr Andrew Morris. This study is a part of a student research project funded by Loughborough University.

Are there any exclusion criteria?

Participants must own a smartphone and have their own car, as well as being a frequent phone user (used daily) and drive regularly (at least twice a week).

Once I take part, can I change my mind?

Yes! After you have read this information and asked any questions you may have we will ask you to complete an Informed Consent Form, however if at any time, before, during or after the sessions you wish to withdraw from the study please just contact the main investigator. You can withdraw at any time, for any reason and you will not be asked to explain your reasons for withdrawing.

Will I be required to attend any sessions and where will these be?

Attendance will be required; the location will be arranged with each participant on an individual basis.

How long will it take?

One interview will be conducted; this will be approximately 45 minutes long.

Is there anything I need to do before the sessions?

No.

Is there anything I need to bring with me?

Bringing your smartphone may be useful for prompting memory during the interview.

What will I be asked to do?

Answer questions on your behaviour and experiences with your smartphone.

Will my taking part in this study be kept confidential?

Yes, all data will be kept completely confidential, no names or identifying information will be published. Audio recordings will be kept until they have been transcribed into a written format and then deleted.

What will happen to the results of the study?

The results of the study will be included in a PhD thesis and possibly be published in a journal or conference paper.

What do I get for participating?

There are no incentives on offer for participation.

I have some more questions who should I contact?

Graham Hancox (g.hancox@lboro.ac.uk)

What if I am not happy with how the research was conducted?

The University has a policy relating to Research Misconduct and Whistle Blowing which is available online at http://www.lboro.ac.uk/admin/committees/ethical/Whistleblowing(2).htm.

9.2 Appendix 2: Study 1 Tables Displaying Willingness to Engage Ratings

The tables, which follow, represent mean rating scale responses showing the participants' propensity to engage with a phone function in each environment and scenario. For the findings to be included in the tables at least 75% of the participants had to have given a rating of their willingness to engage in that scenario and environment. For example *for 'placing a call information need'* less than 75% of participants said expecting an incoming call/ text or email would have an effect on results in all of the environments and therefore the findings from this were not included in the tables.

In the cases where participants considered the scenario to apply for some environments but not others the scenario was included in the tables but the environments where it didn't apply were denoted to be not applicable with an N/A marking. For example having family present in a meeting was not considered applicable, no rating scale ratings were given so it has an N/A next to it. However, the scenario did make sense for all the other environments and was therefore still included in the charts.

9.2.1 Appendix 2 Table 1: Place a Call

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Place Call Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	2.10 1.20	1.75 1.24	3.85 1.14	2.68 1.53	4.10 1.10
Bored Expecting Call/ Email/Text Mean: S.D.:	2.27 1.58	1.75 1.24	3.85 1.14	2.68 1.53	4.10 1.10
Information Need Mean: S.D.	2.55 1.61	3.23 1.60	4.45 1.05	3.50 1.21	4.52 0.84
People Present- Friends Mean: S.D.:	1.20 0.41	N/A	3.38 1.31	2.32 1.38	3.47 1.33
People Present -Family Mean: S.D.:	1.32 0.58	N/A	3.25 1.24	2.00 1.19	3.56 1.41
People Present- Work Colleagues Mean: S.D.:	N/A	1.82 0.95	3.20 1.48	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	1.60 0.63	3.20 1.48	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.24 0.56	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	1.20 0.41	N/A	N/A	N/A
High Workload Mean: S.D.:	1.22 0.43	1.44 1.01	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.70 1.08	1.57 1.28	3.67 1.36	2.00 1.21	2.39 1.29
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.75 1.18	1.57 1.28	3.67 1.36	2.00 1.21	2.36 1.34

