Drivers' Willingness to Engage with their Mobile Phone: the Influence of Phone Function and Road Demand

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Abstract

Drivers normally elect whether or not to engage with a secondary task whilst driving. This study aimed to determine whether drivers' willingness to engage with their mobile phone is affected by demands from the roadway environment and if these effects are more pronounced for some phone functions compared with others. Fifteen video clips were played to twenty participants representing different road scenarios, and therefore demands, such as driving on an empty auto route or turning right on a main arterial road. The participants then used three point Likert scales to rate their willingness to place or answer a call and send or read a text and a five point scale to rate the perceived riskiness of placing and answering a call only. Participants were also asked to think aloud when making their judgements so further insight could be gained. It was found that willingness to engage was affected by both the perceived roadway demands and the phone function under consideration. The perceived riskiness also affected willingness to engage when placing a call only. The think aloud element indicated the participants' reasoning behind these findings as well as identifying possible future areas of research.

Introduction

Fuller [1] suggested that drivers try to maintain an acceptable level of task demand. He proposed the *task capability interface* (TCI) suggesting driver behaviour is affected by the

interaction between task difficulty and the driver's capabilities which determine the level of task demand. Few studies have investigated the factors affecting drivers' decisions on when to engage with their mobile phones. Instead many focus only on the effects on driving performance once they have started their phone interaction. However, 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.

As Lerner [2] 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'.*

There has been some investigation into whether drivers delay their interactions with devices based on the current road environment and road demands. There is evidence to suggest that these factors have little impact on the timing of interactions, often leading to driver error (see Horrey and Lesch [3] and Lerner [2] for further details).

Studies finding conflicting evidence also exist. For example Horrey and Lesch [4] found that as rated demand of traffic scenarios increased participants' willingness to engage decreased, suggesting the driving environment can have an effect on when, and if, drivers interact with non-driving tasks. Esbjörnsson et al [5] reported similar findings in an on-road observation study as did Laurier [6] when looking at the timings of engagement with office work whilst driving. Britshsgi et al [7] found specific road situations where drivers reported being unwilling to use their phone; these included when changing lanes, overtaking, merging with traffic, turning, when passing an intersection or driving in an unfamiliar environment. Further factors found to have an effect included bad weather, heavy traffic conditions and when driving on city roads. Using a survey methodology Ferreira et al [8] found drivers were least likely to use their phone on city roads, were slightly more likely to use them on main

and rural roads and were most willing to use them on highways (auto routes). Conversely, Huemer and Vollrath [9] found, when investigating occupational and private car users' secondary task engagement behaviour, that both demographics had similar engagement rates on an auto route and this was lower than reported for city driving. It was further found that time spent engaged with the task varied depending on the road type with a far shorter task time in city environments and far longer when on an auto route.

Rauch et al [10] used simulated urban and rural stretches of road, varying the demand based on how easily critical incidents, such as a car pulling out or pedestrian crossing the road, could be predicted. It was found that both road type and the situations' criticality significantly influenced willingness to engage, with more tasks being rejected on rural roads and when a critical incident was about to take place. It was also found the harder the critical incident was to predict the more likely it was that the participant engaged in the secondary task, suggesting drivers' perception of how road demand will develop in the near future affects their willingness to engage. Metz et al [11] conducted a very similar study but also varied the secondary task to be either self-paced or system-paced. It was found, that independent of the task type conducted, there was a lower task engagement rate in the critical incident than the non-critical incident situations.

There has been a very large number of studies conducted investigating the effects of phoning on driving performance (see Caird et al [12] for a meta-analysis of the results) but currently few studies have investigated the more specific area of how the road scenario can affect driving performance while using a phone. In an older study by Brookhuis et al [13] it was found, using a test track simulating an empty motorway, busy four way ring road and city traffic, that phone use did affect mental workload but this appeared to be similar regardless of the road scenario experienced. Strayer et al [14] found in a simulator study that talking on a mobile phone led to increased brake reaction time only in a high traffic density condition; there was no effect in a low density condition. Törnros and Bolling [15] found that having a conversation in a complex urban environment led to far more missed peripheral

detection task signals than any of the other, lower demand, environments. Reaction times were also found to be slower in a high speed rural environment compared to a simple urban road environment. These studies highlight how interacting with the phone in more demanding situations may impact driving performance. Given the apparent interaction between environmental demand and phone usage if drivers are found to engage with their phone regardless of driving demand then stricter control of phone usage may be necessary.

