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16. Abstract

This project investigated the decision process involved in a driver's willingness to engage in various technology-related and non-technology tasks. Previous research focused on how well drivers are able to drive while engaged in potentially distracting activities but little work has considered how drivers decide when to engage in in-vehicle activities. The project included focus groups and an on-road study, both employing participants who used in-vehicle technologies, from four age groups: teen (16-18), young (18-24), middle (25-59), and older (60+). For the on-road study, participants drove their own vehicles over a specified route and at specified points they rated their willingness to engage in some specific task at that time and place. Eighty-one different situations (combination of in-vehicle task and driving circumstances) were included. Further information was collected in the take-home booklet completed after the on-road session. Driver willingness to engage in various in-vehicle tasks was related to the technology type, specific task attributes, driving conditions, personal motivations, age, driving style, and decision style. Ratings of willingness and of risk were very highly correlated. Although reported willingness varied substantially with the task it was rather insensitive to immediate roadway characteristics and participants showed relatively little concern for impending (up-road) conditions. Task-related motivations, rather than driving-related considerations, appeared to be dominant decision factors. Participants did not attribute particular risk to basic cell phone tasks (dialing, answering, conversing). These phone tasks were rated roughly comparable to eating something neat or drinking something and were rated less risky than eating something messy or dealing with children in the vehicle. A matrix mapped 36 specific project findings to potential countermeasure approaches, including public education; driver or device user training; user interface design; needs for warnings and information; criteria for function lock-outs; and driver assist system criteria. Some particular countermeasure strategy was suggested for consideration in more than 200 cells in this matrix, so that the findings of the study may prove heuristically fruitful in generating approaches to dealing with driver distraction.

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Summary

This report describes the methods and findings of a National Highway Traffic Safety Administration project on "Driver Strategies for Engaging in Distracting Tasks Using In-Vehicle Technologies." The project investigated the decision process involved in a driver's willingness to engage in various technology-related and non-technology tasks. Distracted driving has been recognized as a significant highway safety concern and is the subject of considerable research and controversy. Nearly all research on this topic has focused on how well people are able to drive while engaged in some potentially distracting activity. Very little work has considered how drivers decide whether and when to engage in some in-vehicle activity. The objective of this research was to determine the basis for drivers' decisions about their willingness to engage in potentially distracting activities.

The project had two major research components: focus groups and an on-road study. Both component methods recruited participants who used in-vehicle technologies to at least some degree, from four age groups: teen (16-18), young (18-24), middle (25-59), and older (60+). First, a series of focus groups was conducted in which participants discussed the factors that influenced their decision making about in-vehicle activities. This provided an initial understanding of the perceptions, motivations, attitudes, and decision factors that underlie driver choices. The subsequent on-road study had two phases: an on-road drive and a take-home booklet. During the on-road drive, participants drove their own vehicles over a specified route. They did not actually engage in in-vehicle tasks, but at specified points they rated their willingness to engage in some specific task at that time and place. Eighty-one different situations (combination of in-vehicle task and driving circumstances) were included. After completing the on-road portion, participants were given a booklet to take home, complete, and return. The booklet questions sought information about participants' familiarity with various in-vehicle technologies, additional situations for willingness and risk ratings, stated reasons underlying ratings, and self-ratings of certain aspects of driving behavior and decision-making style. Together, the focus groups and on-road study provided a systematic set of findings to advance understanding of how drivers decide whether and when to engage in potentially distracting tasks.

The general picture that emerged from this research is that driver decisions about engaging in in-vehicle tasks are strongly related to considerations of task motivations (even if they may appear trivial) and "lifestyle" perceptions, and more weakly related to driving considerations and current or upcoming roadway and traffic attributes. There is little planning and preparation for activities and little tendency for drivers to delay activities until driving task demand is low. The in-vehicle task factor most important in driver considerations is visual demand. Common cell phone tasks did not engender much perceived risk or reluctance to engage in the activity. There were substantial differences in willingness to engage in in-vehicle technology use among different driver groups, with teen drivers and those with "high intensity" driving styles being most willing.

More specifically, driver willingness to engage in various in-vehicle tasks was related to the technology type, specific task attributes, driving conditions, personal motivations, driving style, and decision style. On-road ratings of willingness to engage in a task had a very strong linear

relationship with the perceived risk of engaging in the task. Important differences existed among age groups. While all of the factors studied had some influence, drivers did not seem particularly sensitive to immediate or impending primary driving task demands. There was little difference in willingness related to roadway type (freeway, arterial, winding two-lane highway), but some influence of maneuvers (e.g., exits, merges, turns).