9.2.2 Appendix 2 Table 2: Answer a call

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Answer Call Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	2.63 1.38	1.50 0.90	4.25 1.21	3.42 1.30	4.75 0.55
Bored Expecting Call/ Email/Text Mean: S.D.:	3.27 1.49	1.50 0.90	4.25 1.21	3.42 1.30	4.75 0.55
Information Need Mean: S.D.	2.55 1.57	2.72 1.64	4.35 0.99	3.69 1.20	4.68 0.67
People Present- Friends Mean: S.D.:	1.33 0.62	N/A	3.81 1.38	2.95 1.18	4.35 0.93
People Present -Family Mean: S.D.:	1.47 0.84	N/A	3.69 1.40	2.61 1.29	4.35 0.93
People Present- Work Colleagues Mean: S.D.:	N/A	2.24 1.30	3.90 1.37	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	4.00 1.13	3.90 1.37	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.47 0.87	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	3.00 1.36	N/A	N/A	N/A
High Workload Mean: S.D.:	1.44 0.62	1.33 0.71	N/A	N/A	N/A
Time Pressure Mean: S.D.:	2.25 1.33	1.43 0.76	4.07 1.03	2.50 1.38	3.67 1.03
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	3.13 1.26	1.43 0.76	4.07 1.03	2.50 1.38	4.71 0.73

9.2.3 Appendix 2 Table 3: Send a Text Message

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Send Text Message Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	1.63 0.90	3.00 1.32	4.90 0.31	4.53 0.70	4.45 1.10
Bored Expecting Call/ Email/Text Mean: S.D.:	1.53 1.13	3.00 1.32	4.90 0.31	4.53 0.70	4.45 1.10
Information Need Mean: S.D.	1.70 1.03	3.67 1.50	4.80 0.52	4.31 1.08	4.58 0.84
People Present- Friends Mean: S.D.:	1.07 0.26	N/A	4.00 0.97	2.84 1.26	3.76 1.48
People Present -Family Mean: S.D.:	1.58 0.50	N/A	3.88 0.96	2.44 1.20	3.38 1.54
People Present- Work Colleagues Mean: S.D.:	N/A	3.18 1.33	4.00 1.25	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	2.80 1.37	4.00 1.25	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.41 0.71	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	1.20 0.56	N/A	N/A	N/A
High Workload Mean: S.D.:	1.06 0.24	1.44 1.01	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.30 0.66	1.57 1.16	4.00 1.25	2.58 1.16	2.28 1.23
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.31 0.87	1.57 1.16	4.00 1.25	2.58 1.16	2.36 1.34

9.2.4 Appendix 2 Table 4: Read a Text Message

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Read Text Message Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	2.11 1.10	3.13 1.45	4.95 0.22	4.68 0.58	4.75 0.64
Bored Expecting Call/ Email/Text Mean: S.D.:	2.47 1.60	3.13 1.45	4.95 0.22	4.68 0.58	4.75 0.64
Information Need Mean: S.D.	2.00 1.03	3.44 1.42	4.75 0.64	4.25 1.29	4.63 0.83
People Present- Friends Mean: S.D.:	1.07 0.26	N/A	4.19 0.83	3.53 1.31	4.41 1.06
People Present -Family Mean: S.D.:	1.21 0.71	N/A	4.06 0.85	2.94 1.43	4.06 1.29
People Present- Work Colleagues Mean: S.D.:	N/A	3.82 1.13	4.30 0.95	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	4.40 0.83	4.30 0.95	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.65 1.06	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	2.80 1.52	N/A	N/A	N/A
High Workload Mean: S.D.:	1.11 0.32	1.89 1.05	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.40 0.75	1.79 1.12	4.33 1.11	2.75 1.36	3.61 1.20
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.81 1.11	1.79 1.12	4.33 1.11	2.75 1.36	4.71 0.73

9.2.5 Appendix 2 Table 5: Send an Email

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Send Email Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean:	1.05	2.25	3.80	3.11	2.90
S.D.:	0.23	1.39	1.61	1.70	1.52
Bored Expecting Call/ Email/Text Mean:	1.13	2.25	3.80	3.11	2.90
S.D.:	0.52	1.39	1.61	1.70	1.52
Information Need Mean:	1.10	3.17	3.85	3.31	2.89
S.D.	0.31	1.82	1.53	1.74	1.70
People Present- Friends Mean:	1.00	N/A	2.63	1.84	2.00
S.D.:	0.00		1.41	1.34	1.37
People Present -Family Mean:	1.05	N/A	2.50	1.78	1.94
S.D.:	0.23		1.41	1.35	1.39
People Present- Work Colleagues Mean:	N/A	2.18	2.50	N/A	N/A
S.D.:		1.07	1.58		
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	1.87 1.13	2.50 1.58	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.18 0.53	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	1.07 0.26	N/A	N/A	N/A
High Workload Mean: S.D.:	1.00 0.00	1.44 1.01	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.10 0.45	1.36 0.84	2.93 1.75	1.33 0.49	1.61 0.85
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.13 0.52	1.36 0.84	2.93 1.75	1.33 0.49	1.57 0.76

