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Regulating conversation during driving: a problem for mobile telephones?

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Abstract

Why are hands-free mobile telephones linked to driver distraction and increased involvement in accidents? We suggest that during normal in-car conversation, both the driver and passenger will suppress conversation when the demands of the road become too great. However, a remote speaker on a mobile telephone has no access to the same visual input as the driver, and will be less likely to pace the conversation according to roadway demands. To test this hypothesis pairs of naïve participants drove a circuit of roads including dual carriageways, rural, urban and suburban roads in Nottinghamshire, UK. One of the participants in each pair was the driver, while the other was the conversational partner. Across three laps of the circuit the partner engaged in a verbal task with the driver while sat in the same car (with or without a blindfold), or via a hands-free mobile (cellular) telephone. The number of utterances, words, and questions were analysed for both drivers and passengers across the different types of road. The results demonstrated that the normal in-car conversations were suppressed during the most demanding urban roads. The mobile telephone condition prevented suppression from taking place in the passengers' conversations, and even encouraged drivers to make more utterances that they would normally do with a normal in-car conversation. The results demonstrate a potential problem when using hands-free mobile telephones while driving.
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1. Introduction

Epidemiological studies suggest that over 50 minutes a month of mobile telephone use during driving is associated with a five-fold increase in accident liability (Violanti & Marshall, 1996); that mobile use poses a level of risk comparable to intoxication at the legal maximum (Redelmeier & Tibshirani, 1997); and that mobile users have a higher proportion of rear-end collisions (Wilson, Fang, Wiggins, & Cooper, 2003). One explanation is that the use of hand-held mobiles may interfere with driving, which has indeed been shown to be the case (Briem & Hedman, 1995; Brookhuis, De Vries, & De Waard, 1991; Goodman, Bents, Tijerina, & Wierwille, 1999; Wikman, Nieminen, & Summala, 1998), and has lead to a ban on their use during driving on UK roads. For instance, using event-related brain potentials Garcia-Larrea, Perchet, Perrin, and Amenedo (2001) identified a decline in the readiness of participants to make a motor response due to the use of a hand-held telephone. However, they also noted a second level of interference in performance, common to both hand-held and hands-free telephones, which they argue is characteristic of a general decrease in attention to sensory inputs. This reflects a general consensus in the literature, that though hand-held telephones may be specifically detrimental to concurrent motor tasks, hands-free telephones can also interfere with driving behaviour (e.g. Lamble, Kauranen, Laakso, & Summala, 1999; Patten, Kircher, Östlund, & Nilsson, 2004; Strayer & Johston, 2001).

Research has identified a number of behaviours and measures that are affected by the use of a mobile telephone while driving. These include impaired gap judgment (Brown, Tickner, & Simmonds, 1969; but see Bowditch, 2001), reduced sensitivity to road conditions (Haigney, Taylor, & Westerman, 2000); poor lane maintenance (Briem & Hedman, 1995; Reed & Green, 1999), increased heart rate and subjective workload (Brookhuis et al., 1991; Haigney et al., 2000), and a reduction in headway (Lamble et al., 1999). It must be noted however that not all of these effects may actually lead to a decrease in driving safety. For instance, increased workload may lead to a corresponding increase in concentration, or drivers may avoid certain behaviours such as making gap judgments while conversing on the telephone (e.g. drivers may be unlikely to engage in overtaking maneuvers during a mobile conversation).

The most reported problem with using mobile telephones however is the increase in reaction times to driving-related events (e.g. brake lights, etc.), and an increase in the number of such events missed altogether (Hancock, Lesch, & Simmons, 2003; Irwin, Fitzgerald, & Berg, 2000; Lamble et al., 1999; McKnight & McKnight, 1993; Patten et al., 2004; Strayer, Drews, & Johnston, 2003; Strayer & Johston, 2001). This has a potentially more direct influence upon driver safety. Taken together the evidence thus far suggests that conversing via mobile telephones (including hands-free) interferes with the processing of visual information during driving.

