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Driving Performance During
511 Information Retrieval:
Cell Phone 2

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16. Abstract (Limit: 200 words) As a logical and necessary extension of previous research (Rakauskas, et al., 2005), this study aims to assess the risk of cell phone use for traveler information applications; namely while using Minnesota's 511 interactive voice response (IVR) menu. First, detailed usage, utility, and usability evaluations of the MN511 were conducted. The goal of this design was to help harmonize the transfer of knowledge between access methods while also easing implementation concerns for the MN511 developers. Next, a simulated driving experiment was conducted with the goal of seeing if using an IVR menu leads to more risky driving behavior compared to driving while not accessing a menu. It also allowed us to see if changing the MN511 menu might affect driver performance. While using both phone menus, drivers seemed to compensate for the additional mental workload by delaying their reactions until they felt comfortable taking action. There were no differences between the two menu types for the majority of driving performance measures. This study addresses issues with the 511 IVR menus that were identified during this study and presents recommendations for future development.			
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**Driving Performance During 511 Information Retrieval:
Cell Phone 2**

Final Report

Prepared by:

Michael E. Rakauskas, M.S.
Nicholas J. Ward, Ph.D.

HumanFIRST Program
ITS Institute
University of Minnesota

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Executive Summary

The implications of 511 and cell phone conversations on driving performance has national and regional significance due to the proliferation of cell phones being used in vehicles and the upcoming national prevalence of 511 traveler information services. A recently completed study (Rakauskas, et al., 2005) assessed the "relative" risk of cell phone use to other common risk factors, including existing in-vehicle tasks and alcohol.

As a logical and necessary extension of this research, this study aims to assess the risk of cell phone use for traveler information applications; namely while using 511. There is considerably less scientific research to date focused on the effects that 511 and other interactive voice response (IVR) phone systems present to drivers. This project will assess the effect of cellular phone access to Minnesota's 511 (MN511) traveler information service on driving performance and driver mental effort.

First, detailed usage and usability evaluations of the MN511 were conducted. The usage evaluation allowed the researchers to determine what types of information users are currently requesting from the traveler information system. The usability analysis showed them what portions of the menu violated commonly used tenants of menu design and thus might be problematic for users when searching for information. A utility analysis was also completed to show what information types have the most value to users. Overall this examination of MN511 gave the researchers a perspective on what parts of the current design were working well and what parts could be improved upon. Using this review and incorporating MnDOT's vision of integrating the information online at 511mn.org with the MN511 IVR menu, an alternative version of 511 was outlined (511 V2). The goal of this design was to help harmonize the transfer of knowledge between access methods while also easing implementation concerns for the MN511 developers. Simulated working versions of MN511 and V2 were generated for testing.

Next, a simulated driving experiment was conducted. A group of participants drove a scenario involving a car following task that has proved sensitive to distraction effects. Drivers also reacted to a deceleration event and were asked to drive through relatively slow traffic in order to assess their ability to navigate through dense traffic conditions. Each participant repeated this drive three times, once while answering simple questions aloud, once while accessing a MN511, and another time while accessing 511 V2. In this way, we aimed to see if using an IVR menu leads to more risky driving behavior compared to driving while not accessing a menu. It also allowed us to see if changing the MN511 menu might affect driver performance in any way.

Participants reported that they experienced more mental effort while using the two phone menus than while driving alone. While using the phone menus, drivers also seemed to be compensating for the additional mental workload by delaying their reactions to the lead vehicle until they felt comfortable doing so. This type of behavior is often seen in cases where drivers have to simultaneously engage in a secondary task, as when using a cell phone or navigation system while driving. Surprisingly, there were no

differences found between the simple question condition or the two menu conditions for the deceleration event or lane change measures.

There were no differences between the two menu types for the majority of driving performance measures. This suggests that drivers' driving performance was similar while using the two menus, which is also supported by most of the subjective data. That said, more drivers overall reported a preference of 511 V2 than the current MN511 implementation. There is also evidence to suggest that while using MN511 drivers found but did *not* recognize information they were searching for in more instances than while using 511 V2.

The conclusions of this paper address some issues with the menus that were identified during this study and present both menu-wide and dialogue-specific recommendations for future development. A summary of the high-level recommendations are:

- Long dialogues of information may be made more useful by reducing redundancy within information summaries
- Long dialogues of information may also be made more useful by separating information within information summaries based on the user it is meant to inform, e.g., passenger vehicle drivers vs. truck drivers
- Menu interaction can be expedited (in the user's perspective) by making users select a region before proceeding through the menu. This shortens later dialogues they encounter by removing the need to select a region at numerous points in the menu. By formally introducing users to the main menu options first, they also are more aware of what choices and information is present in the menu
- It is also recommended that after a main menu option is selected, the dialogue identifying that menu option should begin immediately. Introductory sounds should be played in the background, instead of making users wait for the sound to end, as is currently implemented.

It is hoped that by improving the traveler information resources in Minnesota, this study will support the Minnesota State strategy to provide effective traveler services and promote zero fatality objectives.

Introduction

The implications of 511 and cell phone conversations on driving performance has national and regional significance due to the recent proliferation of cell phones being used while driving and the ongoing national prevalence of 511. Learning more about the interaction between these factors will contribute to the debate of crash risk associated with cell phone use, and also suggest policy and design recommendations for the conditions in which 511 may be accessed while driving. As such, this research supports the Minnesota State strategy to provide effective traveler services and promote zero fatality objectives.

It has been suggested that a cell phone conversation causes the driver to be in a state of inattention and is thus more prone to a variety of crash types. There are a number of extensive reviews (e.g., Goodman, et al., 1999; Haigney, & Westerman, 2001) and commentaries (e.g., Hancock & Scallen, 1999; Tijerina et al., 1999) of cell phone use, design, and safety. Though there is a focus on the impact of cell phones on driving, there is a lack scientific research to date focused on the safety and effectiveness of phone-based traveler information systems that may be used while driving.

Of particular interest to state DOTs should be how accessing a menu, such as the 511 traveler information system, interacts with driving a vehicle. Kelly, Stanley, and Lassacher (2005) examined the effects of using a cell phone to interface Montana's 511 traveler information system. They reported that using voice commands to gather information from 511 was as risky as holding a conversation on a hands free cell phone and comparable to many of the cognitive tasks that are often asked of participants.

Studies and guidelines of voice menu systems have begun to establish methodologies for building more accessible and usable interactive voice response (IVR) menus (Bond and Carmac, 1999; ISO, 1994; Schumacher, Hardzinski, & Schwartz, 1995). For example, it has been shown that increased hierarchical menu depth (i.e. number of sequential menu choices) is related to the perceived complexity of retrieving desired information, leading to degraded visual search, decision making, response selection, and certainty when locating information (Jacko & Salvendy, 1996). In this analysis, a utility analysis will be used to show how depth (represented in the cost of finding information) interacts with the breadth (adequacy of information) in Minnesota's 511 (MN511) traveler information service.

Objectives

This study will test the effects of verbally accessing information on driving behavior. To test realistic and representative traveler information applications such as 511, we must first develop a valid theory and guidelines for optimally accessing and processing traveler information. As a starting point, we outline the menu structure of the current MN511 and then review published methodologies for structuring IVR menus (e.g. Schumacher et al, 1995). From this, a detailed evaluation of MN511 was completed, including an expert evaluation and utility analysis on the information types presented within the menu. As a comparison, an alternative menu (511 V2) was proposed and

generated based on literature reviews and recommendations that followed from the MN511 evaluations. This methodology allowed for an objective and quantifiable evaluation of information currently available in MN511 and of proposed improvements.

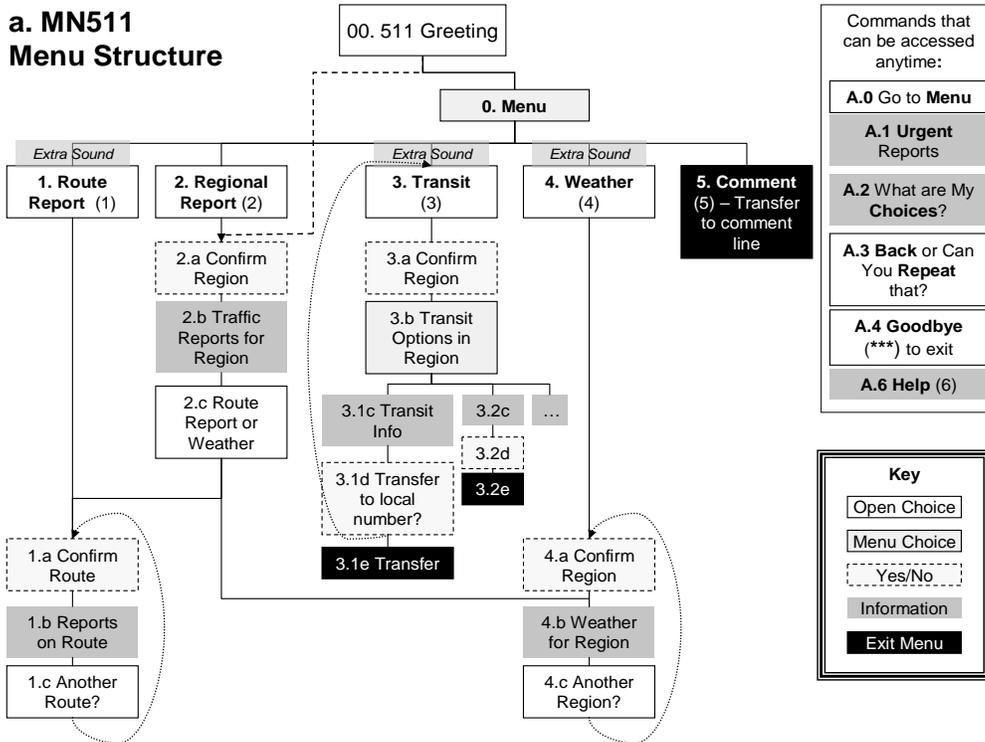
The simulator-portion of this study was completed in the Virtual Environment for Surface Transportation Research (VESTR) at the University of Minnesota's HumanFIRST Program (<http://www.humanfirst.umn.edu>). This high-resolution PC-based simulator was driven while participants used MN511, 511 V2, or while not accessing a menu. Results were analyzed in terms of car following, reaction to a deceleration event, a lane change task, and global measures of driving performance. The usability of both 511 menus was also examined from the participant's experience while driving.

Menu Evaluation

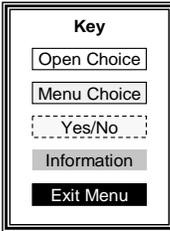
Functional Menu Structure

The functional menu structure based on dialogue prompts (also referred to as “nodes” when discussing the menu structures depicted in Figure 1) and possible actions was identified for the current MN511 implementation (Figure 1a). Based on this structure, a script of the dialogue heard at each prompt in the current MN511 implementation was generated (see Appendix E). In the depictions, both menus are accessed by proceeding from “00. 511 Greeting” downward, except if the user chooses to loop back using the “commands that can be accessed anytime” or is in a depicted loop (see 1.c and 4.c of Figure 1a). Users can do this by speaking their choice during menu nodes or responding with the numbered key entries as instructed.

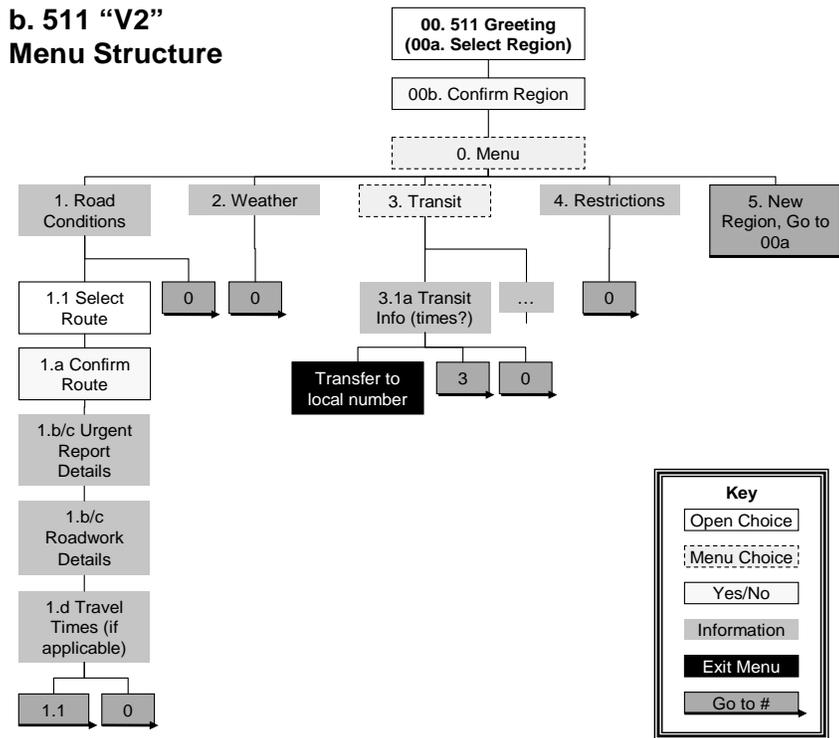
**a. MN511
Menu Structure**



- Commands that can be accessed anytime:
- A.0 Go to Menu
 - A.1 Urgent Reports
 - A.2 What are My Choices?
 - A.3 Back or Can You Repeat that?
 - A.4 Goodbye (***) to exit
 - A.6 Help (6)



**b. 511 "V2"
Menu Structure**



- Commands that can be accessed anytime:
- A.0 Go to Menu (go to 0)
 - A.1 Urgent Reports (go to 1.11e)
 - A.2 What are My Choices?
 - A.3 Back or Repeat
 - A.4 Goodbye (***) to exit
 - A.5 Select New Region (go to 000)
 - A.6 Help (9 & 0)

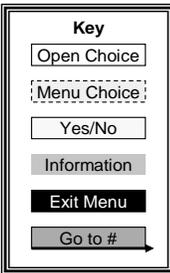


Figure 1. Depiction of a.) MN511, and b.) 511 V2 menu structures; calls start at node 00 and proceed downward.

MN511 Evaluation

An expert, or “heuristic”, evaluation typically involves examining the structure of an interface to see if there are any features, wording, or functionality that go against known principles of usable design. In the case of the 511 menu, the structure and dialogue script were examined in light of published guidelines on IVR menu usability (e.g. Schumacher, et al., 1997). These evaluations are done before any user testing is completed to identify features that may potentially cause problems. Below is a summary of the evaluation (the complete list of findings can be found in Appendix A).

Positive Aspects to Retain. It is first important to mention positive aspects of the current menu as they should be kept in mind when designing future iterations of MN511. It is apparent that the current MN511 design took advantage of 511 past research and standards, as evidenced by these aspects:

- A clear menu structure and a consistent data entry method (MN 2001)
- Provides information in terms of *time-predictable trips* (Mn/DOT, 2002). That is, the information presented in the menu is stated in terms of “exception reporting” of abnormal incidents, construction, etc. that are likely to produce a change in traffic patterns. This is opposed to presenting travel times between set landmarks or routes, which may not be as useful depending on your particular commute.
- Information presented follows the principles described by the Deployment Coalition Guidelines (2005).

MN511 has also followed many published principles of menu design. The menu allows for “dial-through” or “barge-in” navigating (dialing or speaking to interrupt the menu; ISO, 1994), giving the users the ability to skip information. In addition, the amount of time the menu will wait for a response is typically 8 seconds before prompting the user for a response, which adequately assists users that may be accessing this menu while driving. The menu also ends the main menu dialogue by saying, “...that’s all the categories”, which clearly tells the user there are no more options. Jamson, Westerman, Hockey, Carsten (2004) have found that adding elements of driver pace control, such as these, may have a positive impact on driving safety. Some features are accessible from multiple paths, which Bond and Camack (1999) found to be beneficial.

Potential Areas for Improvement. There are always opportunities to improve the menu design by changing aspects of the menu structure and dialogue prompts. A selection of these issues is discussed below, where all menu node references {in curly brackets} are to Figure 1a.

Structurally, it is apparent that the Route Reports option {2} is a focus of both the menu structure and the place users go most often; most probably due to the shortcut offered during the greeting {00}. A potential option for redesign would be to initially ask users which region they are interested and only give them information pertaining to that

area. Users would also benefit by hearing Route Reports as the first option listed in the Main Menu.

A number of potential issues were also identified in the dialogue itself. One issue apparent throughout the menu is that dialogue on many nodes was long, sometimes containing redundant information and other times mixing truck and commuter information (e.g., restrictions). This is most apparent during the Urgent Reports {A1} and regional reports overview {2b} but applies to any “information node” (see the key of Figure 1a). In these instances, the specific information that a user is looking for may be obscured by the wealth of details presented. To remedy this, it is recommended that 1) specific routes be selected first, or 2) information types be selected first. An example of this second point would be to separate traffic incident information from restriction information in order to accommodate and avoid frustrating different user types. For example, if restriction information is presented separately, truck and RV drivers can access it directly while commuters will not have to be exposed to it. In a similar way, the efficiency of users’ experience could be improved by removing extraneous introduction sounds at the beginning of Route Reports {1}, Regional Reports {2}, Weather {4}, and Transit {3} nodes.

Alternative Design- 511 V2

The recommendations described above were used to modify the MN511 structure and dialogue to generate the V2 structure (Figure 1b) and script (Appendix E). The overall goal of V2 was to harmonize information presented on the 511mn.org page with the MN511 IVR menu, thereby improving the user’s interaction with both information sources. It is hoped that achieving this goal will help to harmonize the transfer of knowledge between access methods while also easing implementation concerns of the MN511 developers.

To accomplish this, the menu structure of 511mn.org was conceptualized pictorially, in order to understand what features were available and how these features are connected functionally. Figure 2 shows the 511mn.org menu structure, highlighting in red features that are incompatible with an auditory interface and noting changes to be made when implementing V2 (yellow highlighting and grayed out features). What remains (in the gray oval) is the V2 conceptual menu structure.

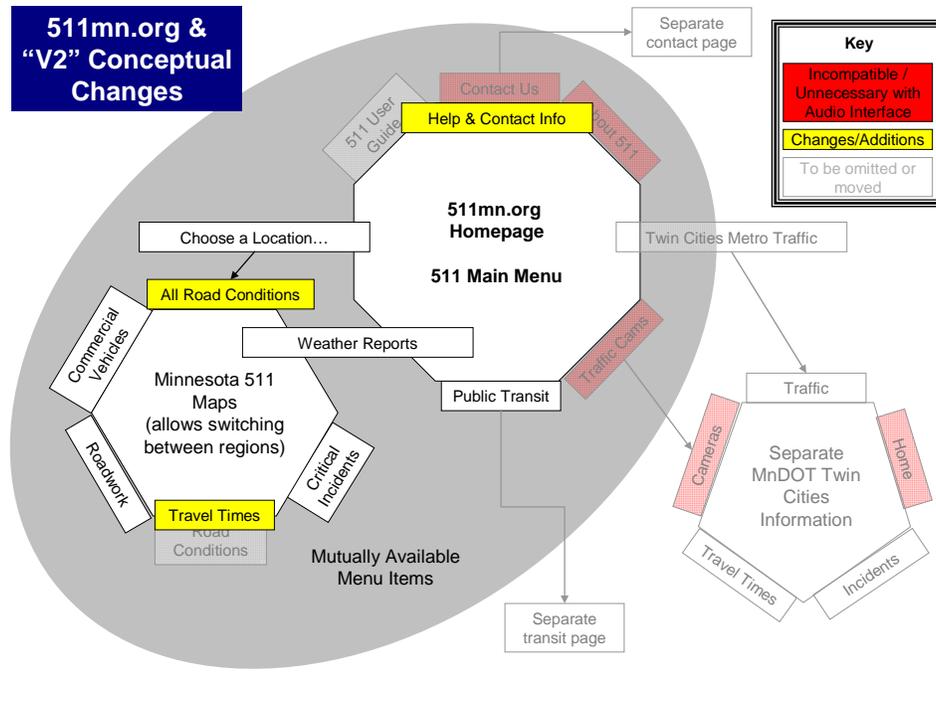


Figure 2. Depiction of V2 conceptual menu structure over the original 511mn.org menu structure, noting incompatible, changed, and omitted features.