9.2.6 Appendix 2 Table 6: Read an Email

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Read Email Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	1.16 0.50	2.50 1.37	4.50 1.00	3.79 1.44	3.60 1.31
Bored Expecting Call/ Email/Text Mean: S.D.:	1.20 0.56	2.50 1.37	4.50 1.00	3.79 1.44	3.60 1.31
Information Need Mean: S.D.	1.10 0.31	3.50 1.42	4.20 1.40	3.75 1.44	3.58 1.57
People Present- Friends Mean: S.D.:	1.00 0.00	N/A	3.06 1.24	2.05 1.31	2.65 1.41
People Present -Family Mean: S.D.:	1.11 0.46	N/A	2.94 1.29	1.94 1.35	2.38 1.54
People Present- Work Colleagues Mean: S.D.:	N/A	2.71 1.07	3.30 1.34	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	3.93 1.28	3.30 1.34	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.29 0.69	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	2.13 1.36	N/A	N/A	N/A
High Workload Mean: S.D.:	1.00 0.00	1.44 1.01	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.20 0.52	1.36 0.84	3.27 1.53	1.50 0.52	1.67 0.97
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.25 0.58	1.36 0.84	3.27 1.53	1.50 0.52	3.57 1.65

9.2.7 Appendix 2 Table 7: Internet Usage

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Internet Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	1.00 0.00	2.31 1.35	4.30 1.26	3.79 1.44	3.65 1.46
Bored Expecting Call/ Email/Text Mean: S.D.:	1.00 0.00	2.31 1.35	4.30 1.26	3.79 1.44	3.65 1.46
Information Need Mean: S.D.	1.25 0.55	3.78 1.48	4.70 0.92	4.75 0.45	4.26 0.83
People Present- Friends Mean: S.D.:	1.00 0.00	N/A	2.75 1.18	2.16 1.50	2.53 1.33
People Present -Family Mean: S.D.:	1.00 0.00	N/A	2.63 1.15	1.72 1.36	2.44 1.46
People Present- Work Colleagues Mean: S.D.:	N/A	2.41 1.00	2.50 1.43	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	1.93 1.22	2.50 1.43	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.18 0.40	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	1.27 1.03	N/A	N/A	N/A
High Workload Mean: S.D.:	1.00 0.00	1.22 0.67	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.00 0.00	1.14 0.53	3.67 1.45	1.83 0.94	1.72 1.02
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.00 0.00	1.14 0.53	3.67 1.45	1.83 0.94	1.57 1.16

9.2.8 Appendix 2 Table 8: Applications

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Applications Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	1.74 1.48	1.31 1.01	3.50 1.64	2.84 1.68	2.65 1.81
Bored Expecting Call/ Email/Text Mean: S.D.:	1.20 0.77	1.31 1.01	3.50 1.64	2.84 1.68	2.65 1.81
Information Need Mean: S.D.	1.85 1.57	1.44 1.04	3.50 1.67	3.44 1.75	2.74 1.66
People Present- Friends Mean: S.D.:	1.47 0.99	N/A	2.31 1.40	1.89 1.49	1.89 1.41
People Present -Family Mean: S.D.:	1.68 1.29	N/A	2.19 1.33	1.56 1.34	1.69 1.25
People Present- Work Colleagues Mean: S.D.:	N/A	1.56 0.93	2.00 1.15	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	1.47 0.92	2.00 1.15	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.29 0.99	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	1.27 1.03	N/A	N/A	N/A
High Workload Mean: S.D.:	1.83 1.50	1.22 0.67	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.65 1.27	1.29 0.83	3.07 1.83	1.50 0.67	1.50 0.86
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.75 1.39	1.29 0.83	3.07 1.83	1.50 0.67	1.29 0.61