The focus groups, in particular, highlighted motivational factors for in-vehicle device use and suggested these are dominant factors over roadway and task demands. These included social, economic, and "lifestyle" motives. Drivers apprear quite willing to use cell phones under almost all circumstances and are more reluctant to use navigation systems and PDAs. For most common cell phone tasks, perceived risk and willingness to engage in the activity were judged similar to drinking something hot or tuning a radio, and less risky than eating something messy (e.g., a taco). The research found that there are a number of task attributes, believed to be important based on the existing driver performance research literature, to which drivers appear relatively insensitive in their decision-making. For example, the disruptive effect of an in-vehicle task on driving performance may be related to how easily the task can be decomposed into discrete subtasks ("chunking") or the demands of error recovery should an input error occur. Such factors did not emerge among the features participants appeared to consider in their decision-making. Individual differences among participants in attitudes about multitasking were also related to the findings. One important finding in this respect distinguished teen drivers from other drivers. Many teens enjoyed the challenge of multitasking and testing their limits, and sought these challenges, while more mature drivers sought to limit challenges.

Based on the focus groups, drivers typically do not show much anticipation in their decisions about distracting tasks. This is true for both pre-trip and en route anticipation. With the apparent exception of business users of the technology, drivers often are not prepared for tasks in terms of location of items (e.g., phone, earpiece, information sources) or pre-programming of devices. They appear not to project ahead much regarding up-road traffic, roadway demands, and driving maneuvers. However, while these impressions emerged from the focus groups, this was a qualitative procedure with a limited sample, and further quantitative treatment would be desirable.

The findings of this project provide a useful first look at the range of factors that influence motorists' decisions about whether to engage in some activity at a given point in time. A conceptual model of driver decision making regarding in-vehicle tasks was developed as a framework to structure the important factors and processes that underlie decisions. The project findings may help direct a variety of safety countermeasures to reduce the problem of distracted driving. Potential safety countermeasures include: public education, driver or device user training, user interface design, needs for warnings and information, criteria for function lock-outs, and driver assist system criteria. A matrix was used to map 36 specific project findings to potential countermeasure approaches, including public education; driver or device user training; user interface design; needs for warnings and information; criteria for function lock-outs; and driver assist system criteria. Some particular countermeasure strategy was suggested for consideration in more than 200 cells in this matrix, so that the findings of the study should prove heuristically fruitful in generating approaches to dealing with driver distraction.

The findings also reveal that teenage drivers saw the least risk in engaging in various tasks, had inflated opinions about their multitasking capabilities, were strongly motivated by social and life-style factors, and had various driving attitude and driving style attributes that compound the potential effects of distraction.

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1.0 Introduction

1.1 Background

The potential hazard of distraction when using in-vehicle technologies has become a major concern in the highway safety field (Llaneras, 2000). In this report, the term "in-vehicle technology" refers to a device that may be used in a vehicle, whether it is a portable device carried into the vehicle or an installed device embedded in the vehicle. Cellular phones are the most familiar example of an in-vehicle device and are the subject of serious debate about appropriate use and needs for regulation. Other in-vehicle devices, such as navigation systems, are becoming more common in new vehicles and more extensive information and communication systems are under development. To minimize the risks of distraction from in-vehicle technologies, two factors must be addressed: (1) the attentional demands the technology design imposes on the driver and (2) the driver's decision to use the technology while driving. The first of these issues has received considerable research attention while the second has received almost none.

Numerous studies have now demonstrated that in-vehicle technology use can have deleterious consequences on aspects of the driving task: lane positioning, speed control, car following, situation awareness, hazard recognition (see Goodman, Barker, and Monk, 2005, for an extensive recent bibliography of this research area). These studies typically have research participants drive a vehicle (or driving simulator) under conditions determined by the experimenter and engage in tasks specified by the experimenter, at times and places controlled by the experimenter. Thus this research addresses the very important question of what can happen when a driver attempts to engage in some task under certain driving conditions. What it does not tell us is what drivers actually choose to do while driving. An in-vehicle technology presents a safety problem to the extent that drivers choose to use it at inappropriate times. The actual risk associated with some device will be a joint function of how that device interferes with driving and the circumstances under which drivers are willing to use that device.