Information regarding incidents, road conditions, construction, and weather was standardized over the MN511 and 511 V2 menus, as outlined in the event database (Appendix D). In comparison to MN511, the 511 V2 design had the following features (all {node} references are to Figure 1b):

- Greeting {00} asked users what region they wanted information from before proceeding through the menu; an additional Main Menu option allows for the selection of a New Region {5}. As shown in the utility evaluation (Appendix C), this helps the user by decreasing the total number of steps to be taken before reaching some types of information.
- Users are now “forced” to use the Main Menu {0}, whereas in MN511 they often skip to Route Reports first
- User goes directly to region-specific information from all Main Menu options {0}, whereas in MN511 they either entered a region after selecting an option (i.e. going through the main menu) or selected an information type after selecting a region (i.e. using the shortcut to regional information)
- MN511’s Route and Regional report options were replaced with a single option, Road Conditions {1}. Regional overviews were removed, leaving only a short general report of road conditions including which routes have active reports

- Route restrictions were removed from route and regional report dialogues and were placed in a separate menu option {4}

Computing the Value of Information Types

How the menu is organized and what actions are allowed affect the user's progress towards their information goals. We used utility theory to determine the relative value or "goodness" of information in both experimental menus in order to compare both menus and recommend how information can be made more accessible. This methodology is a tool by which designers and usability practitioners can quickly quantify comparisons between interface designs as a precursor to user testing. A detailed evaluation of the value provided by the information types (e.g. traffic, transit, weather) in both the MN511 and 511 V2 menus is presented in Appendix C, and summarized here.

This analysis took into account what outcomes are relevant to the user in terms of how he or she will be using the system and then incorporated the cost/benefit of searching for those information types. The frequencies of using information in the menus equate to what the user's goals are when using the menu. These frequencies were identified and quantified as well as the effort it takes to complete these goals, in terms of how many actions are necessary before finding the information. Two separate sets of scores, *probability* of finding information and the *utility* of the information found, are necessary to compute and compare the *value* of information types in the 511 menu structures. For both menus, the total value of meeting each goal (i.e. the likelihood of finding a useful answer to a question) was found to be positive, aside from searching for transit information. This suggests that overall both menus are effective at allowing the user to find and understand the information they are searching for.

Specifically, it seems that the shortcut to regional reports in MN511 (depicted with a dashed connection depicted between {00} and {2.a} in Figure 1a) decreased the cost of finding this type of information, resulting in a relatively high total value. In comparison, using V2 increased the value of regional and urgent information types more dramatically due to an increase in appropriateness of the information even though the cost of finding these types of information increased. Similarly, the value of finding route information is lower when using V2 compared to MN511 because there is a higher cost involved in navigating to this information. As designed, there was higher value for finding transit and weather information types when using the V2 menu as compared to using MN511. These trends were not due to increasing appropriateness of information, but instead this shows how decreasing the cost of finding information (i.e. reducing the number of steps that need to be taken to get to the information) can also add value.

For many of the information types, the V2 menu structure showed improvements in the value afforded to an information-seeking user. It was therefore predicted that the proposed changes to the MN511 menu structure present in V2 would allow for faster and more accurate traffic, transit, and weather information retrieval. When subjective data from this study was used in a follow-up value analysis, our previous results were confirmed that across all information types there was more total value while using V2 than while using MN511.

Questions asked of participants later in the simulation study were categorized by type of information to be retrieved, just as they were in the value analysis. The number of questions for each type of information was based on the usage statistics of MN511; 80% of the requests were for Traffic information (asked for by route or city) and 18% were for Weather. Due to their relatively low level of representation, the 2% for Transit are not represented in this study.

Menu Evaluation Summary

Outlining the functional menu structure and dialogue of the MN511 nodes allowed us to visually see what information the current implementation is presenting to users. We found that there were a number of positive and detracting features of MN511 that could be improved upon, from which we generated the 511 V2 menu design. The main differences between the two menu structures are that V2:

- Initially asks users for the region they would like information on, which:
 - Decreases the number of steps it takes to access information later in the menu
 - Forces users to access a main menu of choices
- Separates information relevant to different types of vehicles, the primary example being the separation of route restrictions to a separate main menu category

The value analysis suggested that the 511 V2 menu would have more value to the users. This was due to the information in V2 having higher relevancy (higher appropriateness) and being easier to access (lower cost). This was confirmed by using the value analysis again on the user data from the simulator portion of this study.

Simulator - Methods

In the context of a simulated driving environment, performance of drivers answering simple questions, using MN511, or using a modified version of MN511 (V2) were compared in terms of risk perception, risk-taking (safety margins), and continuous driving performance. The objectives of the simulator study are twofold:

1. Determine if using an IVR menu lead to more risky driving behavior compared to driving while not accessing a menu.
2. Determine if changing the MN511 menu might affect driver behavior.

Participants

Participants were recruited from the University of Minnesota psychology student pool and compensated with course credit. Potential participants were screened for potential simulator induced discomfort (SID). Potential participants were also screened for experience with MN 511 system by asking if they are aware of traveler-based information systems in MN and if they have heard of or used MN 511. We wanted our participants to have no experience with the system, since Sharit et al. (2003) suggest that measuring a successful interaction with an IVR depends on the user's ability to find information without prior experience using the menu. Results from screening questions relating to traveler information experience are summarized in Appendix F. No participants had previously used the publicly available MN 511.

The final sample consisted of 24 participants split evenly by gender. The age of all participants ranged from 18 to 23 years ($M = 19$). There was no difference between our male and female participants for any of the demographic aspects presented in Table 1. Upon arrival, participants' acuity and peripheral vision were tested using an Optec 2500 vision tester (<http://www.medcompsys.com/vision-screening.html>). One male and two females were tested at 20/40 acuity, all others were tested at 20/30 or 20/20. Twenty-two participants were tested to have a full range of stereo peripheral vision detection (85° though 35° nasal). One male did not see the nasal 35° stimuli and one female did not see the 85° stimuli.

Table 1. Participant sample demographic measures, where Mean refers to the average of all responses and the Mode refers to the most commonly cited response.

Demographic Measure	Mean	Mode
Age	19.5	19
Years Since Obtained License	-	3
Frequently Drive... Highways	100%	Yes
Main Roads	96%	Yes
Urban Roads	83%	Yes
Country Roads	22%	No
Minor Road Crashes / 3 yrs	0.48	0
Major Road Crashes / 3 yrs	0.17	0
Violations... Speeding	30%	No
Careless Driving	0%	No
DUI	0%	No
Primary Vehicle Type	-	Passenger Car

Materials and Driving Simulator

The study used the Virtual Environment for Surface Transportation Research (VESTR) managed by the HumanFIRST Program at the University of Minnesota. VESTR is an immersive motion-base driving simulator operating with SCANeR II simulation software (<http://www.oktal.fr>). VESTR is linked to a full-sized Saturn vehicle and a vehicle dynamics model operating at 100 Hz with the data sampling rate set to 20 Hz. The visual images are projected using Epson 7600 projectors (1024 x 768, 2200 lumens, 400:1 contrast, 24 bit color) at a frame rate greater than 30 Hz. The forward scene is comprised of a five-channel 210-degree field of view on white-painted flat panels with 2.5 arc-minutes per pixel resolution. The side and rear scenes are comprised of a single channel 50-degree field of view on a projection screen and color LCD panels mounted in the side mirror housings. VESTR provides auditory and haptic feedback using a 3D audio system, subwoofer, car body vibration, force feedback steering, and a three-axis electric motion system (roll, pitch, z-axis).

Simulator Scenarios

The driving environment was a straight, four lane divided highway (2 lanes in each direction) which drove through rural and urban ambient environments. Participants experienced the same road network and scenarios three times. Each drive lasted less than 20 minutes and consisted of instructed *car following* and *lane change task* scenarios. A *deceleration event* was also presented at the end of one car following scenario (counterbalanced for order) and two *global measures* were administered after the drives.

Car Following - During the car following scenario, the participant followed a lead vehicle in the right lane at a close but safe distance. Three surrounding vehicles, one ahead of the lead vehicle and two in the left lane next to and in front of the lead vehicle, were all linked in speed to the lead vehicle's speed changes. These vehicles were

intended to give the impression that the participant was following a pack of traffic. The lead vehicle varied its speed in a random sinusoidal pattern, simulating real highway conditions. Unbeknownst to the participant, there was a 30 second practice period before a 6 minute experimental car following segment. During the scenario, participants were explicitly instructed that the primary goal was to constantly maintain a safe headway. The lead vehicle's taillights did not illuminate when it slowed because the decelerations were consistent with releasing the accelerator to decelerate mildly under real world highway driving conditions. Driving performance metrics for this scenario included:

- Mean and variation of time headway to the lead vehicle
- Maximum speed correlation (coherence) between the participant's vehicle and the lead vehicle
- Accelerator pedal consistency, in terms of overall pedal activity (pedal power) and peak movements (pedal peak)
- Ability to maintain stable lane position (variation)

Deceleration Event- During one of the participant's three experimental drives, immediately following the experimental car following segment, the driver had to react to an unexpected deceleration event. First, the lead vehicle began traveling at a constant speed of 50 mph for 15 seconds. Then the vehicle would begin decelerating at a rate of 9.32 miles per second (15 kilometers per second) until the participant hit their brakes. Driving performance metrics for this scenario event included:

- Distance to the lead vehicle- distances at the onset of the event, minimum distance, time to contact (TTC) at the onset of the event, and if they ever had a dangerous "critical" TTC
- Reaction time to release the accelerator and to hit the brake
- Maximum braking force
- Time to recover half of their speed from before the event

Lane Changing – Participants weaved through a convoy of 30 identical vehicles, staggered in groups (as shown in Figure 3 so that participants passed 1, 3, or 5 vehicles at a time before switching lanes. All vehicles were traveling at a constant speed of 50 mph and there was a longitudinal distance of 40 m between each vehicle. Participants were told to pass vehicles when they felt it was safe to do so at a comfortable speed. Driving performance metrics for this scenario included:

- Time to pass all vehicles, time to change lanes, and time to initiate a lane change
- Time headway when changing lanes

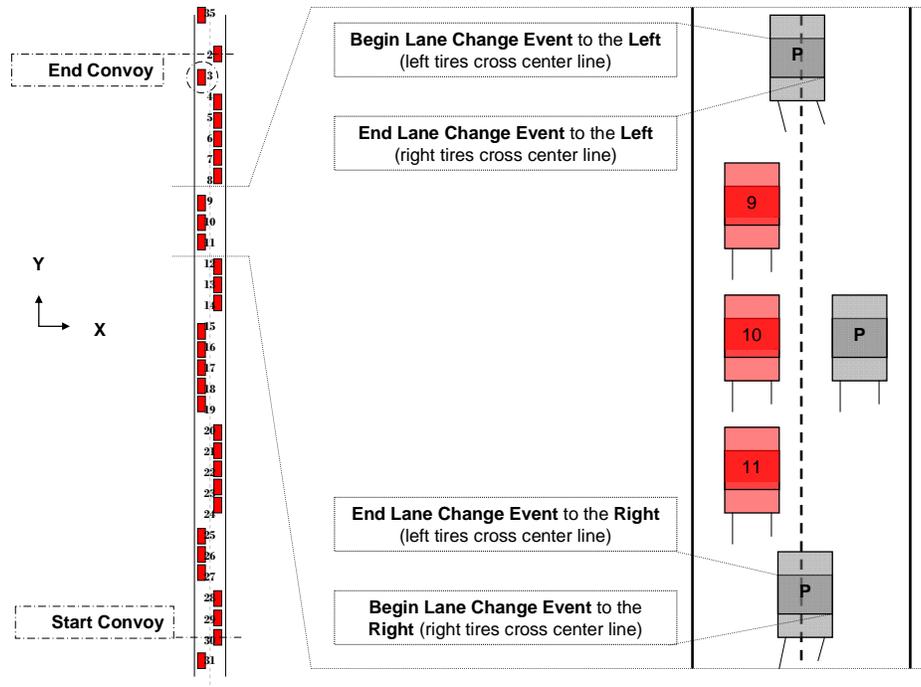


Figure 3. Lane change task diagram

Global Measures- As a measure of situation awareness, along the entire drive, 9 billboards were placed 35 m from the driver’s point of view. Participants were not told to pay attention to these signs, but after the first drive they were shown images of these 6 billboards and 6 others which were not part of the drive. Participants were to answer whether they remember seeing each sign or not. Since some participants did not come close enough to one of the signs to see it (i.e. within 1000 feet), the billboard recognition task measures were analyzed as percentages of the signs that could have possibly been seen. As a measure of mental effort, drivers responded to the NASA-RTLX mental effort scale after every drive. Global performance metrics included:

- Correct recognition and errors on the billboard task
- Mental effort ratings on the six NASA-RTLX dimensions

Experimental 511 Specifications

Participants accessed both MN511 and 511 V2 menus using a Wizard of Oz (WoOz) technique. To the participants, this was no different than calling 511 and speaking commands out loud as if using a hands-free cell phone. One reason for doing using the WoOz is that it allows us to explore the effects of the menu on driving performance alone by eliminating the problems associated with voice recognition software.

Sound files of each node of the menus (as outlined in Appendix E) were recorded using a male voice similar to that of the current MN511 implementation. Using these

files, auditory simulators of both menus were built in MS PowerPoint, where the experimenter could play the relevant sound files when prompted by the participant. A two tailed t-test showed there to be no significant difference in time to find and listen to similar information types while using MN511 (M = 77 sec) or V2 (M = 80 sec, $p = .73$).

Task Questions

During each of the three experimental conditions, participants were prompted to answer five questions at set times during the sessions; three questions during the car following scenario (one during the deceleration, if applicable), and two during the lane change task. Participants were given three minutes to answer each question before the next one was triggered or until the segment or scenario ended. All questions, answers, and optimal paths to the correct information nodes are presented in Appendix G. During the practice drive, participants were given practice questions to answer with the help of a restaurant guide IVR. The questions asked about the operating times and payment options of fictional restaurants. A separate WoOz IVR was generated and operated in the same way as the 511 simulators. Question types differed between the baseline and 511 conditions.

Baseline- Each of these five questions was designed to have the participant seek information from the driving environment (rather than use a 511 IVR menu) and then answer aloud. For example, “Based on current traffic conditions, how severe do you estimate the delay will be to drive through this city?” Questions were designed to be of the same length and demand level as the 511 questions in order to incite similar cognitive responses in order to control for question-asking aspect of the 511 information retrieval tasks.

511 Questions- Each of these questions was designed to have the participant seek information from the 511 menus and then answer aloud. There were two sets of questions, each asking for similar types of information (e.g. route or city specific traffic information, weather information) just for different cities or routes. Each participant heard all ten questions and no questions were repeated. The two lists of questions were counterbalanced between the MN511 and V2 conditions.

Questions were categorized by type of information to be retrieved, and the number of questions for each type of information was based on the usage statistics of MN511; 80% of the requests were for Traffic information (asked for by route or city) and 18% were for Weather (the 2% for Transit are not represented in this study).

To answer any of these questions, participants were instructed to first say, “call 511” to begin the call. Participants then navigated through the menu and said “end call” to after they had found the information. Once 511 had hung up, the participant was to say their answer out loud and continue driving until further instructed. Performance was measured in terms of:

- Task time, beginning after the question had been read and ending after the participant had responded

- Path through the menu (nodes) that the participant visited
- Accuracy of information retrieval, in terms of answering the questions correctly and guessing
- Whether the participant glanced at the map during the task
- Usability scales, mental effort (RSME), and subjective preference scores

Procedures

Participants were told and read a description of the study before signing a typical consent form. They were then administered some questionnaires and the vision tests before being taken to the driving simulator. Once there, they were instructed in what to expect from the simulator and how to respond to the questions that require them to use 511. After practicing this procedure, they completed a practice drive, giving ten minutes of experience with controlling the vehicle, performing the car following task, and practicing calling a phone menu.

After each drive, participants answered questions on the PC outside of the simulator vehicle. Before the first experimental drive, they were told that for all three experimental drives they would be driving on a fictional set of roads through fictional cities. The experimenter went through the names of all the routes and cities while pointing them out on a map. Participants were then given the map which they took into the simulator for reference purposes. They then completed three counterbalanced experimental drives using a within-subject design, where all participants experienced all three experimental conditions:

- *Baseline* - Questions were asked of the same length and demanding similar responses as the 511 conditions, to control for question-asking.
- Two 511 conditions asked participants questions requiring navigating to information in the 511 menus, using one of two 511 menu versions:
 - *MN511* - current 511 Minnesota menu implementation
 - *511 V2* – alternative 511 menu implementation

After all the drives were completed, participants answered some final questions on the PC and were released.

Analyses

Car following, lane changing, and mental effort data were analyzed using a 3 (menu type: baseline, MN511, 511 V2) x 2 (gender: male, female) mixed factor design analysis of variance (ANOVA). Deceleration and situation awareness data were analyzed using a 3 (menu type: baseline, MN511, 511 V2) x 2 (gender: male, female) between

subjects analysis of variance (ANOVA). 511 task question data were analyzed using a 2 (menu type: MN511, 511 V2) x 2 (gender: male, female) mixed factor design analysis of variance (ANOVA). For all data, box-plots were used to identify and remove outliers before running the ANOVAs. A participant must be an outlier greater than 2 standard deviations from the mean to be excluded.

Results & Discussion

Driving Performance

Car Following

For all car following metrics, there were no significant main effects for gender. The mean results for each metric under each menu type are presented in Table 2.

Table 2. Mean results for the car following metrics by menu type, with significantly higher means ($p < .05$) in bold

Car Following Metric	Baseline	MN511	511 V2
Mean Time Headway (sec)	1.49	1.55	1.59
Variation Time Headway (sec)	0.32	0.44	0.61
Coherence (max speed correlation)	0.975	0.970	0.964
Pedal Power	0.167	0.175	0.169
Pedal Peak	0.300	0.270	0.286
Variation Lane Position (m)	0.234	0.226	0.235

Time Headway- For median time headway and variation in time headway, no differences were found between menu types.