9.2.9 Appendix 2 Table 9: MP3 Player Usage

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

MP3 Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	2.05 1.54	1.00 0.00	3.90 1.45	1.58 1.07	2.50 1.67
Bored Expecting Call/ Email/Text Mean: S.D.:	1.47 1.13	1.00 0.00	3.90 1.45	1.58 1.07	2.50 1.67
Information Need Mean: S.D.	1.75 1.37	1.00 0.00	2.85 1.73	1.44 1.09	2.05 1.35
People Present- Friends Mean: S.D.:	1.60 1.30	N/A	2.00 1.21	1.0 0.00	1.53 1.01
People Present -Family Mean: S.D.:	1.58 1.17	N/A	1.81 1.17	1.43 1.09	1.50 0.82
People Present- Work Colleagues Mean: S.D.:	N/A	1.12 0.49	1.60 0.84	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	1.00 0.00	1.60 0.84	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.00 0.00	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	1.00 0.00	N/A	N/A	N/A
High Workload Mean: S.D.:	1.27 0.83	1.00 0.00	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.50 1.15	1.00 0.00	2.87 1.68	1.00 0.00	1.11 0.32
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.375 1.09	1.00 0.00	2.87 1.68	1.00 0.00	1.14 0.36

9.2.10 Appendix 2 Table 10: Games Usage

Mean ratings for willingness to engage and standard deviation values for each environment and scenario.

Games Scenarios	Driving	Meeting	Public Transport	Restaurant	Shopping
Bored Mean: S.D.:	1.00 0.00	1.19 0.54	3.40 1.57	2.63 1.77	2.05 1.57
Bored Expecting Call/ Email/Text Mean: S.D.:	1.00 0.00	1.19 0.54	3.40 1.57	2.63 1.77	2.05 1.57
Information Need Mean: S.D.	1.00 0.00	1.00 0.00	2.20 1.44	2.00 1.79	1.58 1.30
People Present- Friends Mean: S.D.:	1.00 0.00	N/A	1.75 1.13	1.00 0.00	1.71 1.10
People Present -Family Mean: S.D.:	1.00 0.00	N/A	1.63 1.02	1.00 0.00	1.38 0.72
People Present- Work Colleagues Mean: S.D.:	N/A	1.29 0.69	1.60 0.97	N/A	N/A
People Present- Work Colleagues Expecting Call/ Email/ Text Mean:					

S.D.:	N/A	1.07 0.26	1.60 0.97	N/A	N/A
People Present-Authority figure Mean: S.D.:	N/A	1.00 0.00	N/A	N/A	N/A
People Present -Authority figure Expecting Call/ Email/Text Mean: S.D.:	N/A	1.00 0.00	N/A	N/A	N/A
High Workload Mean: S.D.:	1.00 0.00	1.00 0.00	N/A	N/A	N/A
Time Pressure Mean: S.D.:	1.00 0.00	1.00 0.00	1.93 1.39	1.00 0.00	1.11 0.47
Time Pressure Expecting Call/ Email/ Text Mean: S.D.:	1.00 0.00	1.00 0.00	1.93 1.39	1.00 0.00	1.00 0.00

9.3 Appendix 3: Study 2 Video Clip Descriptions

Note: 'The driven vehicle' is used to describe the car which had a video recorder fitted to it, it gives a driver's eye view of the road scene and is the vehicle participants in the study imagined they were in control of when making their willingness ratings.

The reference to the clip saying 'now' refers to an auditory indicator to participants of the exact moment which they were to base their willingness ratings on.

The 'inside lane' refers to the left hand lane of a British motorway. The 'outside lane' refers to the right hand lane of a British motorway- sometimes known as the fast lane.

All video clip recordings took place in dry weather and in the daylight.

Scenario name	Video description	Demand rating
Entering motorway	The driven vehicle is going along a motorway slip road with a large truck in front of it. The vehicle has to enter the motorway, ensuring there are no vehicles in the inside lane-which it is required to merge into, whilst also ensuring it maintains a safe gap to the truck in front, which itself is also attempting to merge with the motorway traffic. The inside lane has a vehicle approaching which the driven vehicle's driver would need to be aware of and time their interaction with. The clip says 'now' whilst the	High