The literature indicates very few objective ways of classifying the demand of a roadway environment, the strongest example found was Fastenmeier [16] as cited in Patten [17] who devised a way of classifying road demand 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 medium 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 relatively objective way to classify road demand experienced at any time by looking at the demands placed on the drivers' resources.

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 driver's willingness to engage with their phone. The main focus of research in this area has been around hands free and hand held calling ([18], [15], [19] and [20]). However, there is a paucity of research regarding willingness to engage. Ferreira et al [8] using a survey found answering a mobile phone call was the most frequently conducted phone task whilst driving followed by making a call, reading a text message and the least conducted task was sending a text message. Very few other studies have considered phone usage based on the functionality used and, as of yet,

no studies appear to have investigated how willingness to engage with the device can be affected by the functionality intended to be used.

Many studies have looked into the consequences of phone use while driving but few, as of yet, have investigated factors influencing whether or not drivers engage with their phone in the first place. Although this study looks into factors affecting drivers' engagement with phone and text functions, an increasing prevalence of smartphones in society (featuring internet connectivity and advanced applications) may cause interaction with a phone while driving to be all the more tempting as technology progresses. Therefore, distinguishing factors which currently encourage or inhibit phone engagement, and why, is of increasing importance.

Aims

The first aim was to determine whether the road demand and/ or phone function intended to be used affected drivers' willingness to engage with their mobile phone.

The second aim was to determine whether the perceived risk of using a mobile phone in different driving scenarios affected drivers' willingness to engage with their phone whilst driving.

The final aim was to gain in-depth insight into what drivers take into consideration when deciding whether or not to engage with their mobile phone whilst 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.

Methodology

In a methodology similar to that of Horrey and Lesch [4] 20 participants (4 females and 16 males) who ranged in age between 23-47 years old (mean: 32) were recruited through

advertisements on university notice boards. All had full UK driver's licenses (held on average for 14 years) and, in a pre-study questionnaire, reported using their phone at least occasionally whilst driving. Fully informed consent was gained from participants after they had read an information sheet explaining what the study entailed.

Participants were all shown (in a randomly selected order) 15 pre-recorded video clips (each 8 seconds long) depicting different road scenarios, 5 were auto route based, 6 were main arterial road based and 4 were city driving environment based (see Table 1 for details of the road scenarios used). Using Fastenmeier's [16] classifications (detailed above) the video clips were rated based on their information processing and vehicle handling demand. The 3 road demand classifications resulted in 5 road scenarios being allocated to each demand classification (see Table 1).

Each video clip played for 5 seconds before a recorded voice said 'now' and it was at this point the participants were invited to make their willingness to engage judgements based on the road conditions observed at that exact point in time.

Participants gave ratings of their willingness to place a call, answer a call, send a text and read a text on a 3 point Likert scale with 1 being 'I would absolutely not do this task now', 2 being 'some chance of doing the task' and 3 'I'm very willing to do this task now'. Participants further rated how risky they thought it would be to both place and answer a call at that point in time on a 5 point Likert scale with 1 being 'no additional risk beyond my normal driving and 5 'I'm fairly likely to be involved in an accident', though the participants were not asked to make this rating for sending or reading a text message to minimise response requirements. The call functionalities were deemed to be of most interest due to being legal in the UK, in hands free mode, unlike text messaging, so participants were only asked to rate the riskiness of the place and answer call functionalities. Participants also gave a final rating of how demanding they perceived the road environment to be on a 5 point Likert scale with 1 being 'not at all demanding' and 5 being 'very demanding'.

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

High Demand	Mid Demand	Low Demand
Entering auto route	Auto route medium traffic	Auto route empty
Leaving auto route	Main arterial stopped at roundabout	Main arterial fast flowing traffic
Auto route 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

It was made clear in the information sheet 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 in case this had an effect on their willingness to engage with the device. 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. Usage of the phone referred to hands free functionality where possible i.e. placing and answering a phone call.