Coherence (Maximum Speed Correlation)- For the speed correlation between lead vehicle and participant vehicle, there was a significant main effect for menu type, $F(2,44) = 4.79$, $p = .013$. Planned contrasts showed that drivers had significantly higher maximum speed correlation during the baseline condition than during both the 511 standard and V2 conditions, $F(1,22) = 7.58$, $p = .012$. No differences were found between the two 511 menu types.

Pedal Power- For the magnitude of pedal response while car following, no differences were found between menu types.

Pedal Peak- For the number of peaks in pedal response divided by the total time of car following, there was a significant main effect for menu type, $F(2,44) = 3.91$, $p = .027$. Planned contrasts showed that drivers had significantly more pedal peaks during the baseline condition than during both the 511 standard and V2 conditions, $F(1,22) = 4.32$, $p = .049$. No differences were found between the two 511 menu types.

Lane Position Variation- For lane position variation, no differences were found between menu types.

Deceleration

No participants collided with the lead vehicle during the deceleration event. For all deceleration metrics, there were no significant main effects for gender. The mean results for each metric under each menu type are presented in Table 3.

Table 3. Mean results for the deceleration metrics by menu type, with significantly higher means ($p < .05$) in bold

Deceleration Metric	Baseline	MN511	511 V2
Following Distance at Start (m)	41	48	49
Following Distance Minimum (m)	34	40	40
Accelerator RT (sec)	0.62	0.87	1.31
Brake RT (sec)	1.21	1.15	1.56
Maximum Braking Force	0.65	0.62	0.59
TTC at Braking Resposne Onset (sec)	6.55	7.96	7.05
Half Recovery Time (sec)	4.56	5.04	5.25
Exceeding Critical TTC	29%	13%	21%

Following Distance: at start- For the following distance at the deceleration event onset, no differences were found between menu types.

Following Distance: minimum- For the minimum following distance from deceleration event onset until the participant's recovered 75% speed, no differences were found between menu types.

Accelerator RT- For the time between the deceleration event onset and releasing the accelerator (if appropriate), no differences were found between menu types.

Brake RT- Two outlying female and one outlying male participant were excluded from this analysis. For the time between the deceleration event onset and the participant's brake onset there was a significant main effect for menu type, $F(2, 15) = 5.39$, $p = .017$. Tuckey HSD post hoc tests showed that participants accessing the 511 V2 menu had slower reaction times to the event than participants using either MN511 ($p = .021$) or not accessing a menu ($p = .006$).

Maximum Braking Force- For the maximum force that the participant applied to the brake pedal there was a significant interaction between menu type and gender, $F(2,18) = 3.56$, $p = .050$. Although follow up tests did not show any significant differences between genders for each menu condition, the means suggest that in the baseline condition females had larger braking force than males, as shown in Figure 4. Also, the results suggest that in the 511 V2 condition females had smaller braking force than males.

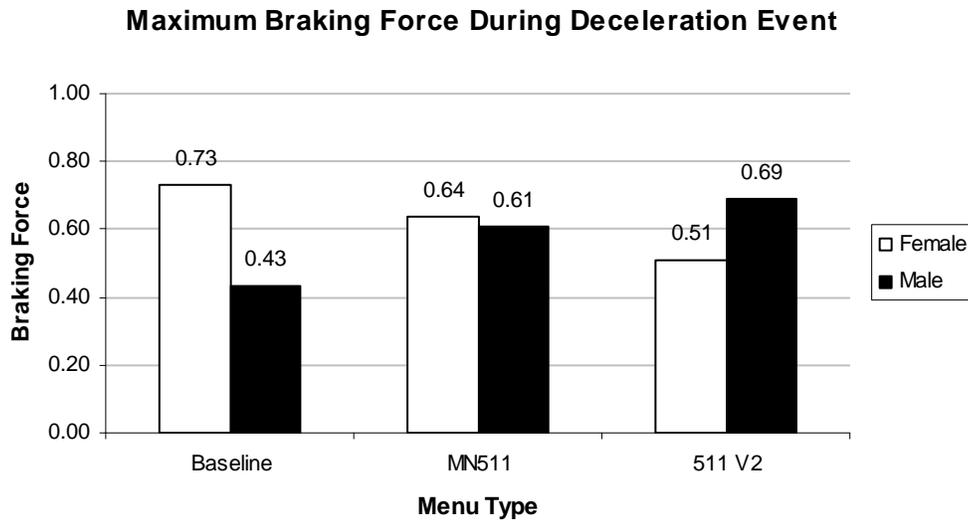


Figure 4. Maximum braking force during the deceleration event by gender and menu type.

TTC at Braking Response Onset- For the time to contact at the onset of the participant's braking response there was a significant interaction between menu type and gender, $F(2,18) = 4.32$, $p = .029$. Although follow up tests did not show any significant differences between genders for each menu condition, the means suggest that in the 511 V2 condition females had longer TTC at the braking response onset than males, as shown in Figure 5.

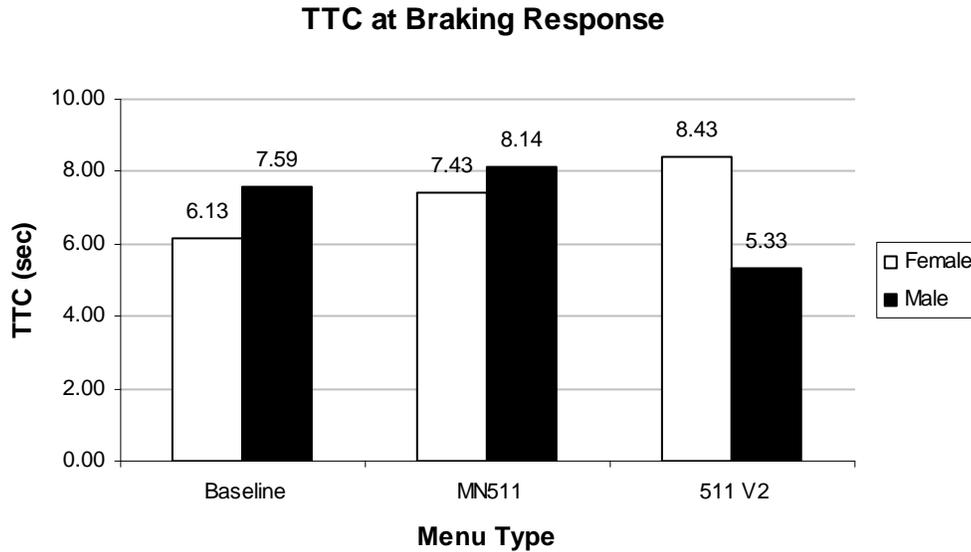


Figure 5. TTC at the time of braking response onset by gender and menu type.

Half Recovery Time- For the time from the deceleration event onset until the participant recovered half of their speed, no differences were found between menu types.

Exceeding Critical TTC- For the percentage of participants who reached this critical TTC, as proposed by Hirst and Graham (1997) of 3 sec plus one foot for each mph difference, no differences were found between menu types.

Lane Changing

No participants collided with any other vehicle during the entire lane change scenario. The mean results for each lane change task metric under each menu type are presented in Table 4.

Table 4. Mean results of the lane change task metrics by menu type.

Lane Change Task Metric	Baseline	MN511	511 V2
Time to Pass All Vehicles (sec)	168	173	186
Mean Time to Change Lanes (sec)	1.37	1.39	1.40
Mean TH during Lane Change (sec)	0.91	0.91	0.92
Variation in TH during Lane Change (sec)	0.15	0.17	0.16
Total Initiation Time (sec)	24.25	21.89	23.23

Time to Pass All Vehicles- For the total time to pass all vehicles in the convoy, there was a significant main effect for gender showing that females took more time to do so ($M = 194$ sec) than males ($M = 158$ sec), $F(1,16) = 4.78$, $p = .044$. There was no difference between menu types.

Mean Time to Change Lanes- One outlying female participant was excluded from this analysis. For the mean time to make a lane change maneuver there was a significant main effect for gender showing that females took more time to do so ($M = 1.58$ sec) than males ($M = 1.23$ sec), $F(1,18) = 13.69$, $p = .002$.

The interaction between main menu type and gender approached significance, $F(1,36) = 3.13, p = .056$. Follow up t-tests suggest that females took longer than males to change lanes while in the baseline and 511 V2 conditions (both $p = .003$), as shown in Figure 6.

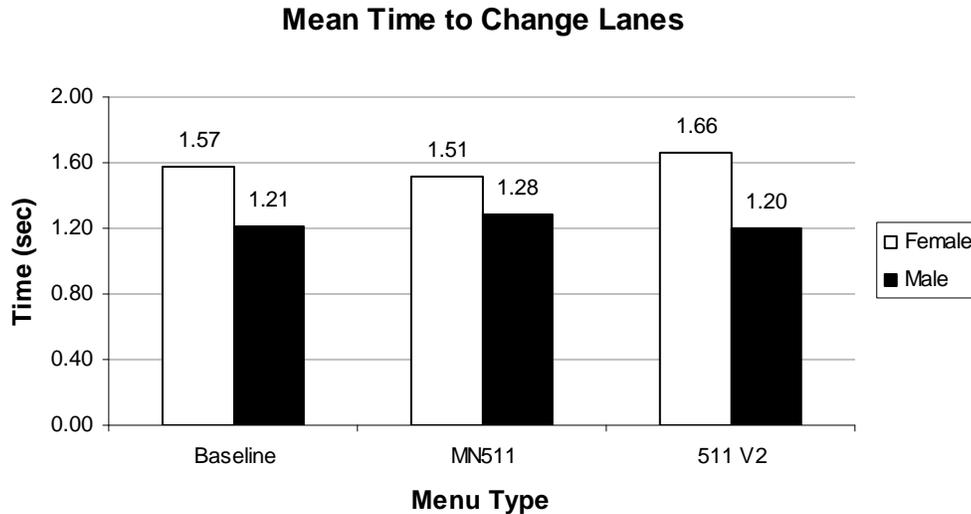


Figure 6. Mean time to change lanes by gender and menu type.

Mean Time Headway (TH) to Next Vehicle- One outlying male participant was excluded from this analysis. For the mean time headway to the next vehicle in front of the participant's while changing lanes, there was a significant main effect for gender showing that females had longer headways ($M = 0.97$ sec) than males ($M = 0.85$ sec), $F(1,19) = 4.49, p = .048$. There was no difference between menu types.

Variation in Time Headway (TH) to Next Vehicle- One outlying female participant was excluded from this analysis. For the variation in time headway to the next vehicle while passing, the main effect for menu type approached significance, $F(2, 38) = 2.97, p = .066$. Planned comparison post hoc tests suggest that participants not accessing a menu had smaller variation in time headway while changing lanes than while using either MN511 or 511 V2 ($p = .011$). No differences were found between genders.

Total Initiation Time (LCIt)- For the total time it took to begin changing lanes after passing the last vehicle in a row, trials where the participant did not pass all vehicles were excluded. There was a significant main effect for gender showing that females took more time in total to change lanes ($m = 27.6$ sec) than males did ($M = 21.3$ sec), $F(1,16) = 7.34, p = .016$. No differences were found between menu types.

Global Measures

Situation Awareness- For the billboard identification task, there were few false positive responses (an incorrect response where they thought that a billboard was in the

scenario when it was not), indicating a low base rate of guessing ($M = 4\%$). There were no significant main effects for or gender or menu type for the percentage of correct responses or total errors (false positives + misses). This analysis was based on one condition since participants only answered the billboard task after their first drive. The lack of statistically significant results may therefore be due to having low power for the analysis. We will take a look at the mean percentages to see if there are any trends suggested by the data.

As shown in Table 5, there was a higher percentage of correct responses after completing the baseline condition than after either of the menu type, and 511 V2 had slightly higher percentage of correct responses than did MN511. Participants in all three menu types seemed to make errors at the same frequency. Overall, these results suggest that in all three menu types, drivers were focusing the majority of their attention on the primary task of driving (car following and weaving) rather than to the ambient environment. Although the percentage trends suggest that there was more effort available to scan the ambient environment during the baseline condition.

Table 5. Correct and error response percentage for billboard situation awareness task by menu type.

Menu Condition	Correct	Errors
Baseline	19%	49%
MN511	14%	51%
511 V2	17%	49%

Mental Effort (NASA-RTLX)- The means for all six NASA-RTLX effort dimensions are presented in Figure 7. Below are discussed the significant differences for main effects on NASA-RTLX dimensions. No differences were reported on any comparison for the performance dimension.

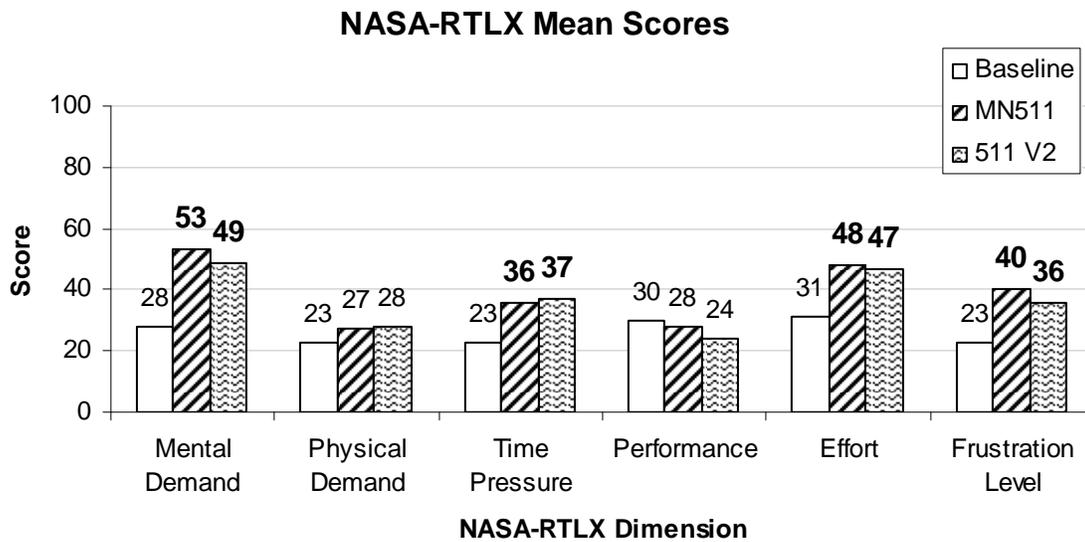


Figure 7. Mean results for the NASA-RTLX effort dimensions by NASA-RTLX dimension and menu type, with significantly higher means in bold

Drivers reported significantly less mental demand [$F(2,44) = 10.56, p < .001$], time pressure [$F(2,44) = 7.36, p = .002$], effort [$F(2,44) = 8.97, p = .001$], and frustration [$F(2,44) = 6.59, p = .003$] during the baseline condition than during both the 511 standard and V2 conditions.

Female drivers reported significantly more physical demand ($M = 34$) than did male drivers ($M = 18$), $F(1,22) = 5.01, p = .036$. Also, reported effort by females ($M = 49$) approached a significantly higher level than male's reported effort ($M = 35$), $F(1,22) = 3.89, p = .061$.

Discussion – Driving Performance

As expected, female drivers showed more cautious lane changing performance and all drivers showed differences in driving performance while using the phone based traveler information systems. However, it seems that the drivers were able to compensate for the added demand such that the degree of change in their performance was minimal and did not adversely affect their safety.

Car following performance is a measure of continuous, longitudinal driving performance and lets us see how drivers cope with a sustained driving task while accessing the 511 menus. During this scenario, the primary task of following the speed changes of the lead vehicle was negatively affected by accessing either menu. Specifically, drivers showed that they were coping with additional workload by having degraded speed-following performance (lower coherence) and decreased stability (more pedal peaks) while accessing the phone menus.

Drivers' ability to react to unexpected events was measured during the deceleration event. Although drivers had longer reaction times to the braking event (brake RT) while using the 511 V2 menu, drivers in both menu conditions were following at further distances from the decelerating vehicle and were arguably at no more risk than baseline condition drivers. This effect may be due to users having to give an additional response while using 511 V2, adding an additional level of menu depth and cognitive task complexity which has been shown by Jacko and Salvendy (1996) to have potential detrimental effects. Specifically, user had to select the region first and always accessing the main menu while using 511 V2. Although some interactions between gender and menu type were present for maximum braking force and minimum TTC, it is unclear what the practical significance of these results are beyond the differences typically found between genders since we were only able to capture data for one deceleration per participant.

Lane change performance is a measure of lateral (lane position) performance and lets us see how drivers cope with an intermittent driving task while accessing the 511 menus. Although drivers accessing a menu had slightly more variation in the amount of following distance they gave (mean TH) over all lane changes, there were no serious affects of menu type during lane changes. On the other hand, there were effects of gender, showing that females gave longer time headways and took longer to make all lane changes. These findings are most probably due to females being more careful in taking longer to prepare for (initiation time) actually perform (time to change lanes) the lane change maneuvers over all conditions.

The global measures show us how accessing the 511 menus may have affected the participants' ability to pay attention to the environment outside the driving tasks as well as to quantify the amount of workload they felt. Drivers reported that they felt more mental demand, time pressure, effort, and frustration while accessing the 511 menus than in the baseline condition. This may have been why drivers had slightly less recognition of billboards (situation awareness task) than did drivers not accessing a phone menu. This data is confirmed by the fact that drivers coped with the additional effort by having longer headways with the lead vehicle during car following.

511 Menu Analysis

As a precursor to the menu analyses, participants were also asked on a five point scale (1 = “Unimportant”, 5 = “Important”) how important it was to find traffic, weather, and transit information. After all testing, participants were asked again how important it was to find traffic and weather information types. Participant’s importance ratings were not significantly affected by the experiment, as no differences were found between pre experiment and post experiment scores (Table 6).

Table 6. Subjective importance ratings of traveler information types.

Information Type	Pre Study	Post Study
Traffic	3.71	3.96
Weather	4.21	4.29
Transit	4.04	-

Effort

Mental Effort (RSME). For the subjective mental effort of finding information, no differences were found between genders or the two menu types (MN511 M = 38 out of 150, V2 M = 35).

Time on Task. For the average time it took to complete a task, no differences were found between genders or the two menu types (MN511 M = 75, V2 M = 73 sec), even though on average drivers had to give significantly more commands to the menu during the 511 V2 condition (M = 3.75) than while using MN511 (M= 2.93), $F(1,22) = 46.41$, $p < .001$.

Map Usage. For the average number of tasks where the participant glanced at the map, no differences were found between genders or the two menu types (MN511 M = 53%, V2 M = 54% of trials).

Accuracy of Information Retrieval

For the percentage of correct, guesses, and incorrect responses, no differences were found between genders or the two menu types (Table 7).

- Correct response - Percentage of correct responses where the correct information was found and the question was answered correctly
- Guess - Percentage of correct responses where the correct information was *not* heard but the question was answered correctly
- Incorrect response – Percentage of incorrect responses. The differences in these error paths and self-reported errors are also examined

Table 7. Percentage and frequency of menu navigation task response types.