	driven vehicle is at the bottom of the slip road just prior to entering the motorway's inside lane.	
Motorway medium traffic	The driven vehicle is in the middle lane of a motorway. When the clip says 'now' there are other cars in the middle lane a safe distance away as well as cars moving quickly past the driven vehicle in the outside lane also the driven vehicle does not have to carry out any manoeuvre, simply keep a safe distance from the traffic ahead.	Mid
Motorway empty	The Driven vehicle is on the inside lane of a motorway. The road is straight and there are no bends or any other cars around at any point in the recording, including when the clip says 'now'.	Low
Leaving motorway	The driven vehicle is on the inside lane of the motorway at a safe distance behind another car. The car ahead, as well as the driven vehicle, then both turn left off of the motorway and onto a slip road. The clip says 'now' as the driven vehicle is just turning onto the slip road and leaving the motorway, it is still a safe distance from the car ahead and the road is straight immediately after turning. There is, however, a bend in the road in the distance and it is not possible to	High

	see what is around that bend.	
Motorway overtake	The car is in the middle lane of a motorway and is approaching a slower moving vehicle in the same lane, there is also traffic in the inside lane of the motorway, the outside, fast lane, is empty. When the clip says 'now' the driven vehicle is in the process of changing to the outside lane to overtake the slow moving vehicle. It would be important to check the lane is clear of traffic adjacent to the vehicle and be aware of fast moving vehicles approaching from behind.	High
Main arterial stopped at roundabout	The driven car is stopped at a roundabout with a car having just gone past from the right hand side. When the clip says 'now' the driven car is still stationary but the road is clear so the driver is about to pull out.	Mid
Main arterial fast flowing traffic	When the clip says 'now' the driven car is going along a straight main arterial road. It is a safe distance from the car ahead and it is possible to see that the traffic in front of that car is still moving without there being any foreseen congestion or reason to stop or slow down.	Low
Main arterial left turn	The driven car is waiting at a traffic light controlled left turn, it is at the	Mid

	front of the queue with no cars in front of it. When the clip says ‘now’ the light has gone green and the vehicle is part way through the turning manoeuvre.	
Main arterial through green light	The driven car is on a straight arterial road at a safe distance from another car ahead of it, in the distance a set of traffic lights can be seen with the option of staying in the left hand lane to go straight on or go into the right hand lane to turn right. When the clip says ‘now’ the driven car is in the left hand lane still and is now very close to the traffic lights, it is going to proceed through the lights as they are still green.	Low
Main arterial going around a roundabout	The driven car has entered a large roundabout in the left hand lane with the intention of going straight on. When the clip says ‘now’ the car is negotiating the turn of the roundabout in the left hand lane and another car can be seen in the right hand lane, slightly ahead of the driven vehicle, the driver needs to be aware this car may cut into their lane if it too wants to go straight on, although it does not and instead follows the roundabout further while the driven car exits the roundabout.	High
Main arterial	The driven vehicle slows down and eventually stops at a stationary red	Low

stationary red light	light. There are two other vehicles ahead of the driven vehicle who do the same. When the voice says ‘now’ the light is still red and the driven vehicle is still sitting stationary at the lights. There is also traffic still moving in the opposite direction so it is clear the lights will be red for a little while longer.	
City environment slow moving traffic	The driven vehicle is in the left hand lane of a built up city environment. Although moving slowly the driven vehicle is very close to the car in front and congestion can be seen in front of that car also. When the clip says ‘now’ the driven car is moving steadily on a straight piece of road but the driver has to be ready to react to the car in front if it was to suddenly stop.	Mid
City environment turn right	The driven vehicle is in a built up city environment. When the clip says ‘now’ the driven vehicle has gone through a green light, in the right hand lane, and is following the flow of traffic around to the right, negotiating a sharp turn with traffic to the left of the vehicle firstly going in the same direction but then continuing straight on whereas the driven vehicle, and a few other vehicles in the same lane, follow the road round to the right. Traffic can be seen in the opposite directions to be	High

	stationary waiting at the lights.	
City environment approaching stationary traffic	The driven vehicle is in a built up city environment on a straight piece of road when it approaches traffic sitting stationary at a red light. When the clip says ‘now’ the vehicle is in the process of slowing down so it too can be stationary behind the vehicles but it is not fully stopped at this point so the driver is having to judge the distance and how much brake to apply to stop in time.	Mid
City environment fast flowing traffic	The driven vehicle is on a straight piece of road in a built up city environment. When the clip says ‘now’ there are many cars that can be seen to be ahead of the driven vehicle but traffic is flowing well and the car is a reasonable distance from the vehicle ahead.	Low