Participants were asked to respond to two practice clips to ensure they were familiar with the scales before starting the experiment and any questions about the methodology were addressed at this point.

Whilst making these decisions participants were also asked to think aloud and talk through any factors influencing their responses; these thoughts were recorded on a Dictaphone and transcribed verbatim.

This study utilised a similar methodology to Lerner [2] but used video footage rather than actual driving to avoid participant risk and to ensure that the participants experienced identical roadway demand scenarios. A second difference was that participants were required to provide a verbal protocol on why they made the ratings to gain more in depth insight on how the roadway may affect willingness to engage with a phone and what factors drivers consider when making these judgements.

Results

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 auto route'). As mentioned earlier 5 road scenarios were then grouped to represent a road demand (e.g. High Demand featured: 'entering auto route', 'leaving auto route', 'auto route 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 Road Demand', the same was then conducted for 'Mid' and 'Low Road Demand' also. It was found that the participants' ratings corresponded with the initial classification with the 'High Road Demand' classification having the highest perceived demand (4.1) and the 'Low Road Demand' classification having the lowest perceived demand (2.3), for mean values and standard deviations please refer to Table 1.

Due to rating scales being used to collect the data, along with the data being non-normally distributed, as can be seen in Figure 1, non-parametric tests were used throughout.

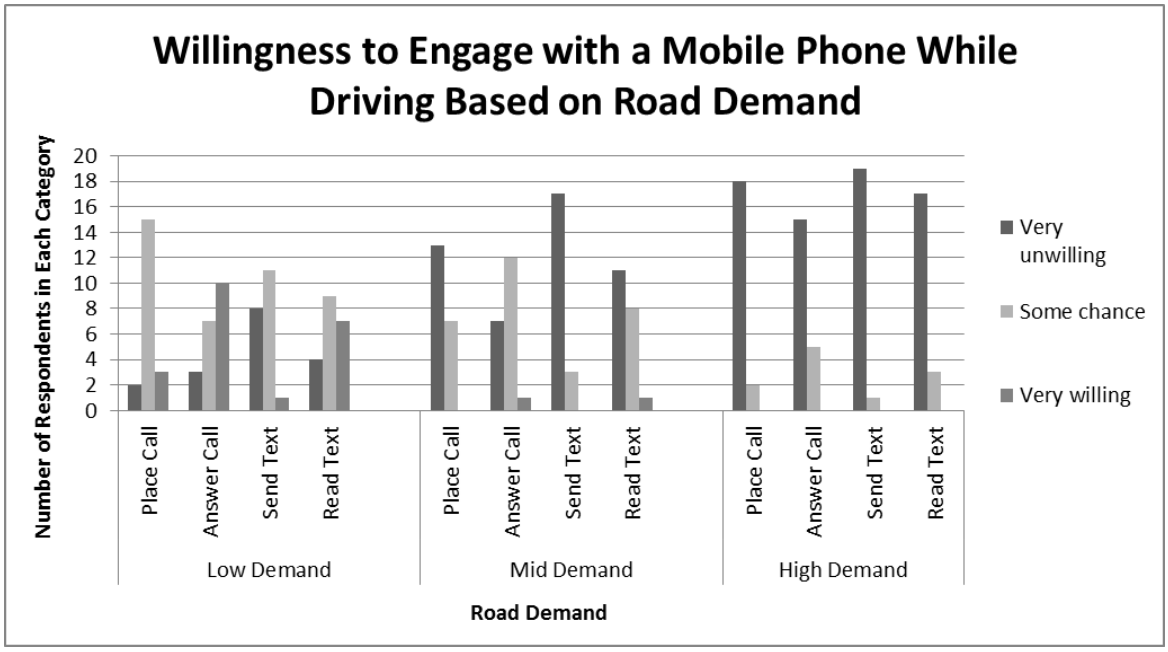

Figure 1: Showing drivers' willingness to engage with mobile phone functionalities based on road demand

Phone Function

As can be seen in Figure 1 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 analysis of variance (ANOVAs) were run for each of the functionality's rating scores for the low, mid and high demand classifications separately.