Response	Menu Type			
	MN511		511 V2	
	%	Count	%	Count
Correct	83%	100	84%	101
Guess	11%	13	10%	12
<i>Find Node</i>		5		6
<i>No Find</i>		8		6
Incorrect	6%	7	6%	7
<i>Find Node</i>		4		1
<i>No Find</i>		3		6

Path Errors- Aside from choosing the wrong city (a problem of remembering the task question), the most prevalent problem participants had with using both menu types was that they did not listen long enough to hear the information about the road they were asked to look up. Instead, participants would listen and hang up or give another command after hearing only the regional/city information. This may be an artifact of the superficial nature of the experimental environment and we might assume that users of a real traveler information system would not be satisfied until they came across the information of *exactly* the road or areas they were searching for.

An interesting pattern exists for these error cases when looking at the number of times a participant found the correct information node but still answered incorrectly; this may be considered equivalent to not comprehending the information correctly. Both menu types had the same number of incorrect responses, as shown in the count data at the bottom of Table 7. However, while using MN511, about half of the errors are due to not finding the information and the other half are due to not comprehending that the information was found. Conversely, there was only one instance where V2 produced a lack of comprehension, while the majority of errors were due to not being able to locate the information. This suggests that the V2 menu structure is either slowing users down so they listen to pertinent information (i.e. not stopping their listening too early) or framing the information in such a way that it is easier to understand.

Self-reported Errors- For the number of self reported errors, no differences were found between genders or the two menu types (7 participants using MN511 and 9 participants using V2).

When asked what errors people made, the most common response was that they forgot the city or route that the question was asking for or they asked for the wrong city or route when using the menu. While using MN511, one participant chose road conditions when s/he wanted to hear weather information. While using V2, one participant forgot the options given to him/her and another two participants had problems understanding what “restrictions” meant.

Usability

Usefulness and Satisfying Scale- For both usefulness and satisfying scores, no differences were found between the two menu types or genders. As a comparison, the usefulness and satisfying scores for the two 511 menus are graphed next to scores for other information telematic systems that were presented in a review of this usability measure (Van Der Laan, Heino, and DeWaard, 1997). As is shown in Figure 8, both 511 menus were rated as having respectably high levels of usefulness and satisfaction.

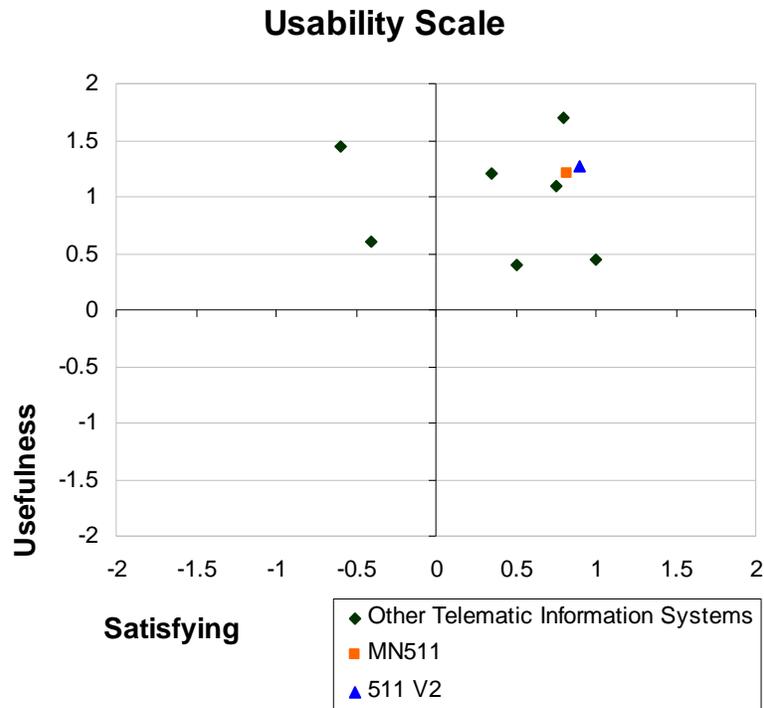


Figure 8. Usability scale results for MN511, V2, and other reported telematic information systems.

Traveler Information Survey- Agreement Scores- Participants were also asked their agreement on a five point scale (1 = “Strongly Disagree”, 5 = “Strongly Agree”) on a number of dimensions. These dimensions came from three sources, as described below. For all statements, no differences were found between genders or the two menu types unless indicated.

The 511 Deployment Coalition outlined a phone survey for current 511 users in their 511 Deployment Coalition Guidelines v3.0 (511 Deployment Coalition, 2005). Relevant questions from this survey were asked of our participants and the means for both menu types are presented and referenced in Table 8 (an additional question from the Coalition is addressed below in Table 9). For the statement, “Using 511 would save me time,” there was a significant main effect for menu type showing that users had a higher agreement with the statement after using V2 than after using MN511, $F(1,22) = 5.25$, $p = .032$.

Table 8. Agreement scores with statements suggested by the 511 Deployment Coalition for both menu types. Significant main effects between menu types ($p < .05$) are indicated in bold.

Coalition Question	Agreement Statements	MN511	511 V2
DCD1d	Reduce Stress	3.5	3.5
DCD3e	Ease of Understanding	4.0	4.4
DCE1a	Save Time	3.7	3.6
DCE1b	Help Decide when to Leave	3.3	3.3
DCE1c	Help Decide Take another Route	4.0	4.1
DCE1d	Help to Arrive on Time	3.3	3.4
DCE1e	Help Decide Take Another Transportation Mode	2.8	2.8
DCE1f	Help Avoid Congestion	4.1	4.1
DCE1g	Help Avoid Unsafe Weather	3.8	3.9

Next, a simulated driving study of 511 in Montana (Kelley et al, 2005) asked drivers a number of questions on the usability and understandability of 511. Selected questions from this study were asked of our participants and the means for both menu types are presented alongside the Montana results (Table 9) for comparison purposes; no statistical comparisons were made between the MN 511 and MT 511 ratings.

Table 9. Agreement scores with statements used in the Montana study for both menu types and the Montana’s 511. Significant main effects between MN menu types ($p < .05$) are indicated in bold.

Coalition Question	Agreement Statements	MN511	511 V2	MT 511
-	Would Use Frequently	3.6	3.7	2.9
-	Complexity	2.2	2.0	2.5
DCD3a	Ease of Finding Information	4.1	4.2	4.0
-	Confidence	3.8	3.9	3.3

For the statement, “I have confidence in this system,” there was a significant main effect for menu type showing that users had a higher agreement with the statement after using V2 than after using MN511, $F(1,22) = 4.40$, $p = .048$.

Finally, we generated a number of additional agreement statements, for which the means of both menu types are presented in Table 10.

Table 10. Agreement scores with statements for both menu types.

Agreement Statements	MN511	511 V2
Information was Useful	4.0	4.3
Trust	3.8	3.8
Reliability	3.8	3.9
Distracting	2.7	2.4
Had Worse Driving Performance	2.6	2.4

For the statement, “I had worse driving performance when I was using 511,” there was a significant main effect for gender, showing that males had less agreement with the statement ($M = 2.0$) than females ($M = 3.0$), $F(1,22) = 12.21$, $p = .002$.

Preference Scores- Participants were asked their menu type preference for eight usability aspects, as shown in Table 11. The purpose of asking these questions was to force the participants to choose one of the two menus for each aspect. Most aspects showed no statistical preference for either menu although all but one had a larger number of people preferring V2. Indeed, combining all of the participants’ scores into an overall score showed that V2 ($M = 17$ participants) was preferred by more participants than MN511 ($M = 7$ participants), $Z_w = 4.17$, $p = .041$. There was no effect for gender for any aspect or for overall preference.

Table 11. Preference results for the two menu types and composite overall preference.

Preference Aspect	MN511	511 V2
Would Use Frequently	33%	67%
Complexity	50%	50%
Ease of Finding Info.	33%	67%
Ease of Understanding	35%	65%
Info. was Useful	46%	54%
Trust	41%	59%
Reliability	30%	70%
Confidence	30%	70%
Overall Preference^a	29%	71%

^a Calculated for each participant as the menu they chose for the majority of aspects (i.e. menu preferred for ≥ 5 aspects)

Traveler Information Survey – Open ended- All 24 users were asked what they liked about each menu type and ways they thought each menu could be improved. Their responses were grouped into categories and are presented in Table 12. Responses relevant to both menus were separated.

Table 12. Most-cited open ended responses when asked what was liked and what could be improved for both menu types, ordered by response count. Requested improvements that are already available in the current menus are shaded.

	MN511	511 V2	Relevant for both menu types
What did you like about the system?	13 Information quality - thorough 10 Easy to use/navigate 2 Divided into cities and area around city	12 Information quality - less irrelevant info 10 Clear, less complex, easy to find information 5 Gave categories first, liked organization	2 Hands free 1 Repeated your choices 1 Can talk-through the prompt 1 Real voice, not automated 1 Consistent
How do you think the system could be improved?	6 Allow choice of information type first 4 Less irrelevant information 2 Less selection confirmation	2 Rename categories	6 Ask question to 511; less menu options 4 Bypass overviews 1 Option to repeat information 1 Different voice per node path

A majority of participants thought that the MN511 menu presented a thorough amount of information and that it was easy to find that information. Some also reported that this menu type presented more information than was needed (e.g. wind speed, restrictions). It is also interesting to note that one-fourth of the participants thought the menu did not allow for choice of information type first when in fact this menu would have done so if they would have navigated to the main menu instead of the immediate shortcut to route reports.

A near-majority of participants also thought that the 511 V2 menu presented a good amount of relevant information and that it was easy to find that information. Some also liked that it forced them to choose a category of information first (just after selecting a region), although some did feel that the categories titles were confusing at first.

It is interesting to note that one-sixth of the participants thought they could not bypass a regional overview, even though the ability to talk-through a prompt was always available and often used by themselves and other participants. Similarly, one person wanted to be able to repeat information once it was heard which was an available feature. A good number of participants also wanted to be able to ask a question directly instead of interacting with a menu.

Discussion – 511 Menu Analysis

Although there were few differences between using the two 511 menu types in terms of driving performance, user preferences did show some interesting trends. To begin, these trends are purely based on preference in that there was no difference in the perceived amount of effort/frustration (RSME scores) or time (on task) it took to retrieve information. There were also no differences in the difficulty (correct responses, guesses) or unfamiliarity (map usage) of the questions, or self-reported errors. Both menus also scored similarly well in terms of perceived usefulness and satisfaction (usability scale) and were praised for the information quality provided.

There were more instances while using MN511 where participants found the correct information node but did not answer correctly (incorrect responses), suggesting

that the V2 menu structure is either slowing users down so they listen to pertinent information (i.e. not stopping their listening too early) or framing the information in such a way that it is easier to understand (i.e. less non-relevant or redundant information). This is confirmed in the agreement scores in that participants reported it was easier to understand and they had more confidence using 511 V2 than they did using MN511. This is also reflected in the forced-preference scores, where more drivers preferred 511 V2 in all categories.

Conclusions

It seems that any negative affect of using the 511 menus while driving was absorbed by the driver's ability to drive with more forgiving safety margins. This was evident during the car following when drivers drove at longer distance from the lead vehicle while accessing a menu than while just answering questions. Drivers were able to cope with multitasking in a similar way during the lane change task, as no differences in performance were detected.

The 511 V2 menu was designed with the intention of making interactions easier by forcing the user to first select a region before selecting the type of information (route, weather, transit). This may have been why users showed a greater comprehension of the information they heard (path error data), reported higher understanding, and confidence (traveler information survey) while using V2. Likewise, participants reported that MN511 presented more information than was needed (e.g. wind speed, restrictions) while a near-majority of participants reported that it was easy to find a good amount of relevant information in 511 V2. It was not surprising when users were forced to choose between the two menus that they preferred V2 over MN511, even though the mental workload scale, usability scales, and most driving performance measures showed no differences between the two menus. We can conclude that changes made to the MN511 menu structure would not significantly affect driving performance, positively or negatively but that MN511 could benefit from the structure and dialogue design of the 511 V2 menu. Furthermore this suggests that users saw some benefit from the proposed design focus of integrating the MN511 phone menu and 511mn.org website organization and information.

Issues and Recommendations

By improving the user's ability to navigate the menu and increase the perceived usability of the menu, users will view the traveler information in MN511 to have more value. Below is a list of three issues that were seen while evaluating MN511 and some recommendations on how to address them during future designs. These issues and recommendations are more general in nature than the detailed recommendations (Appendix A) so that they can be applied to the menu as a whole. Each recommendation also lists the issue's severity; for which an issue can be *Cosmetic* (fix if extra time is available), *Minor* (low priority to fix), *Major* (high priority to fix), or *Imperative* (essential to fix before releasing a new version).

Users are presented with long dialogues of information

Severity: Major

Recommendations:

1. Reduce dialogue "clutter", such as information that may be unnecessary to your main users (e.g. passenger vehicle drivers v. truck drivers). Foremost, make sure repetition of data is removed especially since an option to repeat information is available already. In the case of passenger vehicles,

unnecessary information includes dialogue on wind speed (unless extreme) and restrictions. Information that is removed can be placed in a separate main menu option (e.g. Restrictions was separated in 511 V2) or given as an option after the shortened reports are heard.

- a. Note: “Restrictions” as a main menu option in V2 was confusing to users. Using the titles “Freight Restrictions”, “Truck Information”, or another appropriate title may be more intuitive to users
2. Force users to select a region they want before proceeding through the menu, as was done during 511 V2. This removes a step that all users had to take after selecting a main menu option during MN511 (selecting a region). Because of this, the regional overviews found in MN511 were removed from V2, leaving only a general report identifying routes that have active reports. This helped reduce dialogue “clutter” as is mentioned in #1 above. An additional main menu option may be needed to allow the selection of a new region.

Current shortcut to regional information during greeting bypasses main menu, which seems to create some confusion when users want other types of information

Severity: Minor

Recommendations:

3. Select a region first (see recommendation #2, above). Users will be forced to use the main menu and be exposed to what their options are, whereas in MN511 they are unaware of them when they skip directly to route reports.
4. Remove shortcut and have everyone proceed to the main menu first. As this is equivalent to recommendation #2 without selecting a route, this is a less advisable recommendation.

Once a main menu option is selected, there is increased time to get to the information while listening to introduction sounds.

Severity: Cosmetic

Recommendations:

5. These sounds may be useful in helping experienced users recognize that the menu has brought them to the correct menu option. For this reason, do not remove but instead shorten or place these sounds in the background only while simultaneously presenting the name of the menu option. For example, remove the lead-in portion of the sound and play it in the background while saying, “Minnesota regional weather”.

Design Alternatives

In addition to the 511 V2 alternative menu tested in this study, a number of alternative design options were explored and considered. Since some of these ideas are high level, potentially involve large changes to the MN511 structure, or are beyond the technical capabilities of the time, they were not explored in this study. However, we are

presenting two of them here as they could be adapted and used in the discussion of future MN511 menu iterations. We have also noted when these concepts or ideas were suggested from our user comments and testing.

Natural Language. Researchers have found that using conversational language, or “natural language,” can improve the user experience by increasing accuracy, speed, and user acceptance (Schum et al., 2002, as cited in Staub, 2003). A good number of our participants also wanted to be able to ask a question directly to the menu instead of wading through a menu. There are a number of complications that come with this approach. First is that the initial time a user calls the menu, there may not be an obvious path for the user to take and he or she may be unsure in how to proceed even if prompted. Another downside is that for each command the menu can accommodate, it must be able to understand a larger vocabulary of potential ways to say that command. In this way, having a menu like the current MN511 is actually advantageous in that it limits decision dialogue of the user (Peissner, as cited in Staub, 2003) by providing categorical options early in the interaction (e.g. main menu options) and allowing for freedom as they proceed through the menu (e.g. selecting particular cities or routes).

Use of a Metaphor. Researchers have found that framing the interaction with the menu with something that users are familiar with, e.g. a filing cabinet, can expedite interactions with a menu (Howell, Love, & Turner, 2005). Users were more easily able to visualize the structure of the menu, leading to more positive attitudes towards service, and were confident enough to talk-through the menu more often when a metaphor was used. All of this was accomplished even though there was no difference in either the number of nodes that composed the menu or in user perception of services. An appropriate metaphor for MN511 could be to equate the traveler information services directly with those on the 511mn.org website or that of a navigation system.

Smart Menu. Another idea to reduce the number of interactions with the menu is to provide the menu information on the user in one or both of the following ways. A menu could access the location of a phone caller based on their geographic location based on information provided by cell phone towers or based on the location of their land line they are calling from. In this way, the menu can begin by offering choices that reflect the potential local geographic needs of the user. Another way to add intelligence to the menu would be to have it “learn” common access paths or choices by a particular user and store them for future use. This could benefit the user offering them their “favorite” regions, routes, or menu options first.

Website Integration and Personalization. Allow users to go online and set up preferences of regions, or routes that they may be traveling on later, tied to their cell phone number. Users can then call up and access these preferences directly (again, as “favorites”) by setting up the type of information they desire ahead of time.

Another possibility exists if it is someday possible to identify where the user is by the location of their cell phone, and a user could have personalized settings online where they tell MN511 where they are planning on going. If urgent road or weather events arise

on their planned path, 511 could call or send a text message to notify the user of the upcoming problems.

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Appendix A
Expert Evaluation Results

Overall MN511 Menu Issues

Rules Followed:

- Allows dial-through, or “barge-in” navigating – dialing or speaking to interrupt a prompt when the proper input is known (ISO, 1994)
- Voice is agreeable and assertive
- Ends main list of options by saying, “...that’s all the categories”
- Timeouts are appropriately long to compensate for someone driving or for entering multiple keys; approximately 10 seconds the first time, 8 the second time
 - Could allow more time between commands / minimize paced responses to allow more time to compensate for difficulty in driving environment (Kelly, Stanley, and Lassacher, 2005)
 - Jamson, Westerman, Hockey, Carsten (2004) find that adding elements of driver pace control may increase safety
- Shortcut to route reports provides multiple paths to the same functionality (Bond and Camack, 1999)
- Help offers a standard useful prompt
- Usage of “enter” v. “press” follows the Guidelines (1997), as they suggest using “enter” instead of “press” for multiple entries, which has correctly been done throughout the menu
- “#” is used as expected and not needed as a delimiter (Marics & Engelbeck, 1997)

Issues:

- Ensure that all menu prompts to make sure they’re as brief as possible and using understandable language.
 - CUSTOMER IDENTIFIED: Lots of information (i.e. hard to find the information user is seeking)
 - E.g. For construction, the system lists all construction projects on the route
 - I.e. need for more specification on user’s route through construction areas
 - See if unnecessary words or sounds can be eliminated.
 - If asking for comments isn’t necessary, recommend removing this feature as it adds clutter to them main menu prompt (0)

- Usability test to see that you are using the natural language of your users. E.g. do people think in “Regions”? Could this term be eliminated and just use “closest city” or the equivalent?
- Issue of Relevancy (as addressed on p.27 of 511 Deployment coalition, 2005) in regional and route reports-
 - The reports themselves seem very redundant at times, listing weather too.
 - Do many truck drivers use 511? If so, should the route restrictions be a separate menu item for them, as most if not all commuters would not need this information?
- No way to go back a node in the menu- this is OK since the menu is not that deep and access to the main menu can facilitate new options easily.
- Error conditions should suggest how to fix the problem after multiple errors (Marics & Engelbeck, 1997). This will help user to determine if what they’re saying is incorrect or if their input (spoken) cannot be understood by the IVR menu
- CUSTOMER IDENTIFIED: Voice recognition. A recognized technology limitation by developers and users.
 - Kelly, Stanley, and Lassacher (2005) found 95% of participants self-reported making errors due to the voice response software
- “*” and “0” keys functionality are switched from standards – (Schumacher, et al., 1995)
 - “*” may be thought to return to main menu rather than help. Alternatively, the 511 national Coalition’s suggested standard is to use “9” for help (511 Coalition, 2005)
 - “0” may be thought to help rather than return to main menu.