This may seem to contradict many studies that support sensory-specific attentional resources (Wickens, 1980), especially the superior performance of both a visual and auditory task compared to two tasks that share the same modality (Parkes & Coleman, 1990; Treisman & Davies, 1973). However, multiple resource theory (e.g. Wickens, 2002), proposes four dimensions on which tasks may overlap and therefore draw on the same limited pool of attentional resources. For instance, one dimension distinguishes between processing stages, including perception, cognition and responding. If the conversation requires cognition, or perhaps a verbal response to a question, this may interfere with any aspect of driving that employs those respective processing stages. Thus multiple resource theory can happily accommodate the notion that a conversation could draw upon the same attentional resources that are used for critical sub-tasks in driving.

If we accept that a hands-free mobile telephone conversation may impair driving, one might also suggest that a conversation between a driver and a passenger in the car should also cause similar impairment, yet this does not seem to be the case (Fairclough, Ashby, Ross, & Parkes, 1991; Kames, 1978; Parkes, 1991; though see Sagberg, 2001). There are two possible reasons. First, the nature of the conversation may differ between the two modes, with a mobile conversation being more intense and directed, rather than the casual chat that may occur between passenger and driver. A second possibility–and the focus of this paper–is that an in-car conversation can be modified according to the demands of the roadway (which we will refer to as the conversation suppression hypothesis). As both participants in the conversation have access to the visual scene, the conversation can be suspended when demands become too great. However, the person on the other end of a telephone has no information about the demands of the current situation and is less likely to pause the conversation when the driver's attentional resources need to be focused on the driving task. This theory has been suggested by many researchers (Haigney & Westerman, 2001; Harbluk, Noy, & Eizenman, 2002; Lamble et al., 1999; Strayer et al., 2003), though the only evidence for this was, until recently, anecdotal (Parkes, 1991).

A recent study however by Gugerty, Rakauskas, and Brooks (2004) attempted to investigate this particular hypothesis using pairs of naïve participants. The 'driver' watched a series of animated movies in a simulator and performed a number of various tasks such as hazard detection (including the selection of an appropriate response) and immediate recall tests upon the disappearance of the moving scene. The conversational partner was either sat next to the driver in view of the simulator screen (the in-car condition), or was unable to see either the driver or the screen. This was termed the remote condition. The verbal task was a word game that required the two participants to alternate saying a word that starts with the end letter of the word said by the partner. They measured driving performance and the mean verbal response times, with the prediction that in order to preserve performance on the driving task, the partner would slow the conversation more when they had access to the screen than when they were unable to see what was happening. Conversely they predicted that the driver may slow the conversation more so when their partner was unable to see the screen in an attempt to compensate for the lack of moderation that the partner should display in this condition.

The results revealed that mean verbal response times were slower in the remote condition than with the in-car condition, and this was the case for both drivers and non-drivers. Some of their driving measures (e.g. percent cars recalled, hazard detection response times) were also degraded by the remote conversation task.

In a second experiment they increased the difficulty of the verbal task and allowed the remote partner to see the driver's face. They found that this removed the differences between remote and in-car mean verbal response times. Though they could draw conclusions about the overall pacing of a remote conversation compared to an in-car conversation, and the influence of this conversation upon certain driving-related task performances, their experiments could not address the conversational suppression hypothesis directly because they did not vary the demands of the driving task within a single experiment. There are obviously going to be differences between the nature of a remote and in-car conversation, but the crux of the conversation suppression hypothesis lies with the relative changes that occur within a condition according to a change in driving demands.

As Gugerty et al. (2004) only varied the demands of the verbal task, it is difficult to assess whether there are any relative pacing effects that occur in either the in-car or remote conversation conditions.

A real test of the conversation suppression hypothesis would require a driving task that varies the demand placed upon the driver, and ideally is performed in as realistic a situation as possible. The current paper describes just such an attempt.

In order to maintain a realistic level of demands placed upon drivers, this experiment was conducted on real roads under normal driving conditions. Drivers negotiated a 20 mile circuit three times while engaging in a verbal task with either (a) a passenger in the car, (b) a blindfolded passenger in the car, or (c) a remote partner via a speakerphone mounted in the central instrument panel of the car. The verbal task was a conversational game, with drivers and partners competing against each other to win points.

In any on-road research, safety is of utmost importance. In order to ensure safety drivers were allowed to use their own car. The participants (both drivers and conversational partners) had an average of five years of driving experience since passing their test, and all drivers were comfortable with using a hands-free mobile telephone while driving (at least one year of experience). These measures ensured that all participants had a reasonable level of competence before undertaking the study. An experimenter was present in the back seat of each car during all of the trials. The experimenter was instructed to abort the trial if driving performance seemed impaired at any point during the drive. It was however not necessary to abort any of the trials.