Individual driver attributes are likely to be important considerations for understanding driver decisions about engaging in in-vehicle tasks. In particular, driver age is known to be associated with crashes, performance capabilities, in-vehicle device use, attention-sharing capabilities, and risk perception. Inexperienced teenage drivers and older drivers are groups that merit specific attention. Teen drivers are more likely to engage in high-risk behaviors, have motivations distinct from other drivers, and be less capable in various aspects of the driving task (Lerner, Tornow, Freedman, Llaneras, Rabinovich, and Steinberg, 1999). Older drivers experience a range of perceptual and information-processing decrements and tend to be more risk-averse (Dewar, 2001). Therefore it is important that any effort to investigate driver willingness to engage in technology use give specific consideration to these particular driver groups.

1.2 Objective

This report describes the methods and findings of a NHTSA project on "Driver Strategies for Engaging in Distracting Tasks Using In-Vehicle Technologies." It investigates the decision process involved in the driver's willingness to engage in various technology-related, and non-technology, tasks. Some additional funding was provided by the National Institute of Child Health and Human Development (Contract GS-23F-8144H) for the specific purpose of including teenage driver groups in the participant sample.

The focus of the research presented here concerns the factors influencing a driver's willingness to engage in certain non-driving tasks. Information about driver decision making may contribute to a broad array of distraction-related countermeasures, such as public education, driver training, user interface design, needs for warnings, criteria for lock-outs of certain functions while driving, function allocation for driver assist systems, and design of adaptive driver interface systems.

The project had two major research components. First, a series of focus groups was conducted in which participants discussed the factors that influenced their decision making about in-vehicle activities. This provided an initial understanding of the perceptions, motivations, attitudes, and decision factors that underlie driver choices. Following the focus groups, an on-road study was conducted. This study had two phases: an on-road drive and a take-home booklet. During the on-road drive, participants drove their own vehicles over a specified route. They did not actually engage in in-vehicle tasks, but at specified points they rated their willingness to engage in some specific task at that time and place. Eighty-one different situations (combination of in-vehicle task and driving circumstances) were included. After completing the on-road portion, participants were given a booklet to take home, complete, and return. All participants returned the booklets. The booklet questions sought information about the participant's familiarity with various in-vehicle technologies, additional situations for willingness and risk ratings, stated reasons underlying ratings, and self-ratings of certain aspects of driving behavior and decision-making style. Together, the focus groups and on-road study provided a systematic set of findings to advance understanding of how drivers decide whether and when to engage in potentially distracting tasks.

1.3 Organization of This Report

Section 2.0 describes the methods and findings of the focus groups. Section 3.0 describes the methods and findings of the on-road study. The focus groups and on-road study have been previously reported in detail in project interim reports (Lerner and Balliro, 2003a; Lerner and Balliro, 2003b; Lerner and Boyd, 2004), which contained a number of extensive appendices that provide full details of the focus group moderator's guide, the on-road driving route, the on-road experimenter's protocol, and a complete copy of the take-home booklet.

Section 4.0 discusses the findings and their implications. Subsection 4.1 highlights key findings of the project. Subsection 4.2 presents a conceptual model of the driver decision process. This is an organizational scheme for identifying the key decision factors and their interaction. Subsection 4.3 considers the implications of the findings for safety countermeasures. Countermeasures are suggested for the device interface (warnings, interface attributes), interactive vehicle control (function lock-outs, driver assist systems), and education and training (safety campaigns, driver or user training or licensing).

All participants were recruited from the greater Washington, DC, area. Participants in the young, middle, and older groups were recruited through newspaper advertisements and the services of a marketing research firm. Teen participants were recruited through notices distributed at six public high schools in Montgomery County, Maryland. All participants were paid for taking part in the discussion. In the recruitment process, individuals were sought who had various types of technologies in their vehicle, such as cell phones, personal digital assistants, and navigation systems. Potential participants contacted Westat and provided background information on their age, sex, type of vehicle, frequency of vehicle use, types of in-vehicle technologies, and frequency of use for each technology (typical number of times used per week). Dependent upon eligibility, participants were called back and scheduled for a session.