Location Specific Menu Issues

The outline below describes issues at particular nodes of 511, as outlined in Figure 1a. Suggested changes are listed for each node with footnotes linking each comment to the relevant highlighted dialogue.

00. 511 Greeting

This is 511 travel information, brought to you by the Minnesota Department of Transportation. Say the name of the city in the region you want, or using your keypad, enter the first three letters of the city followed by the pound key, or you can say menu to go to the main menu¹.

- a. [short timeout] (goes to Menu)

Suggested Changes and Comments

¹ Remove the dialogue instructing users to say “menu” to go to the main menu, since a brief timeout brings them right to the menu.

0. Menu

Menu. Here are all of the categories you can choose from. When you hear the one you want, just say it.² Route reports. Regional reports³. Transit. Weather. Comment on 511. Help with 511. That’s all the categories; just say the one you want.

Suggested Changes and Comments

² Replace with: “Please speak the option you want when you hear it.”

³ Since Regional Reports is the most used option, make it the first option listed (switch it with Route Reports)

1. Route report

(sound)⁴ OK.⁵ Route reports. Say the name of the route you want. Or using your keypad, enter the route number followed by the pound key. To hear all the urgent reports on major highways statewide, say urgent reports.

- a. Confirm route – Did you say, ___(route)?
- b. Reports on route – OK/All Right. ___(report)
- c. Another route? – Say the name of another route or say, go to menu.

Suggested Changes and Comments

⁴ Don’t make user wait for sound to end before starting dialogue. Alternatively, delete unnecessary sound

⁵ Delete confirmation OK, it is good after they enter specific city but is extraneous here.

2. Regional report⁶

Minnesota⁷ regional traffic information. Say the name of the city in the region you want, or using your keypad enter the first three letters of the city, followed by the pound key.

- a. Confirm region – Did you way, ___(city/region)?
- b. Regional reports for city – For regions around ___(city).
- c. Route report or weather- Say the name of a route to hear the detailed reports, or using your keypad enter the route number followed by the pound key. [pause]⁸ For a weather report around ___(city), say weather.

Suggested Changes and Comments

⁶ Would be better to have “traffic” be included in this title. Maybe “Regional traffic”.

- i. could make this uniform with the internal menu title and call it Regional information
- ii. Possibly change “Region” to City?

⁷ Delete for consistency with other main menu prompts.

⁸ Eliminate the pause, it is unnecessary and masks this functionality- i.e. people won’t know it’s there.

3. Transit⁹

- (sound)¹⁰ Minnesota¹¹ transit. Say the name of a city in the region you want to hear information of nearby transit providers, or using you keypad, enter the first three letters of city, followed by the pound key. For example say, Minneapolis.
- Confirm region – Did you say, ___(city)?
 - Transit options in region – There are ___ transit providers serving the city of ___. Press 1 for¹² ___...¹³
 - [Number of service] Transit info - ___(provider) operates a ___(type) service.
 - Transfer to local number - For hours, schedules, and rates, I can transfer you to ___(#). Would you like me to transfer you?
 - [Yes] – (Transfers w/o saying anything)¹⁴
 - [No] To hear the previous provider list, say back. For information on other transit providers in Minnesota, say the name of the city in the region you want, or using you keypad, enter the first three letters of city, followed by the pound key. To transfer to the main menu¹⁵, say menu.

Suggested Changes and Comments

⁹ Is this more used than weather? If not, switch positions. This recommendation is given knowing that this is the recommended place to have this, by the 511 Coalition.

¹⁰ Delete unnecessary sound

¹¹ Delete for consistency with other main menu prompts

¹² Should be inverted, “for route report press 1...” etc. the menu currently uses action-goal sequence for options instead of goal-action sequence (Schumacher et al 1995)

¹³ This menu does not say when the list ends, just times out. Treat this like the opening menu and conclude with something like, “That’s all the transit providers, press the key for the option you want.”

¹⁴ Tell the user that they are leaving the 511 menu, prompt them “You are now leaving 511 and transferring to ___(provider).”

¹⁵ This was presented in a new voice. Use the prompt at the end of Weather-Another region? (4.c) instead as it keeps voice consistent and says the same thing

4. Weather

(sound)¹⁶ Weather. Say the name of the city in the region you want. Or using your keypad, enter the first three letters of the city you want followed by the pound key.

- Confirm region – Did you say ___(city)?
- Weather for region – Regional weather report for, ___(city)...
- Another region? – For another regional report¹⁷, say the name of the city in the region you want, or using you keypad, enter the first three letters of city, followed by the pound key. Say menu to return to the main menu.

Suggested Changes and Comments

¹⁶ Don't make user wait for sound to end before starting dialogue. Alternatively, delete unnecessary sound

¹⁷ Shouldn't this be "weather"? Possibly, "regional weather report".

5. Comment¹⁸

[voice and keypad commands are turned off- user cannot stop this menu once it has started].¹⁹ We would be pleased to hear what you think about our new automated system which will continue to be improved based on your feedback. Please leave a comment and when you're done, press pound. [Beep]

Suggested Changes and Comments

¹⁸ Remove this functionality unless it is still desired.

¹⁹ Allow users chance to back out to main menu in case they got here on accident.

A.1. Urgent Report²⁰

[From 00. or 0.] (sound) Here are the urgent traffic reports for all regions of Minnesota. Let's start with the area around Minneapolis. ___(report, see below)

[From 1.b, 2.b, or 4.b] (sound) here are the urgent traffic reports for ___(25 for TC, 40 or 60 for others) miles around ___(city). Let's start with the area north between ___(route) at __ (intersection) and ___(route) at __ (intersection). ___(report, see below)

[Report] Driving conditions are ___(good, fair, poor, ?).

Routes are ___(open/closed) for trucks with permits.

Routes are ___(open/closed) for mobile homes.

[warnings. repeat each of the 2 above "Routes..." statements before each one]

- Be prepared for gusty winds.
- Expect windy conditions.
- Be prepared for cross winds.
- (probably other weather-related)

For trucks with permits, all routes currently ___(open/closed)

Trucks with permits should call for instructions in ___(county) county, ... and ___(county) county.²¹ [warnings]

- Look out for roadwork on ___(route) between __ (intersection) and __ (intersection).
- Look out for bridgework on ___(route) at __ (intersection).
- Look out for water main work.
- Right shoulder closed
- Left shoulder closed.
- Width limit is enforced.
- Look out for flagger.
- Mandatory speed limit is enforced.
- Roadway is reduced to one lane.)

[warnings, correspond to those above]

- Be prepared for gusty winds in ___(county) county, ... and ___(county) county.
- Expect windy conditions in ___(county) county, ... and ___(county) county.

- Be prepared for cross winds in ___(county) **county**, ... and ___(county) **county**²². Moving towards area __(direction- NSEW) of __(city)... (repeat)

Suggested Changes and Comments

²⁰ **Biggest problem** is how this information is not combined in any meaningful way, often repeating the same information. This is probably a symptom of how it is gathered (i.e. the data base lists these separately and it just plays the appropriate parts). However, it makes it very tedious to listen to, making it hard to wait for and locate pertinent information.

- Split the information into meaningful user group categories that the user can choose from. E.g. let them choose between “Traveler/Commuter information”, “Vehicles with permits” and “Mobile homes” categories
- Group related information into meaningful information categories and present these categories of information together. E.g. present “Weather”, “Closures”, then “Roadwork” related issues, not each separate problem.
- This should eliminate the repeating of **this information**, but if not definitely remove the repetition of this information.

²¹ **Warnings** are listed globally then given again with specific counties. Don’t repeat information, give county information the first time.

²² **When** listing counties, don’t repeat the word “county” after each one. Instead, list the names of all the counties, followed by the word “counties”.

A.2. Choices

Say route reports to select reports on a Minnesota highway, or just press 1²³. Say one of our menu categories, or **press 1 for route reports, 2 for regional reports, 3 for transit, 4 for weather, or 5 to leave use a comment on 511**²⁴. When you are done say, goodbye or press star star star. Now, go ahead and say what you want.

- [During any of the Menu choices] You can say help or go to menu at any time, or for help you can press the star key. For the menu press zero. For urgent traffic reports statewide say, urgent reports or just press 1. To repeat this section say repeat that, or press nine. When you are done, say goodbye or press star star star. You will be invited to leave a comment to help improve Minnesota’s 511 system. Now, go ahead and say what you want.

Suggested Changes and Comments

²³ **Should** be inverted, “To select reports on a Minnesota highway, say route reports or just press 1”

²⁴ **Should** be inverted, “for route report press 1...”, etc.

A.4. Goodbye

Thank you for calling 511. (goes to 5. Comment)

A.6. Help (6)

The menu lets you pick the kind of travel information you want to hear. Say one of our menu categories or press 1 for route reports, 2 for regional reports, 3 for transit, 4 for weather or 5 to leave use a comment on 511²⁵.

- a. [During Route Reports] This section allows you to hear traffic reports for selected routes (return and repeat last menu prompt)
- b. [During Regional Reports, Transit, or Weather] This section allows you to select a local region of Minnesota (return and repeat last menu prompt)

Suggested Changes and Comments

²⁵ **Should** be inverted, “for route report press 1...”, etc.

Time Out

[10 seconds for first timeout, approx. 8 seconds for second timeout]

- a. [During Main Menu] – I’m sorry, I didn’t hear you. Say one of our menu categories or press 1 for route reports, 2 for regional reports, 3 for transit, 4 for weather, or 5 to leave use a comment on 511.²⁶
- b. [During Route Reports] I’m sorry, I didn’t hear you. Using²⁷ your keypad, enter ___ (route) the route number followed by the pound key²⁸
- c. [During Regional Reports, Transit, or Weather] I’m sorry, I didn’t hear you. Using your keypad, enter ___ (city) the first three letters of the city you want, followed by the pound key.²⁹
- i. [if multiple cities fit the letters, e.g. “MIN”] For Minneapolis, press 1, for Minnetonka, press 2, ...
- d. [Any menu, second time] – I’m sorry, I still didn’t hear you. To hear other options say, what are my choices, or press the pound key.
- e. [Any menu, third time] – Thank you for calling. Good bye.

Suggested Changes and Comments

²⁶ **Should** be inverted, “for route report press 1...”, etc.

²⁷ **Sometimes** this gap in dialogue includes, “let’s try this another way...” or “I’m sorry your having trouble...”. The former is great, the latter needs to go, it’s patronizing / accusing.

²⁸ **Potential problem:** need to enter the # key to confirm that you’re entering route number and not just hitting “9” to go back or another number for another function. May need to keep this in even though...

²⁹ **Menu only accepts** letters followed by # key. Suggestions:

- a. Assume that a timeout is equivalent to hitting #.
- b. Assume the third letter hit is the delimitator (#).
- c. Take one or two entered keys as input and determine city from that.

Appendix B

Detailed Recognition Data

The recognition data was provided by Mn/DOT's 511 team and represents the time from April, 2005 through March, 2006.

Figure 9 shows the frequency of accessing Traffic, Transit, and Weather features (511 Coalition standards). In MN511, route reports and regional reports both are considered "traffic", thus it is no surprise that 80% of recognized commands were for traffic information. 18% of commands were for weather information and 2% for traffic information.

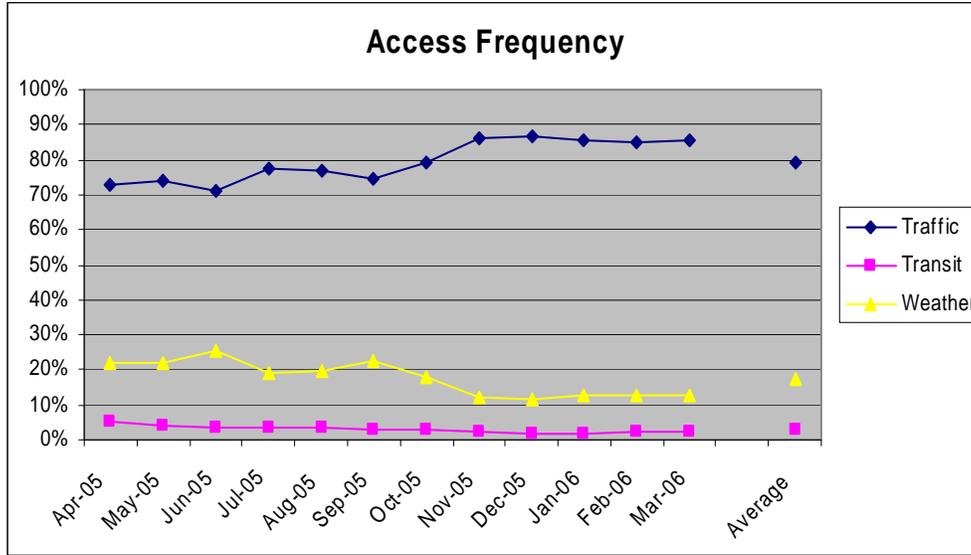


Figure 9. Access frequency from April 2005 through March 2006 of MN511 information types

The most frequently-recognized menu commands are shown in Figure 10. "Menu" is and has been the most frequently recognized command, which is to be expected as this is the first command prompted to the user as well as the universal command to get back to the menu from any location in MN511.

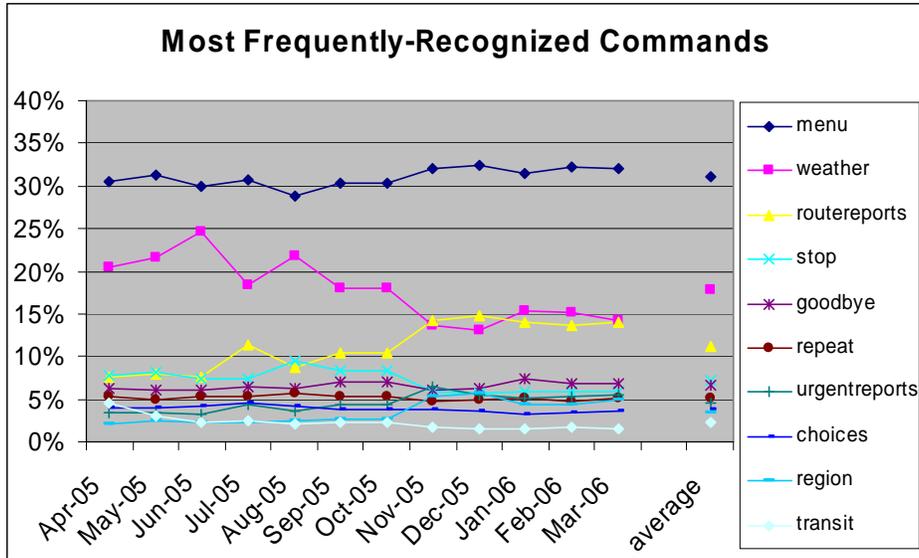


Figure 10. Access frequency from April 2005 through March 2006 of MN511 commands

As shown in Figure 11 below of the most frequently-recognized cities, Minneapolis was the highest frequency of recognized city requested by MN511 users, followed distantly by St. Paul and then a muddle of other Minnesota metropolitan areas. As seen in the data above and the drop in requests in November, it seems that a large number of new users were made aware of MN511 and have continued to request information from all parts of Minnesota. This suggests that MN511 was primarily a twin cities information source before November until more users were made aware of the benefits of using this traveler information system, and now these users continue to use the system even after the winter months.

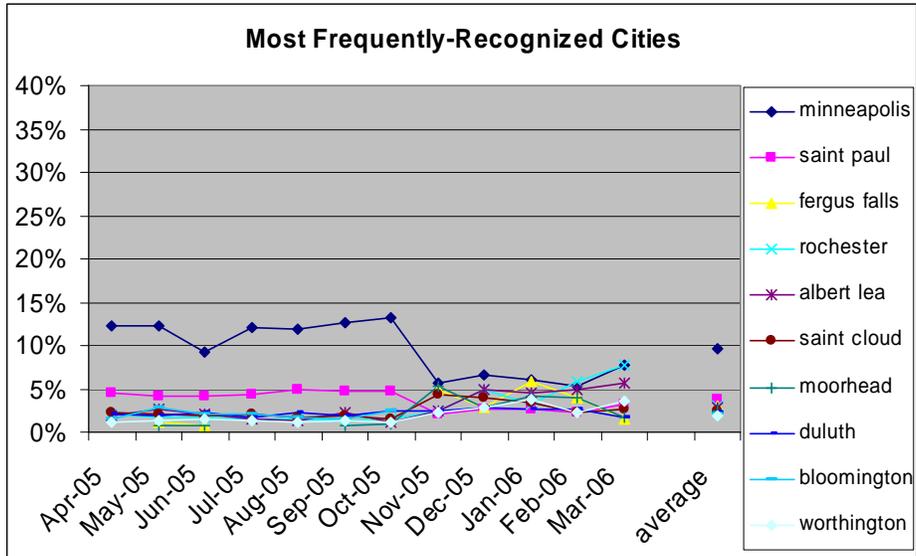


Figure 11. The cities most frequently accessed by MN511 from April 2005 through March 2006.

Figure 12 shows the most frequently-recognized routes requested by MN511 users. As expected and intended by the 511 Coalition, 511 is meant mainly for informing drivers of National Highway System (NHS) and limited access roadways. Minnesota users do appear to be accessing the system most frequently for this NHS and roadway information with no clear changes in request-behavior over the year.

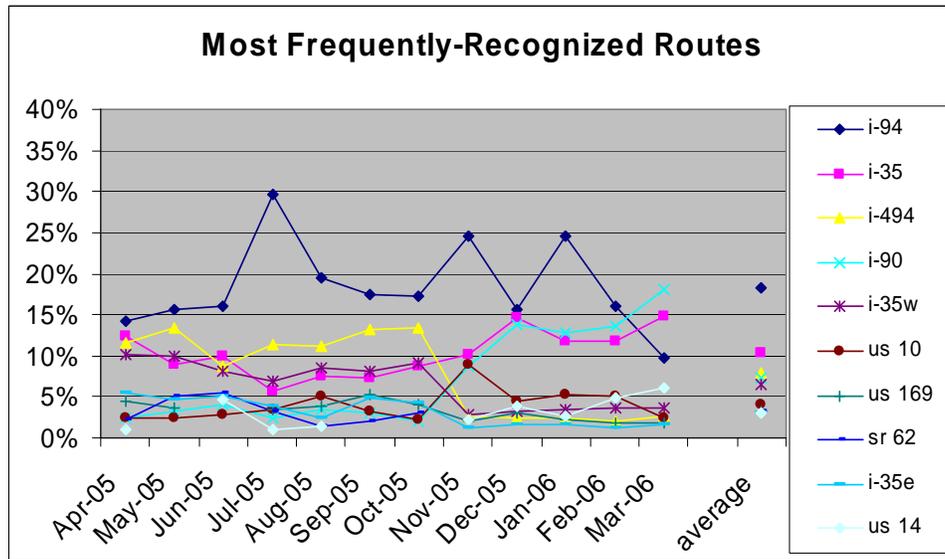


Figure 12. The routes most frequently accessed by MN511 from April 2005 through March 2006.