In order to vary the level of demands of the driving task, the route required drivers to negotiate four main classes of roads: dual carriageways, rural, urban and suburban roads. It has previously been noted that different roads place different demands upon drivers (e.g. Crundall & Underwood, 1998). For instance, rural roads are considered to be fairly undemanding, with fewer vehicles, road signs and advertisements. Urban roads however have a greater number of locations that need to be inspected to ensure the safety of a journey. Pedestrians, road markings and traffic signs need to be fixated regularly, but the salience of advertisements and other non-safety related can compete with safety-related sources of information, further increasing the levels of demand on the driver (Crundall, van Loon, & Underwood, submitted for publication).

It was anticipated that the variation in driving demands should be reflected in the pacing of the conversation between the driver and in-car passenger. For instance, one might expect both passenger and driver to reduce the amount of conversation while negotiating demanding urban roads relative to less demanding rural roads. This variation should be absent in the conversations between drivers and remote partners, at least on the part of the remote partner who will have no visual information on which to base the pacing of the conversation. The driver may also show less suppression. When speaking to an in-car passenger, both parties have access to the visual information and therefore the driver may feel less inhibited about suddenly breaking off the conversation. However, when speaking over a telephone (especially within a formal conversation) the driver may feel socially obliged to continue the conversation, even at the expense of diverting vital attentional resources away from the driving task. Alternatively, the driver may increase the level of suppression (as suggested by Gugerty et al., 2004) in order to counteract the lack of suppression from the remote speaker. However, this may in turn affect the utterance rate of the remote speaker: motivated by the same desire to fill in pauses in conversation, one might expect that the remote speaker could increase their rate of speaking in order to counteract the gaps left by the driver.

2. Method

2.1. Participants

Twenty participants (18 female) were recruited to take part in the study. They had a mean age of 25.7 years and an approximate average of five years of driving experience since passing the driving test. These participants were placed in pairs with one randomly assigned to the role of driver prior to the experiment, while the other was assigned to the role of conversational partner.

2.2. Stimuli

The experimental route was approximately 20 miles around Nottinghamshire, and covered four road types. The dual carriageway was approximately 6.5 miles of the A52, which is a straight road with two lanes and a speed limit of 70 miles/h. Contra flow traffic is separated by a barrier at all points. The time during entrance and exit from the dual carriageway was not included in the coding for this road.

The rural route consisted of 3.8 miles of road with both 30 and 40 miles/h speed restrictions. The majority of this road was a single carriageway with occasional contra flow traffic. There were no traffic signals or junctions on the rural road.

The suburban section consisted of 3 miles of roads through two local villages. These roads had more traffic, two sets of traffic lights, two roundabouts, occasional pedestrians and a small number of retail outlets. Speed was limited to 30 and 40 miles/h.

The urban roads were through the centre of a small town in Nottinghamshire. There were six sets of traffic lights, three roundabouts, and the predominant speed limit was 30 miles/h. Compared to all the other roads, the urban section had more traffic, more shops and advertisements, and more pedestrians. Generally this road type was the most visually cluttered of all. This section was approximately 3 miles in length.

The verbal task that participants were required to undertake was designed as a competitive game between the driver and the partner. For each lap of the 20 mile circuit the partners were asked to pick one of seven envelopes with a topic word written on it, such as TELEVISION, SPORT or MUSIC. Inside the envelope were seven words or phrases related to that topic. Only the partner knew what the words inside the envelope were before the trial began. For example the envelope entitled HOLIDAYS contained the following seven words: Heathrow, First Class, New York, Summer, Cruise, Sun Cream, Spain. During one lap of the 20 mile circuit, the partner had to make the driver say each word by engaging the driver in a conversation relative to the topic. For every word on the list that the driver said, the partner scored one point. In order to ensure that the partner did not just ask straight forward questions, the driver could score points also by guessing which words the partner was attempting to get them to say. Thus for every word that the driver said aloud in conversation, but then guessed was a target word, she would receive two points. The simple mechanics of this word game ensured that, after initial practice in the game, the partner would embed their attempts to elicit the target words in the general conversation so that the driver would not be aware which words were the targets. Additionally because the drivers could only score points for identifying target words that they had said aloud during the trial, this avoided providing a disincentive for conversing on the driver's part. Otherwise, if the driver guessed that New York was a target word before saying it in conversation, she might then refuse to speak any more, safe in the knowledge that she had scored more points than her partner. Pilot studies suggested that the word game did produce verbal interactions similar to natural conversation, at least more so than many of the other verbal tasks that have been used in previous studies (Gugerty et al., 2004; Recarte & Nunes, 2000, etc.).