As a whole, the participants were active drivers, who drove almost every day. All participants were familiar with the use of cell phones while driving, and the majority (73%) had at least some limited experience using personal digital assistants (PDAs) in their vehicles. Less than half (38%) had used a navigation system. These percentages indicate the participants who reported ever using the device in their vehicles (taken from recruitment screen questions). It became evident in the focus group discussion that actual use of PDA's while driving was quite rare, and the "use" may have been while the vehicle was not in motion. Therefore the high percent of participants reportedly familiar with PDA use reflects the availability of this technology for our sample, but does not reflect frequent use. Navigation system users were less common. It was particularly difficult to find teen drivers who had experience with navigation systems and PDAs. Three of the nine teens reported PDA use and two reported navigation system use. However, all nine of the teens recruited reported in-vehicle use of CD players, so along with cell phone use, they were in fact multiple technology users.

2.3 Focus Group Procedure

All focus groups were held at Westat's main office in Rockville, Maryland, from December 2002 through February 2003. Sessions were 1 ½ to 2 hours in duration and were videotaped for further review and analysis.

The focus group followed a structured question path. Instructions to participants emphasized the need to discuss, in a non-judgmental way, what they actually do, rather than what they consider ideal or proper behavior. The discussion began with an "ice breaker" question that served two purposes. First, it allowed everyone to introduce themselves and say something. Second, it brought the discussion to a concrete, rather than abstract, level by focusing on some actual event. This question had each person describe a specific occasion in which they made a particular good or bad decision about whether or not to perform some in-vehicle task. The general structure of the focus group then proceeded along the following sequence of topics:

- **Decision factors**
  Factors that go into thinking when deciding whether or not to do some task while driving.

- **Errors/close calls**
  Close calls that people might have experienced as drivers, or even as passengers, and what factors went into those driving decisions.
- **Motivation and awareness**
  A sense of awareness among participants as to whether or not they are distracted.
- **Risk taking**
  Factors that seem important when accepting risk.
- **Specific driving situations**
  A last chance to recall any factors that go into decision making after presenting a few special cases (e.g., freeway, arterial, rural, and weather).
- **Relative risks**
  Comparison of risk for doing various distracting tasks while driving.
- **Process**
  Process by which participants make decisions and how all of the decision factors that were discussed come into the process.
- **Recommendations**
  Improvements to technologies and overall driving safety.

2.4 Focus Group Findings

2.4.1 Major Themes

Several major themes emerged from the focus group discussions. By major themes, we refer to broad concerns that stood out based on commonality among the focus groups, the intensity of the discussion, the diversity of the described behavior, or the significance of the issue. This section highlights these themes.

Major themes included the following:

- <u>Decision style</u>: People differed considerably in the style in which they made decisions about in-vehicle technology use. Some of these differences were seen as general styles or personality characteristics, not specific to in-vehicle tasks. People described themselves as impulsive, deliberate, cautious, Type-A, and so forth. Other characterizations of differences in decision style were more specific to in-vehicle technology use. This could be roughly dichotomized as "use by exception" versus "refrain by exception." The use-by-exception drivers tended not to use the technology unless there was a specific need and appropriate opportunity. For example, if their cell phone rang during a trip, they would let their voice-mail take a message, unless there was some expectation that it was an important call or if the traffic situation was very benign (e.g., at a stop light). The refrain-by-exception drivers did not give much deliberate consideration to engaging in a task and just acted on the motivation to use the device unless there was some exceptional reason to refrain. This difference may be related in part to whether the person tends to use the device largely for social interactions versus primarily for exchange of information. However, because the focus group format does not record individual data, there is no means of confirming the impression that these were correlated.
- <u>Utilizing personal time and resources</u>: The ability to make use of personal time and resources was a dominant factor in the thinking of many participants. Cell phones, in

particular, were used by some because they considered driving “dead time” that was wasted or because they had so little free time for communication that driving was an opportunity. For work-related communications, use of in-vehicle technologies was seen as important for timeliness and time management. For example, some felt they had to get back to clients quickly to appear responsive or to prevent them from using someone else’s services. Another consideration that was mentioned by some was the desire to fully use their communication resources. If there were a certain number of available minutes on their phone plan, they did not want to “waste” this resource. Also, those who had free service (e.g., free nights and weekends) received no penalty or cost for their use, and therefore figured why not use it. There was some speculation that the tendency to want to use personal time and resources might be greater for those who use the cell phone as their primary (home) phone.