Appendix C

Computing the Value of Information in the 511 Menus

How the menu is organized and what actions are allowed affect the user's their progress towards their information goals while using 511. Our goal is to identify, from the information types already present, how this information can be made more accessible.

Two separate sets of scores, probability and utility, are necessary to compute and compare the value of information types in the menu structures examined in this report. The frequencies of using information in the menus (the user's goals) are identified and quantified in a *probability matrix*. Also, the amount of effort it takes to complete these goals will be quantified in a *utility matrix*, in terms of how many actions are necessary before finding the information.

Probability Matrix

This analysis must take into account what outcomes are relevant to the user in terms of how he or she will be using the system. The probability matrix facilitates this by quantifying how likely the user is to find and identify the information they are searching for. The probability of finding useful information was calculated using the past frequency of accessing each information type in MN511, the percentage of useful information, and a score representing the adequacy of information found.

Requirement Frequencies (p(req))- Usage data from April 2005 through March 2006 of the current MN511 traveler information system was provided by the Minnesota Department of Transportation (Mn/DOT) in order to determine the frequency at which users used each type of information.

The 511 Deployment Coalition recommends that all state-based 511 phone systems should incorporate traffic, transit, and weather information (511 Deployment Coalition, 2005). Data from April 2005 through March 2006, was requested from Mn/DOT's 511 team, in order to determine what types of information were most frequently queried (e.g. traffic, weather) and what specific voice commands were most-frequently given when using MN511 (e.g. "menu", "route reports"). Further analyses on the recognition frequency of particular commands, cities, and routes are presented in Appendix B. It should be noted that this data set has a potential confound, since is difficult to say what paths people are taking while using the menu or whether they were successful in finding the information they were looking for. That said, the discussion below will focus on the available usage data but any results discussed should be considered speculative guideposts for design rather than significant findings.

Using the past data and the Coalition categories as guidelines, we summarized the frequency of calls that access these categories of information, as shown in Figure 13. The larger traffic portion of MN511 (white areas in Figure 13) was also broken down into route report, urgent report, and regional report information categories.

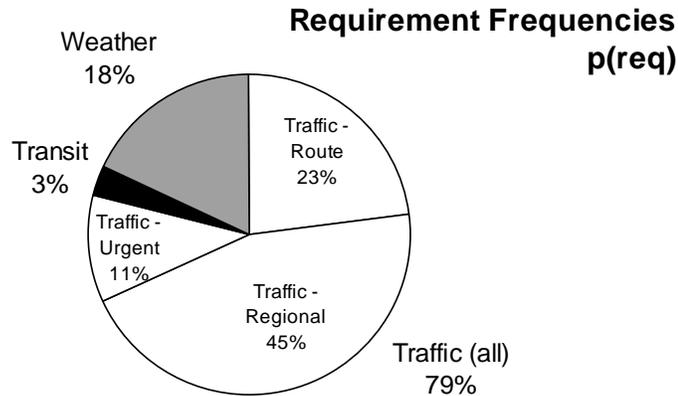


Figure 13. Requirement frequencies of the MN511 traveler information system from April 2005 through March 2006.

Adequacy (A). Not all information presented in a menu prompt may be related to a user's query. The adequacy of information can be quantified in a number of ways (e.g. time to listen to a prompt, number of relevant bits of information) depending on the menu. For this analysis, adequacy was quantified as that the number of relevant sentences at an information node divided by the total sentences at that node. Using the menu script dialogues (Appendix E), the sentences at the information nodes were counted based on relevancy to a passenger vehicle driver using MN511. For example, when finding route information, relevant sentences included those pertaining to a route, while the total sentences included those pertaining to the route, truck permits, and mobile homes. The adequacy scores for MN511 and V2 are presented in the probability matrix (Table C-1).

Probability Outcomes. Since no preexisting data exists on users' understanding of the information presented in MN511, the probability matrix was completed based on three possible outcomes. The resulting probabilities represent how likely a search for each information type will result in each outcome. First, if the user does not find the information they are looking for (NF – not find), the outcome frequency is 1 minus the requirement frequency.

$$\text{NF Outcome Frequency} = 1 - p(\text{req})_{\text{information type}} \quad [1]$$

If the user can find the information but does not believe it is adequate for answering the question (IF – find, inadequate), the outcome is equal to the requirement frequency times the inadequacy of the information they found (i.e. 1 minus the adequacy score).

$$\text{FI Outcome Frequency} = p(\text{req})_{\text{information type}} * (1 - A_{\text{information type}}) \quad [2]$$

If the user finds the information and it is thought adequate to answer the question (FA – find, adequate), the outcome is equal to the requirement frequency times the adequacy of the information they found.

$$\text{FA Outcome Frequency} = p(\text{req})_{\text{information type}} * A_{\text{information type}} \quad [3]$$

The resulting outcomes for MN511 and V2 are presented in the probability matrices (Table 13).

Table 13. Probability matrices of outcomes for finding information using MN511 and V2

Information	p(req)	MN511				V2			
		A	Outcomes			A	Outcomes		
			NF	FI	FA		NF	FI	FA
<i>Traffic</i>	<i>0.79</i>								
Route	0.23	0.92	0.77	0.02	0.21	1.00	0.77	0.00	0.23
Regional	0.45	0.37	0.55	0.28	0.17	1.00	0.55	0.00	0.45
Urgent	0.11	0.45	0.89	0.06	0.05	1.00	0.89	0.00	0.11
Transit	0.03	1.00	0.97	0.00	0.03	1.00	0.97	0.00	0.03
Weather	0.18	1.00	0.82	0.00	0.18	1.00	0.82	0.00	0.18

Utility Matrix

The utility of finding information for a particular information type is determined by the benefit of finding the information less the cost of searching.

Cost (C). The cost or difficulty for finding information was defined as the count of action nodes that need to be taken along the most efficient route of the menu (using the diagrams in Figure 13), weighted by 0.10. The cost scores for MN511 and V2 are presented in the utility matrix (Table 14).

Benefit (q). The most accessible method to realize usefulness of information in the menu would be to have users rate how well their information need was met on a scale (e.g. from 1= “Not at all” to 5 = “Completely”), which is planned for future testing. If actual data had been collected from participants using MN511, then the benefit (q) would equal this scaled subjective response. In lieu of this we have assigned two levels of successful information location outcome, q = 1 for FI and q = 5 for FA. q = 0 was assigned for an unsuccessful search (NF). For all levels of predicted success, the utility of each information type is equal to the benefit less the cost of searching (q – C). The resulting outcomes for MN511 and V2 are presented in the utility matrices (Table 14).

Table 14. Utility matrices of outcomes for finding information using MN511 and V2

Information	Cost	MN511			Cost	V2		
		Outcome (q)				Outcome (q)		
		NF (0)	IF (1)	FA (5)		NF (0)	IF (1)	FA (5)
<i>Traffic</i>								
Route	0.4	-0.4	0.6	4.6	0.6	-0.6	0.4	4.4
Regional	0.2	-0.2	0.8	4.8	0.3	-0.3	0.7	4.7
Urgent ^a	0.2	-0.2	0.8	4.8	0.3	-0.3	0.7	4.7
Transit	0.5	-0.5	0.5	4.5	0.4	-0.4	0.6	4.6
Weather	0.4	-0.4	0.6	4.6	0.3	-0.3	0.7	4.7

^a Cannot be accessed during the 00 nodes of either menu structure

Value Matrix

The value of meeting each goal (i.e. the likelihood of finding a useful answer to a question) can now be calculated by multiplying the probability that a particular piece of information will be found (probability outcomes) by the utility of that piece of information (utility outcome). The total value for each information type is the sum of these value outcomes for each outcome type. The resulting outcomes and total values for MN511 and V2 are shown in the value matrices (Table 15).

Table 15. Value matrices of using current MN511 and V2 information types

Information	MN511				V2			
	Outcomes			Total Value	Outcomes			Total Value
	NF	FI	FA		NF	FI	FA	
<i>Traffic</i>								
Route	-0.31	0.01	0.98	0.68	-0.46	0.00	1.01	0.55
Regional	-0.11	0.23	0.80	0.91	-0.17	0.00	2.12	1.95
Urgent	-0.18	0.05	0.24	0.11	-0.27	0.00	0.52	0.25
Transit	-0.49	0.00	0.14	-0.35	-0.39	0.00	0.14	-0.25
Weather	-0.33	0.00	0.83	0.50	-0.25	0.00	0.85	0.60

There is positive value in searching for all types of information, aside from transit information, using both menus. This suggests that overall both menus are effective at allowing the user to find and understand the information they are searching for.

It seems that the shortcut to regional reports in MN511 (depicted with a dashed connection depicted between nodes 00 and 2.a in Figure 1a) decreased the cost of finding this type of information, resulting in a relatively high total value. In comparison, using V2 increased the value of regional and urgent information types more dramatically due to an increase in appropriateness of the information even though the cost of finding these types of information increased. Similarly, the value of finding route information is lower when using V2 compared to MN511 because there is a higher cost involved in navigating to this information resulting.

As designed, there was higher value for finding transit and weather information types when using the V2 menu as compared to using MN511. These trends were not due to increasing appropriateness of information since the appropriateness of the information stayed constant. Instead, these examples show how decreasing the cost of finding information can also add value.

Menu Evaluation Discussion

For many of the information types, the V2 menu structure showed improvements in the value afforded to an information-seeking user. It is therefore predicted that the proposed changes to the MN511 menu structure present in V2 would allow for faster and more accurate traffic, transit, and weather information retrieval.

All results and stated differences were not tested for statistical significance and as such should be taken with a grain of salt. This methodology is intended to provide a tool by which designers and usability practitioners can quickly quantify comparisons between interface designs as a precursor to user testing. The value scores produced facilitate the identification of where costs and information adequacy can be modified in order to best streamline potential menu designs. The value scores for these information types would be better serviced by results from user testing, specifically a scaled response of how useful information from the system is to answering users questions. The values above represent potential high (FA) and low (FI) values of a 5 point scaled response in order to span the full range of potential outcomes. Testing with real user responses would allow collapsing the FA and FI outcomes by using a benefit score (q) equal to mean information quality score on a subjective scale.

These menus were empirically tested in the simulator portion of this study where drivers will use both systems while driving and measured in terms of driving performance, information retrieval, and perceived value of the information. It is hoped that the amount of attention needed to process menu choices can be reduced and a higher level of attention can be paid to the road.

As suggested above, we can use some of the data from this study to show how much value users found in both menus. Users subjective outcome on the usefulness of the two menus was 4.0 for MN511 and 4.3 for V2. We used these values in the utility matrix instead of the 0, 1, and 5 outcomes and then created a new value matrix by multiplying the new value outcomes with each of the three values in the probability matrix. This resulted in Table 16. This value matrix showed that across all five information types, there was more total value while using V2 than while using MN511.

Table 16. Value matrices of using current MN511 and V2 information types and incorporating the user subjective utility data

Information	MN511				V2			
	Outcome			Total Value	Outcome			Total Value
	NF	FI	FA		NF	FI	FA	
<i>Traffic</i>								
Route	2.77	0.06	0.76	3.60	2.85	0.00	0.85	3.70
Regional	2.09	1.08	0.63	3.80	2.20	0.00	1.80	4.00
Urgent	3.38	0.23	0.19	3.80	3.56	0.00	0.44	4.00
Transit	3.40	0.00	0.11	3.50	3.78	0.00	0.12	3.90
Weather	2.95	0.00	0.65	3.60	3.28	0.00	0.72	4.00

Appendix D
Event Database

Below are presented numbered, structural outlines and their corresponding prompts. The number before each dialogue corresponds to those in Figure 1.

Further explanation of the **actions that may be taken**, as per the Figure 1 Key:

- Open Choice – user can say any appropriate command word (e.g. a city, a route).
- Menu Choice – “directed speech” voice recognition where the user can say any of the menu choices given.
- Yes/No – user can confirm or disconfirm menu choice.
- Information – user is given information but not given any actionable options.
- Exit Menu – user exits system.
- Go to # - user hears the indicated node and proceeds downward from there.
- Options listed in the Anytime list (grey box above the key) can be spoken and executed at any time except for during “Yes/No” (yellow) and “Exit” (red) nodes.

The outline of prompts describe what the user hears while using each menu. Here are a few notes about these scripts:

- Brackets “[]” represent commands given to the system, inactivity, or system state
- Parentheses “()” tell of non-verbal sounds or actions taken by 511 system, or if proceeded by a blank line “__ ()” they indicate what information is to be given in that location. See the key below for possibilities
- Key to available blank line options:
 - (route)
 - I 96
 - I 92
 - US 17
 - US 41
 - CR 25
 - (city)
 - Brunswick
 - Deville
 - Lakewood
 - Minneapolis
 - Parma
 - Wooster

Both experimental menus will draw from the same inventory of City (region), Route, incident, road, and weather conditions (Figure 14). Drivers will be told that they will be driving on a single highway route between two cities. Tables 17, 18, and 19 outline the regional, route, and weather scripts based on the events Figure 14. Note that not all roads mentioned in the table are pictured.

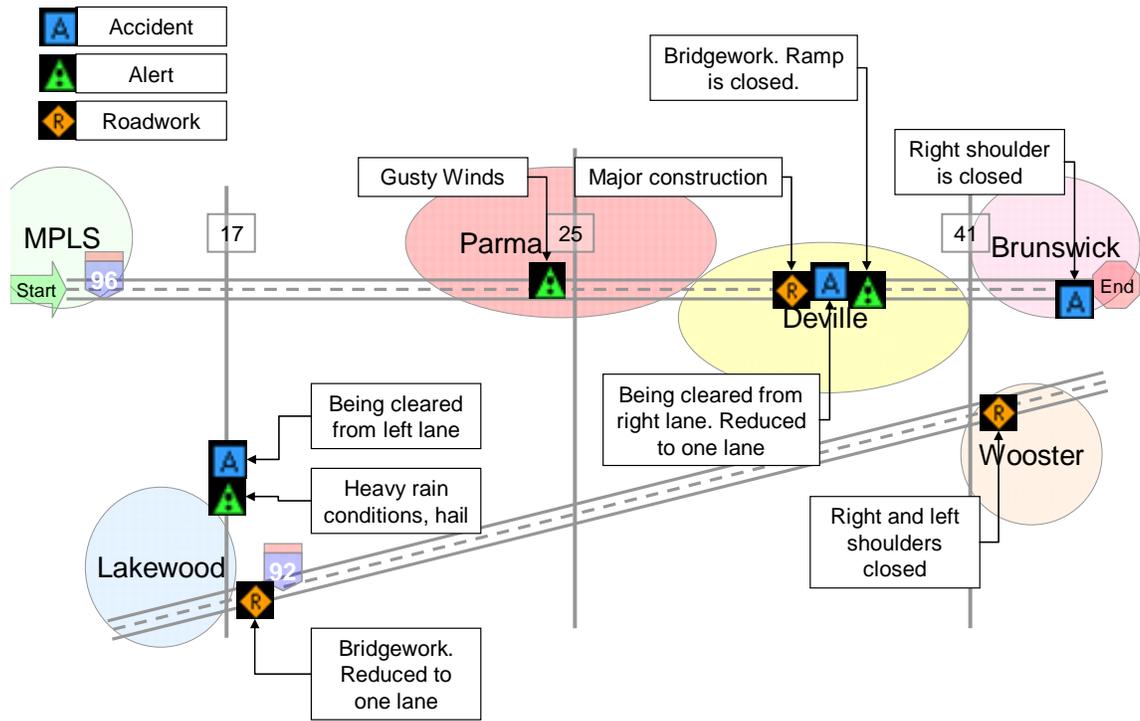


Figure 14. Map inventory of cities, routes, and events that populates the experimental 511 menus.

Table 17. Regional traffic summary scripts that populates the experimental 511 menus by city.

Regional Traffic Summary Script

Universal Script	Brunswick	Deville	Lakewood	Minneapolis	Parma	Wooster
<i>Regional traffic summary, for all regions of Minnesota. Vehicles with permits, all routes are open. Driving conditions are good. Vehicles with permits, all routes are open. Driving conditions are good. Expect moderate winds, expect, mostly sunny weather. Driving conditions are good. Expect moderate winds, expect mostly sunny weather. There...</i>	is one...	are three...	are three...	are no...	are three...	are two...
<i>urgent traffic reports within 40 miles of ___(city), Minnesota...</i>	affecting I 96.	affecting I 96.	affecting I 92 and US 17.	-	affecting I 96 and CR 25	affecting I 92 and US 41.
<i>For all regions around ___(city), Minnesota, excluding route specific restrictions, ...</i>	driving conditions are good.	expect delays.	Expect thunderstorms and wet road conditions. Expect delays.	driving conditions are good.	driving conditions are good.	expect delays.
<i>Also, vehicles with permits, all routes are open. Say the name of a route to hear the detailed report, or using your keypad enter the route number followed by the pound key. [pause w/ sound] For a weather report around (city), say weather.</i>	[report for I 96 or US 41]	[report for I 96 or US 41]	[report for I 92 or US 17]	[report for I 96 or US 17]	[report for I 96 or CR 25]	[report for I 92 or US 41]
<i>Say the name of another route, or say, go to menu, or using you keypad, enter the route number followed by the pound key.</i>						

Table 18. Weather summary scripts that populates the experimental 511 menus by city.

Weather Conditions Script

Universal Script	Brunswick	Deville	Lakewood	Minneapolis	Parma	Wooster
<i>Regional weather report for ___(city), Minnesota. Rest of today...</i>	Sunny. Highs 75 to 80. South winds around 5 miles per hour.	Mostly sunny. Highs around 70. South winds 5 to 10 miles per hour.	Severe thunderstorms throughout the day. Highs around 45. Southeast winds 20 to 30 miles per hour. Chance of thunderstorms 90%. Tonight, mostly cloudy with a 80% chance of thunderstorms. Lows in the mid 40s. Southeast winds around 20 mph.	Cloudy. Highs around 70. East winds 10 to 20 miles per hour. Tonight, party cloudy with a 20% chance of showers and thunderstorms late in the afternoon. Lows around 50. East winds 5 miles per hour.	Cloudy. Gusty winds. Highs around 65. Southeast winds 20 to 30 miles per hour. Tonight, showers and thunderstorms likely later in the evening. Lows 55 to 60. Southwest winds 20 to 30 miles per hour. Chance of rain 70%.	Mostly sunny. Highs around 75. Southeast winds 5 to 10 miles per hour.

Table 19. Route condition scripts that populates the experimental 511 menus by city.