2.2.1. Apparatus

Each driver completed the trials in their own car. All cars were standard two door or four door family cars.

Two mobile telephones were used for the remote partner condition. The remote partners used a Samsung V200, while the drivers used a Nokia 3210. A mobile telephone cradle with an inbuilt speakerphone was fitted in the cigarette lighter socket of each vehicle, allowing hands-free communication.

A Sony CCD-FX200E video camera was securely fixed in the rear passenger seat of each vehicle, facing through the windscreen over the passenger's right shoulder. The camera was focused accordingly to provide an adequate view of the road ahead. An external microphone was used to provide the best possible auditory input from both participants.

2.2.2. Design

There were two within-subjects factors. The first was conversation condition with three levels: in-car conversation, blindfolded in-car conversation, and remote conversation via the mobile telephone. These three conditions provided the partner with varying amounts of information. The in-car passenger had the same visual information as the driver, and much of the same vestibular information. The blindfolded passenger had no visual information, but the same vestibular information as the non-blindfolded passenger, while the remote partner had neither visual nor vestibular information.

The second factor was road type. The four roads used were rural, dual carriageway, suburban and urban roads. Urban roads were considered to be the most demanding, while the rural roads were the least demanding.

The appearance of the different roadways was counterbalanced, with half of the participants undertaking the circuit in one direction, and the other half taking the route in the other direction. The order of the conversation conditions was chosen at random.

The dependant variables of interest were concerned with the pacing of the conversation task across the different conversation conditions and the varying levels of demand imposed by the different roadways. Five minute windows were designated for each road type, beginning from set marker points along the route. Within each of these windows the number of utterances and words for each participant were recorded. Utterances were defined as a word (including non-words such as fillers) or a string of words that were separated by a pause of a gap of approximately one second. A long enough pause in the middle of a sentence can therefore produce two utterances. Likewise if a sentence is interrupted by the other participant involved in the conversation, this would result in two utterances being recorded. Though we predicted suppressive effects upon the number of utterances that in-car conversations might produce through a reduction in the likelihood of starting an utterance during periods of high demand, there was also the possibility that the length of utterances would reflect demand, with shorter utterances occurring more often when the demands were high. To this end the total number of words was also recorded. These were defined as a single unit of an utterance, and again could include non-words, such as "erm...". These two measurements allowed the mean utterance length to be calculated. In addition we were interested to look at the content of the conversation. Accordingly, sentences were divided into statements and questions, with the latter subjected to analysis.

2.2.3. Procedure

The random allocation of driver and partner was made in advance of each experiment so that the allocated driver could bring their vehicle to the testing circuit. Before the first trial, both participants were taken into a quiet room and were given instructions concerning the driving task and the verbal game. They were also informed that an experimenter would be in the car at all times in order to keep score of the game, but also to abort the experiment if safety appeared to be compromised at any point.

The driver was informed that they should behave as they normally would do while driving, and should ensure that all traffic laws were adhered to. Drivers were informed that any breach of the law would be their responsibility, and they signed informed consent documents to say that they were happy to take part. They were also told that they could withdraw from the experiment at any point, and would not have to give a reason for doing so.

After a practice with the word game, the driver was informed of the route to be taken. All drivers had experience with the local routes and could easily appreciate the circuit, which adhered to the main roads and was clearly marked. Before the first trial participants were encouraged to ask the experimenter any questions concerning the route, the word game, or any safety related matters.

During each circuit the road scene was filmed through the windscreen along with the conversation of the two participants. At the end of each circuit, the driver was instructed to park the car. The experimenter then told the driver how many target words the partner had elicited from the driver during the test circuit (where one word equalled one point). The driver was allowed as many guesses of those target words as the partner had scored points. For every word that the driver correctly identified (and had said aloud during the trial) she scored two points. After the completion of this circuit, the partner would choose a new topic for the next circuit. This procedure was repeated until all three conversation conditions were completed.