- Pre-trip preparation: Drivers engaged in a variety of pre-trip preparations for technology use. This seemed particularly so for those who conducted business from their vehicles (e.g., real estate agents, sales people, consultants). They tended to place cell phones, PDAs, papers and notebooks, in accessible places. Some put on earpieces (discussed further under “non-use of safety features”). Navigation system owners sometimes pre-programmed new destinations (in addition to frequently used destinations already stored). However, many ran off hard-copy directions or maps (through MapQuest) to use instead of, or to supplement, the navigation system.
- Passenger effects: Participants indicated that driver decision making was influenced in several important ways by the presence and type of passengers. The presence of children tended to make the driver more cautious about in-vehicle activity. Some also indicated they were more safety cautious with adult passengers as well. The presence of adult passengers raised certain social concerns about rudeness; this was especially true for business people who had clients in the car. On the other hand, passengers could serve as facilitators for using technologies, looking up numbers or keying in destinations. There was also some discussion of the status of having in-vehicle technologies and showing them off. It was not clear from the discussion whether this actually led to additional use when passengers were present.
- Non-use of safety features: Participants tended to be aware of certain safety features but not to use them. Earpieces for the cell phone were frequently discussed. Some people tended to wear them or have them handy for most trips, some only for trips where they thought a call was likely. Others never used them, even if they acknowledged some benefit. There was a general belief that using an earpiece did make driving while using a phone safer. A number of participants had voice recognition systems, but these were considered unreliable and were rarely used. Speed dialing on the cell phone was also not used much. There was a feeling that if a number was commonly dialed, the driver usually new it by memory anyway, and that was more convenient than programming and trying to remember the speed dial number. There was also some discussion of the virtues of a driver lock-out for entering navigation system destinations. Those who had navigation systems that locked out entry while driving were generally supportive of the feature. Those who could key in entries while driving were generally not opposed to the lockout, except for the ability of a passenger co-pilot to have access. For both cell phones and navigation systems, a number of the participants acknowledged that they never read the instruction manuals that came with the product and were not aware of various features or procedures that might be related to safety.
- Determining opportunity: A range of factors were raised in discussing what provided an opportunity for engaging in a task. There was not always good agreement on these factors.

For example, some felt that cell phone use was reasonable while driving on a freeway, while others felt it was inappropriate during high speed driving. Some felt that congested traffic provided a good opportunity for phone use, while others felt this was a risky condition. Being stopped for a traffic signal was commonly seen as a good opportunity to initiate a task. Participants expressed reluctance to engage in tasks during inclement weather. Another aspect of opportunity had to do with the quality of phone reception. Some people had good awareness of areas where they tended to experience drop-out and took this into account in their decisions. Although participants noted risky conditions that would not normally be considered opportune times to engage in a task, they frequently qualified the remarks with exceptions (e.g., unless it's a family member calling, unless I'm running late).

- Decision factors noted: A substantial portion of the focus group discussion was devoted to factors that the driver may take into account when making a decision. Many factors were raised related to the technology, the purpose of the task, executing the task, and the roadway. In these discussions, the first factors raised tended to relate to the task: the motivational issues, task demands, and utilization of time. Factors of traffic interaction were also generally raised without probing. However, roadway (e.g., roadway type, features such as curves), environment (e.g., urban, weather, pedestrians), and maneuver (e.g., turns, merges) factors were generally not among the initial factors raised by the group. They did not seem to be what first came to mind when participants considered the question. Although participants acknowledged their significance, more probing was required to get at some of the roadway and environmental factors than to task issues. This suggests that drivers may be less sensitive or responsive to roadway demands than to other aspects of the decision.
- Awareness and decision: There was some acknowledgement that although they recognized the risks of in-vehicle tasks (at least under certain conditions), people "just did it." There was often nervous laughter and defensive joking in discussing this, and it was difficult to express a rationale for the driver decision. Explanations were sometimes in terms of lifestyle or personality factors (e.g., busy, sociable, never have time, impulsive). People also described a loss of awareness during extended phone use, with terms like "zoned out" or "sucked in."
- The "other" driver: In conducting the focus groups, we tried to keep the emphasis on discussing personal behavior and experience (what you do) rather than normative behavior (what you should do) or the behavior of other drivers. None the less, we still got some discussion of why certain acts may be inadvisable for other people to be doing. Some actions were seen as dangerous or irresponsible when done by others, but there was little acknowledgement that the participant himself had a problem. This is not a surprising observation. It is well-established in the literature that drivers generally tend to view themselves as more competent or safer than others. Still the point is important to acknowledge for distracted driving situations.
- Changes with technology experience: The most commonly expressed opinion about experience with the technology was that the frequency of use tended to increase with experience. For cell phones, people felt they became more comfortable talking while driving and more adept at operating the phone. Participants talked about learning the layout of the keypad so that they did not need to look at it while entering a number. They also discussed how some phones provide good tactile feedback from the buttons, so that it is less necessary to look at the handset once you get practiced at using it. Other phones were more difficult to use without looking. Not everyone agreed that they tended to use the device more with