9.4 Appendix 4: Study 2 Participant Information Sheet

This information sheet was provided to participants prior to taking part in the study

Information Sheet

The aim of this study is to find out to what extent the roadway environment (such as stationary at traffic lights compared to travelling on an empty motorway) affects phone use while driving. You will be asked to view a number of video clips of different driving scenarios (such as entering a motorway from a slip road) and then give a rating from 1 to 3 on:

- The likelihood of you answering a call, placing a call, sending a text and reading a text in that scenario.

As well as a rating from 1-5 on:

- How risky you think using your phone at that point would be (the chance of it leading to an accident if you answered or placed a call)
- How demanding you perceived the road environment to be

Along with these ratings you will be asked to talk through why you choose the ratings you did so that further insight into factors affecting drivers' phone use can be gained.

Please imagine you want to answer/read a short but important phone call or text message or remembered you have a time constrained need to place a call or send a text message.

> *Examples include your line manager calling. You have a relative in hospital and the hospital phones. You've forgotten your house keys and you need to ask someone not to leave the house. Someone is expecting you at a certain time but you're running very late.*

For all videos we ask you to imagine the same driving scenario:

For answering a call/ reading a text message ‘you are driving alone in dry, clear weather on a weekday afternoon and you are expecting an important call or text which has some time pressure attached to’

For placing a call/ sending a text message ‘you are driving alone in dry, clear weather on a weekday afternoon and you remember it’s important you promptly place a call or send a text message to a person in your phone’s phone book’.

You will be played two practice videos clips followed by a chance to ask any questions that you may have.

You have the right to withdraw from this study at any point

We would ask that you report what you would actually do in these scenarios not what you think you should do. All results will be completely anonymous and your name will not be linked to any findings published.

Thank you for taking the time to participate in this study.

Graham Hancox

Loughborough Design School

9.5 Appendix 5: Study 2's Table Used to Give Ratings of Willingness, Riskiness and Demand for the Video Clips

Clip 1	Ratings 1-3
Willingness to place a call	
Willingness to answer a call	
Willingness to send a text message	
Willingness to read a text message	
	Ratings 1-5
Demand of the road environment	
Riskiness of placing a call	
Riskiness of answering a call	

9.6 Appendix 6: Study 3 Information Sheet

This Information sheet was provided to participants prior to taking part in the study

Information Sheet

Aim

The study is investigating phone usage behaviour whilst driving

Tasks

You will first be asked to practice a number of simple phone tasks.

You will then be given a chance to practice driving in a simulated driving environment and get used to how the car behaves and handles.

When driving in the simulator please try and keep the speed to a constant 50mph

If you see a car in front of you please overtake it, keeping the speed constant at 50mph if you can

Next you will drive the simulated car but also be presented with the opportunity to interact with the phone tasks you practiced earlier. Please imagine you are in a real driving scenario (not a simulator) and drive how you would normally drive on the road. If you feel you would normally carry out the phone tasks whist driving then you will go ahead and interact with the task, if not you will carry on driving and ignore the phone task, simply ask yourself how you would behave in real life and act accordingly. It is how you act with your phone in real driving scenarios which is of interest.

When considering whether or not you would engage with the phone please consider the phone calls/ texts to be important

- *Examples of an important call include your line manager calling. You have a relative in hospital and the hospital phones. You've forgotten your*

house keys and you need to ask someone not to leave the house.
Someone is expecting you at a certain time but you're running very late

If you have interacted with your phone please then go back to the home screen of your phone so you start from the same menu each time.

Also please check your phone's auto locking function is disabled so you will not have to unlock your phone each time.

Lane Change Task

Next we will move on to a different driving simulator and a different driving task. You be asked to carry out certain phone tasks regardless of whether or not you would normally interact with your phone and your performance will be measured.

Please note: some people can feel nauseous when in a driving simulator, if this is the case then please inform the experimenter immediately and a break will be given.

Please be aware you have the right to withdraw from this study at any point

All results will be completely anonymous and your name will not be linked to any findings published.

Thank you for taking the time to participate in this study.

Graham Hancox

Loughborough Design School