There was a significant effect for the type of functionality used in low road 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 mid road 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 road demand classification $X^2(3) = 17.966$, p<.01, showing participants were more likely to engage with some functions than others in a high road 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).

Road Demand

As can be seen from Figure 1 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 with a Bonferroni correction so all 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 road 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 road 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 $Z=-3.466$, $p<.0167$).

Risk Ratings

The participants' ratings of perceived risk when placing or answering a call were also collected to assess the influence of the road environment on level of perceived risk. 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).

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.

Correlations

Possible relationships between perceived demand and perceived risk were explored using Spearman's product-moment correlation coefficients.

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. 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 and riskiness and demand were also correlated with one another (see Table 2 for place a call correlation coefficients).

Answer call correlations

In the high demand scenarios perceived riskiness was significantly associated with willingness to answer a call, 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, 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 3 for answer call correlation coefficients).

Table 2: Place a call correlation coefficients for perceived demand of the road environment, perceived riskiness of placing a call and willingness to place a call

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

Table 3: Answer a call correlation coefficients for perceived demand of the road environment, perceived riskiness of answering a call and willingness to answer a call

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

Think aloud

The results from the 'think aloud' segment of the study offered insight as to why the above 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.

Discussion

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

Fuller's [1] 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 competence 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 functionality is intended to be used).

Driving Road 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, based on Fastenmeier's road demand classification reflecting both the physical and cognitive demands of different road environments.

Evidence from the 'think aloud' part of the study helps illustrate 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 is illustrated in a quote for turning left at traffic lights '*I'm turning and I'm watching the other traffic so a lot going on. 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 both cognitive and physical factors being taken into consideration.

Further illustrations include 'w*hen entering a motorway (auto route) 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*', again mentioning both physical and cognitive demand as factors influencing their willingness to engage.

Table 1 shows the driving scenarios used and the demand classification under which they were placed. Participants were also asked to rate how demanding they perceived each road

scenario to be and the participants' average demand score for the low, mid and high classifications were all significantly different from one another. It can be seen in Table 1 that the participants' average demand scores for each category also corresponded with the classification given by the researcher, i.e. the low demand classification had the lowest participant demand rating and the high demand classification had the highest participant demand rating. This may suggest that Fastenmeier's classification method is a valid method for classifying road demand, though further large scale studies would be needed in order to fully validate this finding.

The demand of the road environment was found to have an effect on drivers' willingness to engage with their mobile phone with low road demand situations seeing the highest willingness ratings for phone usage and high road demands the lowest rating of willingness to engage.

This finding was to be expected based on Fuller's model as the low demand from the road placed less demand on the driver providing additional resources for interaction with a secondary task without exceeding their target threshold of acceptable task demand.

This finding agreed with previous studies such as Horrey and Lesch [4] who 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 so finding similar results was not unexpected. Though, Lerner [2] also used a similar methodology but found conflicting evidence, instead finding willingness to engage was not affected by the road demand experienced. However, Lerner [2] asked drivers to drive on a real road environment and rate their willingness to use their phone, it is unclear how this difference may have contributed to a different result.

The 'think aloud' element of the experiment provided valuable insight into what drivers were taking into account when making their decisions. For example one participant mentioned

how their phone use could be dictated by the level of phone signal the road way provided. '*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'.* This illustrates how the roadway affects willingness to engage but not just the demand of the roadway, as would be expected, but its communications infrastructure as well.

The same participant also went on to say '*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... there's roundabouts constantly so… if I do then only on the dual carriageway parts of it so I'm not under too high a workload*' This also illustrates how the road demand can be taken into account with the driver reporting preferred stretches of road on their regular journeys to engage with their phone and these were the ones which were perceived to be of lower demand.

There was also further evidence to suggest that having 'expert' knowledge of the road network may affect phone usage. If drivers knew there were good 'opportunities' to use their phone they might delay their phone usage until they were reached. These opportunities appeared to equate to less demanding roadways. '*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'*. 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 auto route on a slip road as the demand was predicted to greatly increase at this point.