experience. Some felt the opposite – that the device was a "new toy" at first, but they became more selective about use as time went on. Another experience factor was a "close call" or crash. One participant drastically changed behavior after almost hitting a pedestrian, no longer using a phone while driving. Others indicated that while an incident might make them more cautious for a while, the effect is transient. There was also some discussion of broader experience with cell phones (outside of driving), particularly generation effects. Younger people who grew up using cell phones might have different abilities and attitudes than older drivers.

- Phone use tasks: People made distinctions among the various tasks related to a cell phone. Dialing was seen to be more complex and riskier and there was more selectivity in when a call would be placed. Looking up stored numbers was seen as difficult. Answering the phone was seen as simple. Talking while driving was somewhat more complex to discuss (situational) and opinions varied considerably. Different types of conversations were also distinguished (e.g., social conversations, brief information exchanges, business calls). Call waiting was raised as a feature that increased the complexity of the task; handling multiple calls was seen by some as particularly distracting while driving. It was also noted that having a manual transmission made phone use more difficult.
- Call screening: Many of the participants made use of the caller ID function of their cell phones. It is routine for them to check the caller and then decide whether to answer or let the voice mail handle the call. There was a frequent recognition that responding to an incoming call was "automatic" or "impulsive" or had some sense of urgency. However, "responding" does not necessarily mean answering the call; it may involve picking up the handset and checking the caller ID, then deciding what to do.
- PDA use tasks: PDAs were not seen as a big part of the distracted driving problem. This is because they were seldom used while driving by most participants, in large part because they were too difficult to use while driving. Some occasionally used PDAs in business to check schedules or get notification of an appointment. Other tasks that involved input (usually with the stylus) were not seen as reasonable to do. Also, there were legibility problems under many driving conditions, including poor contrast and glare. While there may be PDA users in the broader driving public, the sample that participated in the focus groups did not generally see PDA use as reasonable.

2.4.2 Teen Drivers

Teen drivers are distinct from more mature drivers in their crash rates, crash characteristics, driving styles, travel patterns, attitudes, and capabilities (Lerner et al., 1999). These factors make them particularly vulnerable to the risks of distracted driving. Therefore this is a group of particular interest. Unsurprisingly, one general observation of the focus groups was that the self-described attitudes and behaviors of the teen participants were in many respects different from those of the more mature participants. Therefore, key findings for the teen driver focus group are presently separately here.

Key findings included the following:

- Decision Style/Process: One of the objectives of the focus group was to try to understand the factors that go into decisions about whether or not to engage in some in-vehicle technology task. This interest included external factors (e.g., road, traffic, time, environment), task factors (physical and cognitive requirements, purpose, motivations), and individual approaches to decision making. Although a substantial portion of the focus group discussion was devoted to factors that the driver may take into account when making a decision, few if any generally significant factors were uncovered. The participants reported very little consideration of any factors when deciding to engage in a task. Even when the teens were probed on such factors as task demands, purpose of the task, roadway, environment, and maneuver, they just did not seem to matter. Participants seem to execute secondary tasks almost whenever they get the impulse to do so, minus a few personal exceptions. This almost universal trend in the teen group is in contrast to many of the adults in the more mature groups. Given the nature of a focus group, one could question whether the teen drivers are (1) genuinely insensitive to roadway and task factors, (2) less introspective or self-aware in recognizing what influences them, or (3) less candid in describing how they actually behave. However, the general sense that emerges from the focus group is that there is minimal consideration, conscious or otherwise, about engaging in technology use while driving, and rather exceptional conditions are required for use to be deferred. In the words of one participant, "It's like breathing – we don't think about doing it or whether or not we should do it – we just do."
- Crashes and Close Calls: In the small sample of nine teen participants, all had experienced a close call and five were directly involved in car crashes. During the opening portion of the discussion, each participant recalled and described a personal incident involving technology use. In the focus group of more mature drivers, many individuals had trouble recalling any specific incidents. For the teen drivers, everyone clearly recalled close calls, serious driving errors, and/or actual crashes. All but one of the crashes occurred during the use of in-vehicle technologies (particularly cell phones and CD players). For example, one participant recalled an accident where he drove off of the road and almost totaled his car because he was looking down to read a text message sent by a friend, on a day where the roads were icy. However severe these crashes seemed to be, participants' driving or technology-use behavior did not appear to be influenced, even for a short period of time. It seemed more common for the teens to blame the external environment rather than the incident; if behavior changed, it was related to the external conditions. For example, the participant mentioned earlier decided not to drive on icy roads anymore, but continues to text message while driving.
- Continuous Cell Phone Use: Cell phones and driving seemed to go hand in hand for teen drivers. Most participants indicated that they talked on the phone almost all of the time while driving. They talk from the time they get in their car to the time they arrive at their destination. It is "just what they do" ("The cell phone is my life!"). It was interesting to note that despite a request to turn off their cell phones, at least four calls were received during the focus group itself. The participants explained how they have grown up using cell phones and multitasking in various ways, making it easy and "natural" to behave this way. Most participants got their cell phones either before they started driving or just around the same time. They are two social activities (talking and driving) that were