Route Conditions Script Elements

Universal Script	Brunswick	Deville	Lakewood	Minneapolis	Parma	Wooster
OK, I 96. ...	There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road in Brunswick. The right shoulder is closed.	On I 96 westbound at mile marker 33 in Deville there is an accident being cleared from the right lane. The roadway is reduced to one lane. The right lane is closed near Square Lake road in Deville. Look out for major road construction in both directions on I 96 between Champ boulevard and Gordon road in Deville. Traffic is reduced to one lane. Bridgework is in progress at Gordon road in Deville. The exit ramp is closed in both directions. The mandatory speed limit is enforced. Traffic is stop and go westbound between Sugar Ridge Road to Champ boulevard near Deville. Expect delays. There is slow traffic on I 96 eastbound, from Gossimer road to Square Lake road near Deville. Expect delays.	-	This route has no reports of traffic problems.	On I 96, be prepared for gusty winds in Parma.	-
All right, I 92. ...	-	-	Bridgework is in progress on I 92 at Pearl View drive near Lakewood. Traffic is reduced to one lane in both directions.	-	-	On I 92 in both directions look out for construction between US 41 and Deerfield avenue in Wooster. The right and left shoulders are closed. A width limit is in effect. The mandatory speed limit is enforced. There is slow traffic westbound from US 41 to Deerfield avenue in Wooster. Expect delays. There is slow traffic eastbound from Deerfield avenue to US 41 in Wooster. Expect delays.
OK, US 17. ...	-	-	There is an accident on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Expect delays. Traffic is stop and go between Samson lane and Springton road near Lakewood. Expect delays. Expect heavy rain conditions between I 96 and I 92. Hail is expected between I 96 and I 92.	-	-	-
All right, US 41. ...	This route has no reports of traffic problems.	This route has no reports of traffic problems.	-	-	-	On US 41 there is stop and go traffic northbound between Reed road and Deerfield avenue near Wooster. Expect delays. Traffic is stop and go southbound between Reed road and Deerfield avenue near Wooster. Expect delays.
OK, CR 25. ...	-	-	-	-	This route has no reports of traffic problems.	-

Appendix E

Experimental Menu Dialogues

These scripts follow the structures depicted in Figure 1 and the event outlines presented in Appendix D.

MN511

00. 511 Greeting

This is 5 1 1 travel information, brought to you by the Minnesota Department of Transportation. Say the name of the city in the region you want, or using your keypad, enter the first three letters of the city followed by the pound key, or you can say menu to go to the main menu.

- b. [timeout] (goes to Menu)

0. Menu

Menu. Here are all of the categories you can choose from. When you hear the one you want, just say it. Route reports. Regional reports. Transit. Weather. Comment on 5 1 1. Help with 5 1 1. That's all the categories; just say the one you want.

1. Route report

(sound) OK. Route reports. [*] Say the name of the route you want. Or using your keypad, enter the route number followed by the pound key. To hear all the urgent reports on major highways statewide, say urgent reports.

- d. Did you say, ___(route)?
 - i. [if "no", goto [*]]
- e. [Route Reports]
 - i. [I 92] All Right, I 92. On I 92 in both directions look out for construction between US 41 and Deerfield avenue in Wooster. The right and left shoulders are closed. A width limit is in effect. The mandatory speed limit is enforced. Bridgework is in progress at Pearl View drive near Lakewood. Traffic is reduced to one lane in both directions. There is slow traffic westbound from US 41 to Deerfield avenue in Wooster. Expect delays. There is slow traffic eastbound from Deerfield avenue to US 41 in Wooster. Expect delays.
 - ii. [I 96] OK, I 96. On I 96 westbound at mile marker 33 near Square Lake road, inn Deville there is an accident being cleared from the right lane. The roadway is reduced to one lane. The right lane is closed near Square Lake road in Deville. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge road, inn Brunswick. The right shoulder is closed. Look out for major road construction in both directions on I 96 between Champ boulevard and Gordon road, inn Deville. Traffic is reduced to one lane. Bridgework is in progress at Gordon road in Deville. The exit ramp is closed in both directions. The mandatory speed limit is enforced. Traffic is stop and go westbound between Sugar Ridge Road to Champ boulevard near Deville. Expect delays. There is slow traffic on I 96 eastbound, from Gossimer road to Square Lake

- road near Deville. Expect delays. Be prepared for gusty winds in Parma.
- iii. [US 17] OK, US 17. There is an accident on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Traffic is stop and go between Samson lane and Springton road near Lakewood. Expect delays. Expect heavy rain conditions between I 96 and I 92 near Lakewood. Hail is expected between I 96 and I 92 near Lakewood.
 - iv. [US 41] All Right, US 41. On US 41 there is stop and go traffic northbound between Reed road and Deerfield avenue near Wooster. Expect delays. Traffic is stop and go southbound between Reed road and Deerfield avenue near Wooster. Expect delays.
 - v. [CR 25] OK, CR 25. This route has no reports of traffic problems.
- f. Say the name of another route or say, go to menu.

2. Regional report

Minnesota regional traffic information (with sound in background). [@] Say the name of the city in the region you want, or using your keypad, enter the first three letters of the city, followed by the pound key.

- d. Did you say, ___(city)?
 - i. [if “no”, goto [@]]
 - Regional traffic summary, for all regions of Minnesota. Vehicles with permits, all routes are open. Driving conditions are good. Vehicles with permits, all routes are open. Driving conditions are good. Expect moderate winds, expect, mostly sunny weather. Driving conditions are good. Expect moderate winds, expect mostly sunny weather. There...
 - i. [Brunswick] is one urgent traffic report within 25 miles of Brunswick, Minnesota, affecting I 96. For all regions around, Brunswick, Minnesota, excluding route specific restrictions, driving conditions are good. Also, vehicles with permits, all routes are open. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number followed by the pound key. [pause with sound] For a weather report around Brunswick, say weather.
 - 1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 - 2. [I 96] OK, I 96. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road, inn Brunswick. The right shoulder is closed.
 - 3. [US 41] OK, US 41. This route has no reports of traffic problems.
 - ii. [Deville] are three urgent traffic reports within 25 miles of, Deville, Minnesota, affecting I 96. For all regions around, Deville, Minnesota, excluding route specific restrictions, expect delays. Also, vehicles with permits, all routes are open. [\$] Say the name

of a route to hear the detailed report, or using your keypad, enter the route number followed by the pound key. [pause with sound] For a weather report around Deville, say weather.

1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 96] OK, I 96. On I 96 westbound at mile marker 33 near Square Lake Road, in Deville there is an accident being cleared from the right lane. The roadway is reduced to one lane. The right lane is closed near Square Lake road in Deville. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road in Brunswick. The right shoulder is closed. Look out for major road construction in both directions on I 96 between Champ boulevard and Gordon road in Deville. Traffic is reduced to one lane. Bridgework is in progress on I 96 at Gordon road in Deville. The exit ramp is closed in both directions. The mandatory speed limit is enforced. Traffic is stop and go on I 96 westbound between Sugar Ridge Road to Champ boulevard near Deville. Expect delays. There is slow traffic on I 96 eastbound, from Gossimer road to Square Lake road near Deville. Expect delays.
 3. [US 41] OK, US 41. This route has no reports of traffic problems.
- iii. [Lakewood] are three urgent traffic reports within 40 miles of, Lakewood, Minnesota, affecting I 92 and US 17. For all regions around, Lakewood, Minnesota, excluding route specific restrictions, expect thunderstorms and wet road conditions. Expect delays. Also, vehicles with permits, all routes are open. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number followed by the pound key. [pause with sound] For a weather report around Lakewood, say weather.
1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 92] OK, I 92. Bridgework is in progress on I 92 at Pearl View drive near Lakewood. Traffic is reduced to one lane in both directions. Traffic is stop and go between Samson lane and Springton road near Lakewood. Expect delays. Expect heavy rain conditions between I 96 and I 92 near Lakewood.
 3. [US 17] OK, US 17. There is an accident on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Expect delays. Hail is expected between I 96 and I 92 near Lakewood.
- iv. [Minneapolis] are no urgent traffic reports within 40 miles of, Minneapolis, Minnesota. For all regions around, Minneapolis, Minnesota, excluding route specific restrictions, driving conditions

are good. Also, vehicles with permits, all routes are open. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number followed by the pound key. [pause with sound] For a weather report around Minneapolis, say weather.

1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 96] OK, I 96. This route has no reports of traffic problems.
 3. [US 17] OK, US 17. This route has no reports of traffic problems.
- v. [Parma] are three urgent traffic reports within 25 miles of, Parma, Minnesota, affecting I 96 and CR 25. For all regions around, Parma, Minnesota, excluding route specific restrictions, driving conditions are good. Also, vehicles with permits, all routes are open. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number followed by the pound key. [pause with sound] For a weather report around Parma, say weather.
1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 96] OK, I 96. On I 96, be prepared for gusty winds in Parma.
 3. [CR 25] OK, CR 25. This route has no reports of traffic problems.
- vi. [Wooster] are two urgent traffic reports within 40 miles of Wooster, Minnesota, affecting I 92 and US 41. For all regions around, Wooster, Minnesota, excluding route specific restrictions, expect delays. Also, vehicles with permits, all routes are open. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number followed by the pound key. [pause with sound] For a weather report around Wooster, say weather.
1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 92] OK, I 92. On I 92 in both directions look out for construction between US 41 and Deerfield Avenue in Wooster. The right and left shoulders are closed. A width limit is in effect. The mandatory speed limit is enforced. There is slow traffic on I 92 westbound from US 41 to Deerfield avenue in Wooster. Expect delays. There is slow traffic on I 92 eastbound from Deerfield avenue to US 41 in Wooster. Expect delays. Traffic is stop and go southbound between Reed road and Deerfield avenue near Wooster. Expect delays.

3. [US 41] OK, US 41. On US 41 there is stop and go traffic northbound between Reed road and Deerfield avenue near Wooster. Expect delays.
- Say the name of another route, or say, go to menu.
 - i. [if a route is said, go to the “1” for that city]

3. Transit

(sound) Minnesota transit. [\$] Say the name of a city in the region you want to hear information of nearby transit providers, or using you keypad, enter the first three letters of city, followed by the pound key. For example say, Minneapolis.

- e. Did you say, ___(city)?
 - i. [if “no”, goto [\$]]
- f. There is one transit provider serving the city of ___(city). Press 1 for Jones Transit services.
- g. [One] Jones Transit services operates a flexible fixed route service.
- h. For hours, schedules, and rates, I can transfer you to 612 555 4614. Would you like me to transfer you?
 - i. [Yes] – (end call)
 - ii. [No] To hear the previous provider list, say back. For information on other transit providers in Minnesota, say the name of the city in the region you want, or using you keypad, enter the first three letters of city, followed by the pound key. To transfer to the main menu, say menu.

4. Weather

(sound) Weather. [¥] Say the name of the city in the region you want. Or using your keypad, enter the first three letters of the city you want followed by the pound key.

- d. Did you say ___(city)?
 - i. [if “no”, goto [¥]]
- e. [Weather report]
 - i. [Brunswick] Regional weather report for, Brunswick, Minnesota. Rest of today, Sunny. Highs 75 to 50. South winds around 5 miles per hour.
 - ii. [Deville] Regional weather report for, Deville, Minnesota. Rest of today, Mostly sunny. Highs around 70. South winds 5 to 10 miles per hour.
 - iii. [Lakewood] Regional weather report for, Lakewood, Minnesota. Rest of today, severe thunderstorms throughout the day. Highs 45 to 50. Southeast winds 20 to 30 miles per hour. Chance of thunderstorms 90%. Hail is expected. Later tonight, mostly cloudy with a 80% chance of thunderstorms. Lows in the mid 40s. Southeast winds around 20 miles per hour.
 - iv. [Minneapolis] Regional weather report for, Minneapolis, Minnesota. Rest of today, Cloudy. Highs around 70. East winds 10 to 20 miles per hour. Later tonight, partly cloudy with a 20%

chance of showers and thunderstorms late in the afternoon. Lows around 50. East winds 5 miles per hour.

- v. [Parma] Regional weather report for, Parma, Minnesota. Rest of today, cloudy. Gusty winds. Highs around 65. Southwest winds 20 to 30 miles per hour. Later tonight, showers and thunderstorms likely later in the evening. Lows 55 to 60. Southwest winds 20 to 30 miles per hour. Chance of rain 70%.
 - vi. [Wooster] Regional weather report for, Wooster, Minnesota. Rest of today, Mostly sunny. Highs around 75. Southeast winds 5 to 10 miles per hour.
- f. For another regional report, say the name of the city in the region you want, or using your keypad, enter the first three letters of city, followed by the pound key. Say menu to return to the main menu.

5. Comment

[voice and keypad commands are turned off- user cannot stop this menu once it has started]. We would be pleased to hear what you think about our new automated system which will continue to be improved based on your feedback. Please leave a comment and when you're done, press pound. [Beep]

A.1. Urgent Report

[note, "urgent reports" is not understood as a command from 00. or 3.b-e]

[From anywhere before a city is specified, including 1.b]

(sound) Here are the urgent traffic reports for major routes in, Minnesota. Say stop to cancel this report. For all regions of Minnesota. Vehicles with permits, all routes are open. Driving conditions are good. Vehicles with permits, all routes are open. Driving conditions are good. Expect moderate winds, expect, mostly sunny weather. Driving conditions are good. Expect moderate winds, mostly sunny weather. Let's start with the area near, Minneapolis. There are no traffic problems to report at this time. Moving to the area near Deville. On I 96 westbound at mile marker 33 near Square Lake Road, inn Deville there is an accident being cleared from the right lane. The roadway is reduced to one lane. The right lane is closed near Square Lake road in Deville. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road, inn Brunswick. The right shoulder is closed. Look out for major road construction in both directions on I 96 between Champ boulevard and Gordon road, inn Deville. Traffic is reduced to one lane. Bridgework is in progress at Gordon road in Deville. The exit ramp is closed in both directions. The mandatory speed limit is enforced. Traffic is stop and go westbound between Sugar Ridge Road to Champ boulevard near Deville. Expect delays. There is slow traffic on I 96 eastbound, from Gossimer road to Square Lake road near Deville. Expect delays. Moving to the area near Parma, be prepared for gusty winds. Moving to the area near Brunswick. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road, inn Brunswick. The right shoulder is closed. Moving to the area near Lakewood. There is an accident on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Bridgework is in progress at Pearl View drive near Lakewood.

Traffic is reduced to one lane in both directions. Traffic is stop and go between Samson lane and Springton road near Lakewood. Expect delays. Expect heavy rain conditions between I 96 and I 92 near Lakewood. Hail is expected between I 96 and I 92 near Lakewood. We can finish with the area near Wooster. On I 92 in both directions look out for construction between US 41 and Deerfield avenue in Wooster. The right and left shoulders are closed. A width limit is in effect. The mandatory speed limit is enforced. There is slow traffic on I 92 westbound from US 41 to Deerfield avenue in Wooster. Expect delays. There is slow traffic on I 92 eastbound from Deerfield avenue to US 41 in Wooster. Expect delays. On US 41 there is stop and go traffic northbound between Reed road and Deerfield avenue near Wooster. Expect delays. Traffic is stop and go southbound between Reed road and Deerfield avenue near Wooster. Expect delays. For another region of Minnesota say the name of the region you want, or say main menu.

- [From anywhere past a point where a city was specified, including 2.b-c, or 4.b-c]
- a. [Brunswick] (sound) Here are the urgent traffic reports for 25 miles around Brunswick, Minnesota. Say stop to cancel this report. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road in Brunswick. The right shoulder is closed. For another region of Minnesota say the name of the region you want, or say main menu.
 - b. [Deville] (sound) Here are the urgent traffic reports for 25 miles around Deville, Minnesota. Say stop to cancel this report. On I 96 westbound at mile marker 33 near Square Lake Road, in Deville there is an accident being cleared from the right lane. The roadway is reduced to one lane. The right lane is closed near Square Lake road in Deville. Look out for major road construction in both directions on I 96 between Champ boulevard and Gordon road, in Deville. Traffic is reduced to one lane. Bridgework is in progress at Gordon road in Deville. The exit ramp is closed in both directions. The mandatory speed limit is enforced. Traffic is stop and go westbound between Sugar Ridge Road to Champ boulevard near Deville. Expect delays. There is slow traffic on I 96 eastbound, from Gossimer road to Square Lake road near Deville. Expect delays. For another region of Minnesota say the name of the region you want, or say main menu.
 - c. [Lakewood] (sound) Here are the urgent traffic reports for 40 miles around Lakewood, Minnesota. Say stop to cancel this report. There is an accident on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Bridgework is in progress at Pearl View drive near Lakewood. Traffic is reduced to one lane in both directions. Traffic is stop and go between Samson lane and Springton road near Lakewood. Expect delays. Expect heavy rain conditions between I 96 and I 92 near Lakewood. Hail is expected between I 96 and I 92 near Lakewood. For another region of Minnesota say the name of the region you want, or say main menu.
 - d. [Minneapolis] (sound) Here are the urgent traffic reports for 40 miles around Minneapolis, Minnesota. Say stop to cancel this report. There are no traffic problems to report at this time. For another region of Minnesota say the name of the region you want, or say main menu.

- e. [Parma] (sound) Here are the urgent traffic reports for 25 miles around Parma, Minnesota. Say stop to cancel this report. There are no traffic problems to report at this time. For another region of Minnesota say the name of the region you want, or say main menu.
- f. [Wooster] (sound) Here are the urgent traffic reports for 40 miles around Wooster, Minnesota. Say stop to cancel this report. On I 92 in both directions look out for construction between US 41 and Deerfield avenue in Wooster. The right and left shoulders are closed. A width limit is in effect. The mandatory speed limit is enforced. There is slow traffic on I 92 westbound from US 41 to Deerfield avenue in Wooster. Expect delays. There is slow traffic on I 92 eastbound from Deerfield avenue to US 41 in Wooster. Expect delays. On US 41 there is stop and go traffic northbound between Reed road and Deerfield avenue near Wooster. Expect delays. Traffic is stop and go southbound between Reed road and Deerfield avenue near Wooster. Expect delays. For another region of Minnesota say the name of the region you want, or say main menu.

A.2. Choices

Say route reports to select reports on a Minnesota highway, or just press 1. Say one of our menu categories, or press 1 for route reports, 2 for regional reports, 3 for transit, 4 for weather, or 5 to leave us a comment on 5 1 1. When you are done say, goodbye or press star star star. Now, go ahead and say what you want.

- b. [During any of the Menu choices] You can say help or go to menu at any time, or for help you can press the star key. For the menu press zero. For urgent traffic reports statewide say, urgent reports or just press 1. To repeat this section say repeat that, or press nine. When you are done say, goodbye or press star star star. You will be invited to leave a comment to help improve Minnesota's 5 1 1 system. Now, go ahead and say what you want.

A.4. Goodbye

Thank you for calling 5 1 1. (goes to 5. Comment)

A.6. Help (6)

The menu lets you pick the kind of travel information you want to hear. Say one of our menu categories or press 1 for route reports, 2 for regional reports, 3 for transit, 4 for weather or 5 to leave us a comment on 5 1 1.