'*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'. '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'.

It wasn't just an expected high workload ahead which was mentioned as a reason for reduced phone usage but also, conversely, an expected low workload which could lead to increased phone usage. '*The boredom factor, you're joining the motorway (auto route) 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 the expected low workload acted as a motivator for using the phone at that moment.

Whether it was due to an expected high or low workload ahead, the think aloud element of the study helped to highlight that demand of the road affects phone usage not just in terms of what is being experienced at the time but predicted future road demand also. The effect that upcoming road demands and local road knowledge can have on willingness to engage is an area which is currently under-researched and could potentially be an important area for future study.

Phone Functionality

When combined, the phone task and road demand was expected to affect how drivers viewed the overall task demand, if this exceeded their acceptable level of demand then phone tasks would not be undertaken.

The results from the study suggested that sending a text was the least likely function to be engaged with in all road demands and answering a call the most likely.

Answering 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 think aloud part of the study helps to explain why this difference may have been found. '*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 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; it was generally perceived to be a less demanding 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.

It wasn't just the phone interactions which were perceived as being different when placing or answering a call, the think aloud data also showed conversational differences for placing and answering a call. '*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'.*

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 scenario. This difference appeared to come from sending a text requiring far more concentration and interaction than reading a text message '*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 (send a) text while driving, I just think it's too dangerous'*.

There were only two functions which had significantly different willingness to engage ratings in the high road demand classification. This suggests in high road demand environments the function intended to be used had much less of an effect on willingness to engage. This may possibly support, and be explained by, Fuller's [1] model which suggests that drivers try to maintain a certain task difficulty level. Drivers were willing to interact with certain functions in low road demand environments as they had spare resources, so answering a call or reading

a text would be possible whilst still maintaining the desired level of task difficulty. However, other functions, such as sending a text message, which may have been perceived as more demanding would not be attempted as this would have exceeded the desired task demand level. However, the high road demand scenarios were perceived as too demanding to leave spare resources for any phone interaction so the function intended to be used had less of an effect.

Perceived Riskiness

The Friedman's ANOVAs and Wilcoxon signed-rank tests showed that the perceived level of risk varied according to the road demand experienced at the time. 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 and vice versa. However, for answering a call riskiness and demand were not associated with one another in any of the road demands. From the findings already discussed this may be expected as generally participants saw answering a call as less risky than placing one so a road being perceived as demanding didn't necessarily mean that answering the call would also be seen as risky. Answering a call was generally seen as being simple to carry out so added little additional demand.

Limitations

There were some limitations to the study's design, the most notable being that the procedure did not allow for driver adaptions to the increased road demand to be taken into account. For example, when drivers are faced with an increased demand in real road driving they may react by reducing their speed and thus reduce some of the demand placed on them. This adaption may then have implications on their willingness to engage with their phone. It was believed necessary to experimentally control such behaviour as each participant may have adapted by varying degrees making it difficult to conclude whether their willingness to

engage was a result of their level of adaption to the road demand or a product of the road demand itself.

Conclusion

In conclusion this study explored how both roadway demand and phone functionality can affect willingness to engage with a mobile phone whilst driving. It was found that both factors had an effect on willingness to engage, finding a higher propensity to engage in road environments perceived to have a lower demand and a higher willingness to interact with some phone functions compared to others. Furthermore, for placing a call this decision seemed to be based, at least in part, on the level of risk drivers perceived using the phone would create. However, this was not the case for answering a call. Uniquely, the think aloud element of the study also added insight as to why drivers made the choices they did. This study focused on how the road demand experienced at that time affected willingness to engage. It is suggested that future studies should investigate how local road knowledge and anticipated, upcoming, road demand can also affect willingness to engage with a phone. This study also only focused on one part of Fuller's [1] model, how demand can affect behaviour, the second part of the model suggests that competence may also have an effect. It is therefore proposed that studies investigating how either phone competence or driving competence may affect willingness to engage with a mobile phone whilst driving would further add to knowledge in the willingness to engage research area.