3. Results

Five-minute windows of each roadway were identified on all the video tapes of drivers for subsequent verbal coding. Within these windows, the number of utterances, and the average number of words per utterance were calculated. Additionally utterances were categorized as either questions or statements. As the verbal data produced by driver and partner is not independent, separate analyses were conducted on the two groups of participants. Pre-planned weighted contrasts were also conducted. Contrasts for the conversation factor compared the mobile telephone to the blindfold condition, and compared the normal in-car conversation to the mean of the blindfold condition and the mobile telephone condition. Contrasts for the different road types assumed that the cluttered urban route would be the most demanding and compared every other road type against this extreme.

Unfortunately, some areas of the route produced interference between the mobile telephone and the video camera, preventing full coding of the mobile telephone condition for half of the participant pairs. The subsequent analysis refers to the data from the remaining half of the participants for which we have full data.

3.1. Number of utterances

Independent analyses of variance were conducted on the number of utterances made by both the drivers and the partners. Both analyses revealed a main effect of road type ($F_{driver}(3,12) = 6.5$, $p < 0.01$; $F_{partner}(3,12) = 3.9$, $p < 0.05$). In regard to the driver, pre-planned contrasts revealed that the main effect of road type was primarily due to a difference between the mean number of utterances on the rural roads and on the urban roads (with means of 76 and 56 respectively; $F(1,4) = 15.6$, $p < 0.05$). The driver contrasts also revealed an interesting interaction with the blindfold and mobile conditions producing different numbers of utterances when compared across the dual carriageway and urban roads ($F(1,4) = 39.8$, $p < 0.005$). The pattern suggests that drivers produce fewer utterances on cluttered urban roads compared to the dual carriageways with normal in-car conversations (though the choice of pre-planned contrasts did not permit a direct comparison of the telephone and normal in-car conditions, the blindfold condition did follow the normal condition closely). This reduction possibly represents the increased demands placed on the driver on urban roads. However, when conversing on a mobile telephone the noticeable decrease in utterances on urban roads was absent, suggesting that the mobile conversation was not suppressed on the urban roads as it had been with the blindfold and normal in-car conversations. The mean number of driver utterances across all conditions can be seen in Fig. 1.

Contrasts conducted on the number of utterances made by the passenger confirmed that the greatest difference between road types was between the rural and urban roads ($F(1,4) = 6.7$, $p = 0.06$), with urban roads producing the fewest utterances. Though the omnibus Fs did not reveal an interaction between conversation type and road type, the planned interaction contrasts

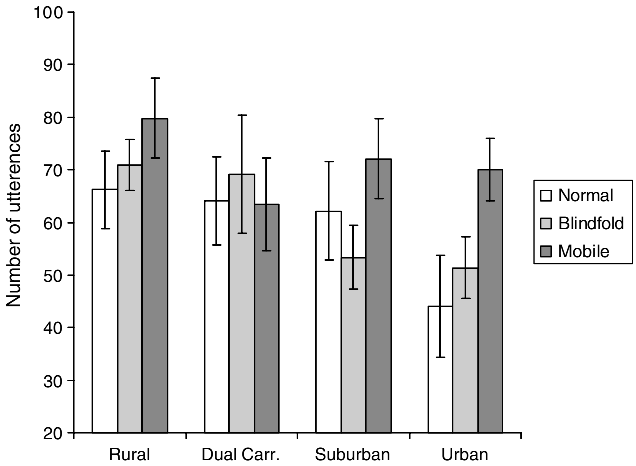

Fig. 1. The number of utterances produced by the driver across road type and conversation condition.