introduced to them at similar times. Also, since participants are so frequently on the phone while driving, it is very common for them to be involved in three tasks at any given time: driving, talking, plus one other (e.g., eating, listening to music).

- Driving Without Hands: Most participants described a driving style which included having only one hand on the wheel, regardless of whether or not they were engaging in a secondary task. Perhaps this driving style makes occupying the second hand (e.g., with a cell phone) less strenuous or distracting. All nine participants reported sometimes steering with their knees while using both hands for other tasks. It did not seem to matter whether the tasks were technology related or non-technology related. If the driver's hands were being occupied, they steered with their legs.
- Searching For CDs: Digging CDs out of CD books and holders seemed to be a major distracter among this age group. Some CD cases held up to 200 CDs, requiring the driver to sort through the book to find the desired CD. In many cases, these CD books are kept in the back seat, which necessitates the driver to reach back for them. It was also common to store CDs in cases that attached to the sun visor. This too was seen as distracting because you have to look up and take your eyes off the road in order to find the CD of choice. Although some participants with external CD players expressed some awkwardness in inserting the CD, it seemed apparent that the greater distraction was searching for and retrieving the CD.
- Text Messaging, PDAs, and Games: All nine participants reportedly use cell phone text messaging while driving. This is in marked contrast to the more mature groups. Some described having memorized the keypads so that they can easily enter text while not having to look down at the keypad. Most also used PDAs at least occasionally, although they acknowledged this was somewhat more awkward to do, and might require the driver to have to steer using the knees. When asked directly about engaging in electronic games while driving, very little of this was reported. However, the opinion was expressed that this had more to do with the poor quality of the games available.
- Seat Belt Use: All participants revealed that they wear seat belts almost every time they drive. Many of them also ask their front seat passengers to wear their seat belts as well. This routine and "natural" seeming use of a safety device stood in contrast to the cavalier attitudes about safety when using technology or engaging in secondary tasks while driving. Also, participants admitted that when they are passengers in a vehicle rather than the driver, they are less insistent on wearing seat belts. The rationale behind this seemed to be that teens feel more "secure" when someone else has the responsibility of driving.
- Environmental Effects: Very few environmental factors were mentioned as influential in the decision process. It seems that the teen participants rarely considered the environment, and when and if they did, it was a result of a personal incident. For example, one participant disliked freeway merges as a result of an accident. Another participant felt uncomfortable on icy roads as a result of an accident. Another participant showed caution in both rain and darkness because those were the conditions when he was in his accident. Having personal exceptions was much more typical among this group than overarching common factors. Of the very few that did emerge were familiarity of the location and traffic.
- Pride in Skills and Challenge: Many of the participants expressed pride in their ability to do multiple tasks. They enjoy the physical challenge of accomplishing difficult demands,

such as digging around in the back seat for something while driving and talking. A few female participants acknowledged that they were not particularly capable drivers, especially when multitasking. However, there was even a certain amount of pride in describing their poor performance.