- c. [During Route Reports] This section allows you to hear traffic reports for selected routes (return and repeat last menu prompt)
- d. [During Regional Reports, Transit, or Weather] This section allows you to select a local region of Minnesota (return and repeat last menu prompt)

Time Out

[10 seconds for first timeout]

- f. [During Main Menu] – I'm sorry, I didn't hear you. Say one of our menu categories or press 1 for route reports, 2 for regional reports, 3 for transit, 4 for weather, or 5 to leave a comment on 5 1 1.

- g. [During Route Reports] I'm sorry, I didn't hear you. Using your keypad, enter the route number followed by the pound key
 - h. [During Regional Reports, Transit, or Weather] I'm sorry, I didn't hear you. Using your keypad, enter the first three letters of the city you want, followed by the pound key.
- [8 seconds for second timeout]
- i. [Any menu, second time] – I'm sorry, I still didn't hear you. To hear other options say, what are my choices, or press the pound key.
 - j. [Any menu, third time] – Thank you for calling. Good bye.

No Understand

[only during 00.] I'm sorry, I didn't get that. Let's try this another way. Enter the first three letters of the city in the region you want, followed by the pound key, or you can say menu to go to the main menu.

511 V2

00. 511 Greeting

This is 511 travel information, brought to you by the Minnesota Department of Transportation.

- a. [&] Say the name of a city in the region you want, or using your keypad, enter the first three letters of the city.
- b. Did you say, ___(city)?
 - i. [if “no”, goto [&]]
- c. [timeout] (goes to regular timeout functionality, but disallow going to Menu)

0. Menu

OK, ___(city). Here are all of the categories you can choose from. Please speak the option you want when you hear it. Road Conditions. Weather. Transit. Restrictions. New City. That’s all the categories; just speak the one you want.

1. Road Conditions

Regional traffic information (with sound in background).

- ii. [Brunswick] There is one urgent traffic report within 25 miles of Brunswick, Minnesota, affecting I 96. For all regions around, Brunswick, Minnesota, driving conditions are good. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number. Say menu to access other options.
 1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 96] OK, I 96. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road, inn Brunswick. The right shoulder is closed.
 - a. [travel times]
 3. [US 41] OK, US 41. This route has no reports of traffic problems.
 - a. [travel times]
- iii. [Deville] There are three urgent traffic reports within 25 miles of, Deville, Minnesota, affecting I 96. For all regions around, Deville, Minnesota, expect delays. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number. Say menu to access other options.
 1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 96]] OK, I 96. On I 96 westbound at mile marker 33 near Square Lake Road, inn Deville there is an accident being cleared from the right lane. The roadway is reduced to one lane. The right lane is closed near Square Lake road in Deville. There is an accident on I 96 eastbound at mile

marker 44 near Sugar Ridge Road in Brunswick. The right shoulder is closed. Look out for major road construction in both directions on I 96 between Champ boulevard and Gordon road in Deville. Traffic is reduced to one lane. Bridgework is in progress on I 96 at Gordon road in Deville. The exit ramp is closed in both directions. The mandatory speed limit is enforced. Traffic is stop and go on I 96 westbound between Sugar Ridge Road to Champ boulevard near Deville. Expect delays. There is slow traffic on I 96 eastbound, from Gossimer road to Square Lake road near Deville. Expect delays.

a. [travel times]

3. [US 41] OK, US 41. This route has no reports of traffic problems.

a. [travel times]

iv. [Lakewood] There are three urgent traffic reports within 40 miles of, Lakewood, Minnesota, affecting I 92 and US 17. For all regions around, Lakewood, Minnesota, expect thunderstorms and wet road conditions. Expect delays. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number. Say menu to access other options.

1. Did you say, ___(route)?

a. [if “no”, goto [\$]]

2. [I 92] OK, I 92. Bridgework is in progress on I 92 at Pearl View drive near Lakewood. Traffic is reduced to one lane in both directions. Traffic is stop and go between Samson lane and Springton road near Lakewood. Expect delays. Expect heavy rain conditions between I 96 and I 92 near Lakewood.

a. [travel times]

3. [US 17] OK, US 17. There is an accident on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Expect delays. Hail is expected between I 96 and I 92 near Lakewood.

a. [travel times]

v. [Minneapolis] There are no urgent traffic reports within 40 miles of, Minneapolis, Minnesota. For all regions around, Minneapolis, Minnesota, driving conditions are good. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number. Say menu to access other options.

1. Did you say, ___(route)?

a. [if “no”, goto [\$]]

2. [I 96] OK, I 96. This route has no reports of traffic problems.

a. [travel times]

3. [US 17] OK, US 17. This route has no reports of traffic problems.
 - a. [travel times]
- vi. [Parma] There are three urgent traffic reports within 25 miles of, Parma, Minnesota, affecting I 96 and CR 25. For all regions around, Parma, Minnesota, driving conditions are good. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number. Say menu to access other options.
 1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 96] OK, I 96. On I 96, be prepared for gusty winds in Parma.
 - a. [travel times]
 3. [CR 25] OK, CR 25. This route has no reports of traffic problems.
 - a. [travel times]
- vii. [Wooster] There are two urgent traffic reports within 40 miles of Wooster, Minnesota, affecting I 92 and US 41. For all regions around, Wooster, Minnesota, expect delays. [\$] Say the name of a route to hear the detailed report, or using your keypad, enter the route number. Say menu to access other options.
 1. Did you say, ___(route)?
 - a. [if “no”, goto [\$]]
 2. [I 92] OK, I 92. On I 92 in both directions look out for construction between US 41 and Deerfield Avenue in Wooster. The right and left shoulders are closed. A width limit is in effect. The mandatory speed limit is enforced. There is slow traffic on I 92 westbound from US 41 to Deerfield avenue in Wooster. Expect delays. There is slow traffic on I 92 eastbound from Deerfield avenue to US 41 in Wooster. Expect delays. Traffic is stop and go southbound between Reed road and Deerfield avenue near Wooster. Expect delays.
 - a. [travel times]
 3. [US 41] OK, US 41. On US 41 there is stop and go traffic northbound between Reed road and Deerfield avenue near Wooster. Expect delays.
 - a. [travel times]
- Say the name of another route, or for more options in [city], say menu.
 - i. [if a route is said, go to the “1” for that city]

2. Weather

Weather.

- i. [Brunswick] Regional weather report for, Brunswick, Minnesota. Rest of today, Sunny. Highs 75 to 50. South winds around 5 miles per hour.

- ii. [Deville] Regional weather report for, Deville, Minnesota. Rest of today, Mostly sunny. Highs around 70. South winds 5 to 10 miles per hour.
- iii. [Lakewood] Regional weather report for, Lakewood, Minnesota. Rest of today, severe thunderstorms throughout the day. Highs 45 to 50. Southeast winds 20 to 30 miles per hour. Chance of thunderstorms 90%. There is a crash on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Expect delays. Hail is expected between I 96 and I 92 near Lakewood. Later tonight, mostly cloudy with a 80% chance of thunderstorms. Lows in the mid 40s. Southeast winds around 20 miles per hour.
- iv. [Minneapolis] Regional weather report for, Minneapolis, Minnesota. Rest of today, Cloudy. Highs around 70. East winds 10 to 20 miles per hour. Later tonight, partly cloudy with a 20% chance of showers and thunderstorms late in the afternoon. Lows around 50. East winds 5 miles per hour.
- v. [Parma] Regional weather report for, Parma, Minnesota. Rest of today, cloudy. Gusty winds. Highs around 65. Southwest winds 20 to 30 miles per hour. Later tonight, showers and thunderstorms likely later in the evening. Lows 55 to 60. Southwest winds 20 to 30 miles per hour. Chance of rain 70%.
- vi. [Wooster] Regional weather report for, Wooster, Minnesota. Rest of today, Mostly sunny. Highs around 75. Southeast winds 5 to 10 miles per hour.
- g. [Automatically return to 0. Menu]

3. Transit

Transit.

- i. There is one transit provider serving the city of ___(city). Press or say 1 for Jones Transit services. That's all the transit providers, say or press the key option you want.
- j. [One] Jones Transit services operates a flexible fixed route service.
- k. For hours, schedules, and rates, I can transfer you to 612 555 4614. Would you like me to transfer you?
 - iii. [Yes] – You are now leaving Minnesota 5 1 1 and transferring to Jones Transit services. (end call)
 - iv. [No] Say back to hear the previous provider list, or say go to menu.

4. Restrictions

Vehicle permits and restrictions. [info]

9. Help (A6)

- a. [During 00a Select Region] This section allows you to select a city in Minnesota. Say the name of the city in the region you want, or using your keypad, enter the first three letters of the city.
- b. [During 0. Main menu, Weather, Transit, or Restrictions] The menu lets you pick the kind of travel information you want to hear. Say the name of a menu category, or for road conditions press 1, for weather press 2, for transit press 3, for restrictions press 4, or to select a new region press 5.
- c. [During Road Conditions] This section allows you to hear traffic reports for selected routes (return and repeat last menu prompt)

A.1. Urgent Report

[From anywhere past 00., except after 3.a]

- a. [Brunswick] Here are the urgent traffic reports for 25 miles around Brunswick, Minnesota. Say stop to cancel this report. There is an accident on I 96 eastbound at mile marker 44 near Sugar Ridge Road in Brunswick. The right shoulder is closed. For another region of Minnesota say the name of the region you want, or say main menu.
- b. [Deville] (sound) Here are the urgent traffic reports for 25 miles around Deville, Minnesota. Say stop to cancel this report. On I 96 westbound at mile marker 33 near Square Lake Road, in Deville there is an accident being cleared from the right lane. The roadway is reduced to one lane. The right lane is closed near Square Lake road in Deville. Look out for major road construction in both directions on I 96 between Champ boulevard and Gordon road, in Deville. Traffic is reduced to one lane. Bridgework is in progress at Gordon road in Deville. The exit ramp is closed in both directions. The mandatory speed limit is enforced. Traffic is stop and go westbound between Sugar Ridge Road to Champ boulevard near Deville. Expect delays. There is slow traffic on I 96 eastbound, from Gossimer road to Square Lake road near Deville. Expect delays. For another region of Minnesota say the name of the region you want, or say main menu.
- c. [Lakewood] (sound) Here are the urgent traffic reports for 40 miles around Lakewood, Minnesota. Say stop to cancel this report. There is an accident on US 17 southbound being cleared from the left lane at mile marker 93 near Lakewood. Bridgework is in progress at Pearl View drive near Lakewood. Traffic is reduced to one lane in both directions. Traffic is stop and go between Samson lane and Springton road near Lakewood. Expect delays. Expect heavy rain conditions between I 96 and I 92 near Lakewood. Hail is expected between I 96 and I 92 near Lakewood. For another region of Minnesota say the name of the region you want, or say main menu.
- d. [Minneapolis] (sound) Here are the urgent traffic reports for 40 miles around Minneapolis, Minnesota. Say stop to cancel this report. There are no traffic problems to report at this time. For another region of Minnesota say the name of the region you want, or say main menu.

- e. [Parma] (sound) Here are the urgent traffic reports for 25 miles around Parma, Minnesota. Say stop to cancel this report. There are no traffic problems to report at this time. For another region of Minnesota say the name of the region you want, or say main menu.
- f. [Wooster] (sound) Here are the urgent traffic reports for 40 miles around Wooster, Minnesota. Say stop to cancel this report. On I 92 in both directions look out for construction between US 41 and Deerfield avenue in Wooster. The right and left shoulders are closed. A width limit is in effect. The mandatory speed limit is enforced. There is slow traffic on I 92 westbound from US 41 to Deerfield avenue in Wooster. Expect delays. There is slow traffic on I 92 eastbound from Deerfield avenue to US 41 in Wooster. Expect delays. On US 41 there is stop and go traffic northbound between Reed road and Deerfield avenue near Wooster. Expect delays. Traffic is stop and go southbound between Reed road and Deerfield avenue near Wooster. Expect delays. For another region of Minnesota say the name of the region you want, or say main menu.

A.2. Choices

To select reports on a Minnesota road, say road conditions or just press 1. Say one of our menu categories, or for road conditions press 1, for weather press 2, for transit press 3, for restrictions press 4, or to select a new region press 5. When you are done say, goodbye or press star star star. Now, go ahead and say what you want.

- c. [During any of the Menu choices] You can say help or go to menu at any time, or for help you can press the star key. For the menu press zero. For urgent traffic reports statewide say, urgent reports or just press 1. To repeat this section say repeat that, or press nine. When you are done, say goodbye or press star star star. Now, go ahead and say what you want.

A.4. Goodbye

Thank you for calling 511.

Time Out

[10 seconds for first timeout]

- a. [During Main Menu] – I’m sorry, I didn’t hear you. Say one of our menu categories, or for road conditions press 1, for weather press 2, for transit press 3, for restrictions press 4, or to select a new region press 5.
- b. [During Route Reports] I’m sorry, I didn’t hear you. Using your keypad, enter the route number
- c. [During Regional Reports, Transit, or Weather] I’m sorry, I didn’t hear you. Using your keypad, enter the first three letters of the city you want,.

[8 seconds for second timeout]

- d. [Any menu, second time] – I’m sorry, I still didn’t hear you. To hear other options say, what are my choices, or press the pound key.
- e. [Any menu, third time] – Thank you for calling. Good bye.

Appendix F

511 Screening Questionnaire Summary

A total of 69 potential participants completed the screening questionnaire, of which 42 were female and 27 were male. The mean age of respondents was 20.32 years with a range from 18 to 43 years and a mode and median age of 19. The mean number of years they have been driving was 4.49 years with a range from 2 to 27 years and a mode and median experience of 3 years.

The screening questionnaire contained items used to determine potential participants predilection towards motion sickness and their experience and awareness of MN511. The latter questions are summarized in Table 20, with the count of participants giving that answer in parentheses before each response.

Table 20. Responses to screening questions relating to experience and awareness of MN511, with number of participants in parentheses.

Yes or no, are you aware of any traveler-based information systems in Minnesota? If yes, please list the ones you are aware of.	Yes or no, have you heard of 511? If yes, please describe what it is and what it does in your own words.	Yes or no, have you ever used Minnesota's 511? If so, please describe how you accessed it.
(60) No (3) 511 (2) It is a phone number you can call to find information for the road reports, traffic, and weather (1) Amber Alert, Highway Helpers, traffic radio reports, electronic alert highway signs (for traffic and accident warnings). (1) Visitor Centers (1) Just the transit planner for the Metro. (1) Google maps (1) GPS??	(57) No (11) I think it's a service you can call to find out about weather and road conditions, construction, etc. (1) I've heard of it but have 0 idea what it does	(68) No (1) yes, from a cell phone

Appendix G
Task Questions

Questions are categorized by type of information to be retrieved, and represented by a two letter abbreviation and number. Also given is the optimal path needed to get to the information through both the “MN511” and “V2” menus [non-shortcut path in brackets].

Route [RT#]

Optimal Paths:

- MN511- 00, 2.a-c, 1.a-b. [00, 0, 1, 1.a-b]
- V2- 00, 00.a-b, 0, 1, 1.1, 1.a-c

City (Region) [CY#]

Optimal Paths:

- MN511- 00, 2.a-b [00, 0, 2, 2.a-b]
- V2- 00, 00.a-b, 0, 1

Weather [WE#]

Optimal Paths:

- MN511- 00, 2.a-c, 4.b. [00, 0, 4, 4.a-b]
- V2- 00, 00.a-b, 0, 2

Transit - *No questions were asked of this category, as it represents less than 5% of usage requests. This category is included here for completeness.*

Optimal Paths:

- MN511- 00, 0, 3, 3.a-b, 3.#c
- V2- 00, 00.a-b, 0, 3, 3.#a

Urgent City (Region) Reports [UC#] - *No questions were asked of this category, due to time constraints and integration into design of Road Condition functionality. This category is included here for completeness.*

Optimal Paths:

- MN511- 00, 2.a-b, A.1
- V2- 00, 00.a-b, 1

Urgent Statewide Reports - *No questions were asked of this category, as it represents a function no longer desired by the developers and Mn/DOT. This category is included here for completeness.*

Optimal Paths:

- MN511- 00, A.1
- V2- *not available*

Experimental Question Order

Below are listed the questions in the order presented to each participant.

Practice

1. PracticeIVRPractice1.wav

Q: If you eat at Mario's Italian Restaurant, can you pay with a check?

A: No.

2. (at the end of) Practice-511.wav

Q: ... How late is the Spaghetti Factory open on Friday nights?

A: 11pm.

3. PracticeIVRPractice3.wav

Q: How late is Mario's Italian Restaurant open on Monday nights?

A: 9pm.

Baseline

1. 511-0-task1.wav : WB1

Q: Based on the weather you are experiencing now, will you need to wear your sunglasses when you arrive at your destination?

A: Probably.

2. 511-0-task2.wav : RB4

Q: One of your friends is traveling 10 minutes behind you on this highway. Is there a chance the traffic conditions will delay your friend's trip?

A: Probably not.

3. 511-0-task3.wav : CB3

Q: You will be traveling back on this highway tomorrow at the same time of day. From what you have seen today, will you have to fight any extra traffic due to construction?

A: No.

4. 511-0-task4.wav : CB1

Q: Based on current traffic conditions, how severe do you estimate the delay will be to drive through this city?

A: Moderate.

5. 511-0-task5.wav : RB1

Q: One of your friends is taking this same highway in the other direction later today. What traffic conditions should he expect to encounter?

A: No traffic.

Menu1

1. 511-1-task1.wav : CY1
Q: Will you be delayed passing through Deville on I 96?
A: Roadwork, down to one lane, heavy traffic and delays eastbound I-96.
2. 511-1-task2.wav : WE1
Q: If you go to Wooster, will you need to bring your scarf?
A: No, conditions are sunny and clear.
3. 511-1-task3.wav : RT3
Q: Will you be delayed CR 25 North in Parma?
A: (gusty winds) No, road conditions are good on I-96 in both directions.
4. 511-1-task4.wav : RT1
Q: One of your friends is taking US 17 North from Lakewood. What conditions will he encounter?
A: Heavy rain and hail conditions and a major crash incident on US 17 Southbound.
5. 511-1-task5.wav : CY4
Q: Are road surface conditions on I 96 safe to drive through Parma, right now?
A: (gusty winds) Yes, there are no reports of traffic problems.

Menu2

1. 511-2-task1.wav : RT2
Q: If you take CR 25 South from Parma, will you encounter any problems?
A: No.
2. 511-2-task2.wav : WE2
Q: If you go to your friend's cabin in Lakewood today, will it be nice enough to go hiking?
A: No, rainy and thunderstorms, high 45 – 50 degrees.
3. 511-2-task3.wav : RT4
Q: One of your friends is driving US 41 North from Wooster. Is there a chance she will be delayed?
A: Yes, heavy traffic conditions on US 41 between I-92 and I-96.
4. 511-2-task4.wav : CY3
Q: You are traveling to Wooster tomorrow. Will you have to fight any extra traffic on I 92, due to construction?
A: Yes, Roadwork on I-92 has traffic down to 1 lane in both directions.
5. 511-2-task5.wav : CY2
Q: You have forgotten your hat and gloves and are thinking of going back to Minneapolis for them. Would you run into any delays on I 96?
A: No incidents, conditions are clear.