References

(1) Fuller R. Towards a General Theory of Driver Behaviour. Accident Analysis & Prevention 2005;37(3):461-472.

(2) Lerner, N. Deciding to be Distracted. Proceedings of the Third International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design; 2005.

(3) Horrey W, Lesch M. Driver-Initiated Distractions: Examining strategic adaptation for in-vehicle task initiation. Accident Analysis & Prevention 2009 1;41(1):115-122.

(4) Horrey W, Lesch M. Factors Related to Drivers Self-Reported Willingness to Engage in Distracting In-Vehicle Activities. Human Factors and Ergonomics Society Annual Meeting Proceedings: Human Factors and Ergonomics Society; 2008.

(5) Esbjörnsson M, Juhlin O, Weilenmann A. Drivers Using Mobile Phones in Traffic: An Ethnographic Study of Interactional Adaptation. International Journal of Human-Computer Interaction 2007;22(1):37-58.

(6) Laurier E. Doing Office Work on the Motorway. Theory, Culture & Society 2004;21 (4-5):261.

(7) Britshsgi V, Penttinen M, Rämä P. Finnish Drivers and the use of In-Vehicle Technologies- Comparison of the focus group study and the internet survey. In: Pace J, Mendoza L. (eds.) Proceedings of European Conference on Human Centred Design for Intelligent Transport Systems; 14-15th June; HUMANIST Publications; 2012.

(8) Ferreira A, Rôla S, Simões A, Piccinini G. Perceptions of Portuguese Drivers about the Usage of Mobile Phone While Driving. In: Pace J, Mendoza L. (eds.) Proceedings of European Conference on Human Centred Design for Intelligent Transport Systems; 14-15th June; HUMANIST Publications; 2012.

(9) Huemer A, Vollrath M. Driver Secondary Tasks in Germany: Using Interviews to Estimate Prevalence. Accident Analysis & Prevention 2011 9;43(5):1703-1712.

(10) Rauch N, Gradenegger B, Kruger H. User Strategies for the Interaction with In-Vehicle Devices While Driving. Intelligent Transport Systems,2008;2(4):266-275.

(11) Metz B, Schömig N, Krüger H. Attention During Visual Secondary Tasks in Driving: Adaptation to the Demands of the Driving Task. Transportation Research Part F: Traffic Psychology and Behaviour 2011 9;14(5):369-380.

(12) Caird J, Willness C, Steel P, Scialfa C. A Meta-Analysis of the Effects of Cell Phones on Driver Performance. Accident Analysis & Prevention 2008;40(4):1282-1293.

(13) Brookhuis K, De Vries G, De Waard D. The Effects of Mobile Telephoning on Driving Performance. Accident Analysis & Prevention 1991;23(4):309-316.

(14) Strayer D, Drews F, Johnston W. Cell Phone-Induced Failures of Visual Attention During Simulated Driving. Journal of Experimental Psychology: Applied 2003 3;9(1):23-32.

(15) Törnros J, Bolling A. Mobile Phone Use – Effects of Conversation on Mental Workload and Driving Speed in Rural and Urban Environments. Transportation Research Part F: Traffic Psychology and Behaviour 2006 7;9(4):298-306.

(16) Fastenmeier W. Die Verkehrssituation als Analyseeinheit im Verkehrssystem. Rheinland: Koln: Verlag TUV; 1995. p. 27-78.

(17) Patten CJD. Understanding the Effects of Cognitive Workload on Driving from a Human Information Processing Perspective. Department of Psychology, Stockholm University; 2005.

(18) Törnros J, Bolling A. Mobile Phone Use—Effects of Hand-held and Hands-Free Phones on Driving Performance. Accident Analysis & Prevention 2005 9;37(5):902-909.

(19) Backer-Grøndahl A, Sagberg F. Driving and Telephoning: Relative Accident Risk When Using Hand-Held and Hands-Free Mobile Phones. Safety Science 2011 2;49(2):324-330.

(20) McEvoy S, Stevenson M, Woodward M. The Prevalence of, and Factors Associated with, Serious Crashes Involving a Distracting Activity. Accident Analysis & Prevention 2007 5;39(3):475-482.