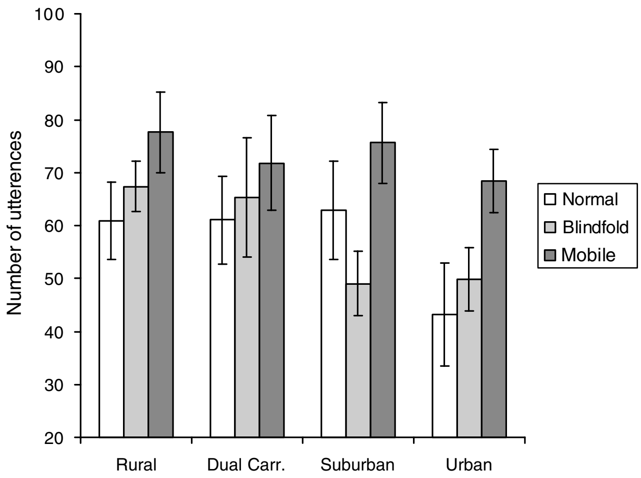

Fig. 2. The number of utterances produced by the passenger across road type and conversation condition.

revealed a marginal effect when comparing the number of utterances in the normal in-car conversation with the mean of the blindfold and mobile telephone conditions, across the suburban and urban roads ($F(1,4) = 5.7$, $p = 0.076$). As can be seen in Fig. 2, this is due to the decrease in the number of utterances in normal and blindfold in-car conversations on urban roads. The number of utterances is however maintained at a high rate, with no evidence of suppression, when the passengers are conversing via a mobile telephone. Overall the pattern of results for passengers' utterances closely follows that of the drivers'.

As an alternative analysis one could look separately at the simple main effects of the three conversation conditions across road type. Differences between road type should be noticed for normal in-car conversations, perhaps even for blindfold in-car conversations, but not for the mobile conversation. These analyses were conducted with repeated pre-planned contrasts. The contrasts revealed differences in the number of utterances made by drivers when comparing the rural roads to the urban roads in the normal condition ($F(1,4) = 13.5$, $p < 0.05$), and in the blindfold condition ($F(1,4) = 12.1$, $p < 0.05$), but there were no differences in the mobile condition. Similarly the contrasts from the simple main effects of the passengers' number of utterances demonstrated differences between suburban and urban roads in the normal conditions ($F(1,4) = 11.0$, $p < 0.05$), and between rural and urban roads in the blindfold condition ($F(1,4) = 13.6$, $p < 0.05$). Again, there were no differences in the mobile condition.

The results of all these analyses have demonstrated that both drivers and passengers tend to reduce the number of utterances on urban roads compared to various other roads that may be considered less demanding, providing that the conversational partner is in the car. This reduction even appears to occur when the passenger is wearing a blindfold, though the absolute reduction is utterances is somewhat less than when the passenger can see the road ahead.

3.2. Mean number of words per utterance

Analysis of the mean number of words per utterance revealed no omnibus effects for the driver, though the interaction contrast between dual carriageways and urban roads, when comparing

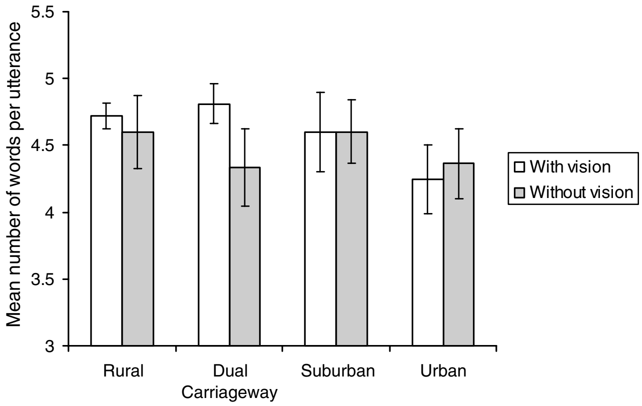

Fig. 3. The mean number of words per utterance produced by the driver across the different road types.

normal conversations with the mean of the two no-vision conditions, was significant ($F(1,4) = 8.0$, $p < 0.05$). With normal conversations, the length of the utterance dropped considerably between the dual carriageways and the urban roads. The average length of the utterance in the mean of the two no-vision groups was more constant, though actually shorter than the normal condition on several of the road ways (see Fig. 3).

Analysis of passengers' mean number of words produced a main effect of road type ($F(3,12) = 4.7$, $p < 0.05$), with longer utterances for both dual carriageways ($F(1,4) = 14.6$, $p < 0.05$) and suburban roads ($F(1,4) = 8.5$, $p < 0.05$) compared to urban roads. There was no interaction between road type and conversation condition.

3.3. Number of questions asked

The mean number of questions asked by the driver might be expected to be small considering that the partner in the conversation is attempting to elicit information from the driver, however the numbers of questions asked by drivers averaged 9.2 in a five minute analysis window. The partners asked 7.2 questions on average, suggesting that the conversation was realistic to the extent that the task did not bias the partner to simply fire questions at the driver.

Analysis of the number of questions produced by the driver failed to reveal any main effects, though there was a significant effect noted in the planned contrast that compared the blindfold condition (8.4 questions on average) with the mobile telephone condition (11.2 questions on average; $F(1,4) = 8.4$, $p < 0.05$). The in-car condition had an even smaller mean number of questions (8.0) though the relatively large variance in this condition prevented the main effect from reaching significance [$F(2,8) = 1.5$].

The passenger analysis revealed a main effect of road type ($F(3,12) = 5.9$, $p < 0.01$), with less questions on the rural roads ($F(1,4) = 61.4$, $p < 0.001$) and suburban roads ($F(1,4) = 15.5$, $p < 0.05$) compared to the urban roads. These effects can however be better explained by the interaction between conversation and road type that was also noted in the omnibus Fs ($F(6,24) = 2.8$, $p < 0.05$). The interaction contrasts revealed differences between the blindfold condition and the mobile telephone condition across both the dual carriageway ($F(1,4) = 12.6$, $p < 0.05$) and subur-

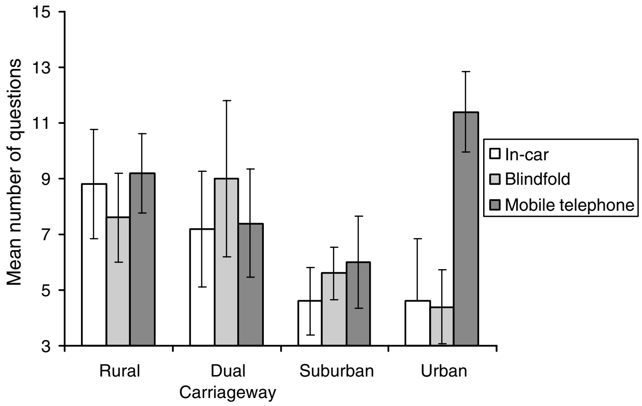

Fig. 4. The mean number of questions asked by the partner across all conditions.

ban roads ($F(1,4) = 9.8$, $p < 0.05$) compared to the urban roads. This is primarily due to a relatively large increase in the number of questions asked by the partner in the mobile telephone condition during the urban roads (see Fig. 4).

The increase is so large that despite a close relationship between the means for the blindfold and in-car conditions, the interaction contrast that compared the mean of the no-vision conditions to the normal in-car conversation also revealed a difference across the rural and urban roads ($F(1,4) = 9.2$, $p < 0.05$).

4. Discussion

The initial hypothesis predicted that normal (i.e. sighted) in-car conversations would be paced by both driver and passenger to reflect the on-road demands at any one moment. This suggests that both speakers might suppress the conversation when demands are sufficiently high. When visual information is not available to the partner (as in our blindfold and mobile telephone conditions) it was predicted that the partner would not pace the conversation, though we were less sure as to what the driver might do. One could argue that social pressures might force the driver to maintain the level of conversation during high demand driving, or alternatively, the driver may compensate for the partner's lack of conversational suppression, and reduce her level of interaction even further.

The results of this study have demonstrated a number of effects, even with the considerable reduction in experimental power that resulted from the loss of data due to the interference between the mobile telephone and the video equipment.

The most noticeable finding is the sensitivity of the conversation measures to the type of road. This confirms that the choice of roadway as a manipulation of processing demand appears to have had the desired results. In most measures the urban roads tended to have reduced levels of conversation, suggesting that the demands were perceived as greater by the driver, and to a certain extent by the conversational partner as well.

The driver also displayed sensitivity to the conversation condition according to the level of demand induced by the roadway. With a normal in-car conversation the driver tended to reduce the number of utterances and the length of those utterances from the dual carriageway to the urban roads. The mobile telephone condition produced short utterances that did not vary in length across these two roads. More importantly the overall number of utterances in this condition was not reduced on the urban roads, as it was in the normal conversation condition. This suggests that the driver is conversing more on the high demand urban roads when speaking via a mobile telephone, than when conversing with a sighted in-car passenger. The blindfold condition is interesting, as, in regard to the number of utterances, the driver appears to treat the blindfolded passenger the same as an in-car passenger, despite the fact that the passenger cannot see anything. Fairclough et al. (1991) have suggested that psychological distance may play a role in the problems associated with mobile telephone communications. The current results may perhaps be taken as evidence in favour of this hypothesis, for the mere presence of the passenger is enough to encourage normal levels of conversation from the driver. Though the reported effect in this paper is directly due to the physical distance of the passenger from the driver, the fact that the physical distance should have no influence upon the blindfolded passenger's ability to judge roadway demands suggests something more subtle in the driver's mental model of the conversational situation.

Due to the interdependent nature of the conversation measures across driver and partner however, one must also consider the effects upon the partner's conversation before drawing conclusions about the driver's conversation.

The marginal significance of the interaction contrast for the number of utterances produced by the partner suggests that when the in-car passenger can see the demands of the road ahead, then they will reduce the number of utterances made during urban driving, at least compared to suburban driving. This is not due to a corresponding increase in utterances in the drivers, for they also reduce the number of utterances on urban roads when engaged in a conversation with a passenger who has access to the same visual information. Neither can this effect be explained in regard to the average length of utterances, as urban roads tend to have the shortest utterances for both drivers and passengers. It therefore appears that with a normal in-car conversation, joint suppression does occur during periods of high demand.

When the passenger is speaking via a mobile telephone however, the number of utterances is not reduced on the urban roads, as happens in the normal condition. Instead conversation remains at levels comparable with the conversation recorded on less demanding roads. Again the length of utterances cannot explain this in terms of a trade off between the absolute number of utterances and the number of words, as the pattern of results for the average length of an utterance on urban roads does not differ according to the conversation condition for either drivers or passengers.

The results suggest that conversational suppression only occurs when both the driver and the passenger can see the road ahead. Suppression fails to occur with mobile telephone conversations, in regard to the number of utterances which remains as high at that recorded on less demanding road ways. The average length of an utterance is affected by both the roadway (with shorter utterances on more demanding roads) and the conversation condition (with the mobile telephone conversation producing the shortest utterances), though there is no difference in utterance length for urban roads across the conversation conditions. This suggests that though utterance length is sensitive to both independent variables, it cannot explain the lack of suppression noted in the urban roads for mobile telephone conversations (i.e. there is no evidence of a trade off, with shorter utterances in the urban mobile condition accounting for the relatively high number of utterances on urban roads with a normal in-car conversation).

In regard to the number of questions, the drivers did not show sensitivity to road type, though overall they asked more questions of their partner when conversing over the mobile telephone. The partner also asked a greater number of questions over the mobile telephone, but only when on the urban roads. The only way that this effect could have occurred is as a reaction to the driver's conversation, as the partner had no visual information that the road type had changed. In response to a change in the driver's conversation on the urban roads (perhaps the driver's verbal responses become vaguer as she increasingly had to switch attention between the urban road and the conversation), the passenger responds by asking more questions (though as the passenger does not increase their number of utterances in this condition, there will be a concomitant reduction in simple statements). This may partly explain why the drivers produce more utterances in the mobile telephone condition on the urban road than they would do with a normal in-car conversation, as they are responding to an increasing number of questions.

In conclusion the reported data support the conversation suppression hypothesis. Differing road types do induce different levels of conversation, with urban roads tending to reduce normal in-car conversations. However, when conversing via a mobile telephone, remote partners tend to maintain their level of conversation, increasing the ratio of questions to statements, perhaps in an effort to push the conversation forward due to a decrease in the quality of the driver's interaction. Though drivers should devote more attention to the road at this point, they also maintain a high level of verbal interaction during urban roads. Incidentally, the significant differences found for the drivers tended to distinguish between the mobile telephone conditions and the blindfold conditions, treating all in-car passengers' conversations the same regardless of whether they were wearing a blindfold. The partner's conversation however was more greatly affected by the presence or lack of visual information. This suggests that the drivers and partners are sensitive to different factors (or biases) in the control of conversations. It is hoped that future research will further specify the effects of conversational suppression, the conditions under which it does or does not occur, and whether drivers employ any compensatory strategies to avoid excessive demands during conversations (such as reducing speed, or limiting demanding maneuvers).

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