- Passenger Effects: Several passenger effects arose during this focus group. Some participants said they were more likely to use their phones when they had passengers in their vehicles. The teen participants explained that they typically use their phones when making evening plans and that the evening is when they are most likely to be driving with someone. Some participants thought the opposite of this was true, indicating the boredom of driving alone lead to increased phone use. Participants also said that passengers did not seem to influence their driving behaviors in general. Whether they are alone, with a friend, or someone of the opposite sex, they drive however they normally would drive. The only exception to this is when a passenger makes a direct request to slow down or somehow alter their behavior because they feel nervous or unsafe.
- Age/Generational Differences: The teen drivers believed they were more capable than their parents' generation in being able to multitask while driving. This is mainly attributed to their growing up "wired" and being accustomed to multitasking. One participant even described research findings that confirmed their superiority. Some felt the ability to engage in other activities depended on the individual, not age, but in general teens were considered more capable.
- Gender Differences: The teen participants brought up a unique topic that the more mature groups never mentioned: gender. The majority of participants felt that differences existed in the skill and security of male and female drivers. Some felt that females are much less skilled in the use of in-vehicle technologies and driving in general. Some felt that males exhibit more skill and confidence, making them better drivers and task executors. Others felt that males are poorer drivers because they are more willing to take risks and show off while driving, whereas females were not prone to such behaviors. Although there seems to be a wide range of views, the one thing that is apparent is that teens recognize some differences between the genders.
- Typicality of Peers: The recruiting flyer used for the focus group specifically sought teens who were users of in-vehicle technologies. Late in the session, the participants were asked if they thought the discussion would be much different if a "random" sample of teen drivers had been recruited. They felt that as a group, they were not at all atypical. Whether they were asked about technology use, seat belt use, driving style, and so forth, all participants felt that their peers act in similar ways and share similar attitudes concerning driving.

2.4.3 Comparative Risk Ratings

During the focus group sessions, a brief rating form was distributed to each participant. The form was comprised of 32 possible tasks a person may do while driving a vehicle. Twenty of the tasks involved the use of technological devices (e.g., answering a cell phone call). The remaining 12 tasks provide a comparison set of non-technology tasks (e.g., drinking something hot). Participants rated the risk of each task on the following 1-to-5 scale:

1 = no risk beyond that of normal driving; don't need to worry about it
2 = little risk; requires only a little extra attention
3 = moderate risk; can generally be done safely, but only with care
4 = risky; requires extreme caution
5 = extremely risky; should never be done while driving
X = no idea

Participants who felt they were too unfamiliar with a task to make a judgment indicated so by marking an X**.**

Table 2-1 presents the summary of these risk ratings. Mean ratings are shown separately for the adult participants (young, middle, and older age groups) and the teen participants. Because the discussion in the teen group was in many ways quite different from that of the other groups, the teen risk ratings were kept separate so that they could be individually considered and contrasted with other participants. The mean for the adult sample is based on 35 of the 36 participants (one participant failed to hand in a form) and the mean for the teen sample is based on the nine teen participants. Participants were not individually identified on the rating forms, so it was not possible to relate ratings to individual participant attributes. In Table 2-1, the 32 rated tasks are shown as rows of the table. In Section 3 of this report, findings are presented for very similar ratings collected from a larger sample (N = 88) with balanced age groups. The findings of the smaller sample from the focus group portion of the study are treated qualitatively only here, with formal statistical analysis of the larger sample provided in Section 3.3.4.

The participants clearly saw differences among tasks in the degree of risk and used the full range of the rating scale. For the adult group, the mean risk ratings ranged from 1.37 (turn up temperature in the climate control system) to 4.81 (key in and send e-mail on PDA). The degree of group consensus varied from item to item, with the standard deviation for the least-agreed upon item (drink something hot) being about double that of the better-agreed upon items. The teen group's mean risk ratings ranged from 1.00 (check the speedometer) to 4.00 (search for some information on the Internet). For every one of the 32 tasks, the teens rated less risk than the adult sample.

Tasks	Mean Rating: Adult	Mean Rating: Teen
Cell phone-Key in call	3.29	2.00
Cell phone-Answer call	2.49	1.44
Cell phone-Have an extended conversation	3.03	2.22
Cell phone-Have a brief "exchange of information"	2.24	1.67
Cell phone-Look up a stored phone number	3.80	2.78
Cell phone-Take notes during conversation	4.65	3.13
PDA-Open and read an e-mail	4.56	3.00
PDA-Open and listen to a voice mail	3.79	2.50
PDA-Key in and send and e-mail	4.81	3.50
PDA-Check your schedule	3.79	2.50
PDA-Schedule a meeting using a scheduler	4.38	2.75
PDA-Search for some info on the internet	4.72	4.00
PDA-Look up an entry in an address book	4.09	2.50
Nav. system-Read an electronic map	3.38	2.25
Nav. system-Key in destination address	3.96	2.25
Nav. system-Retrieve a stored destination	3.22	2.00
Nav. system-Change your destination	3.87	2.50
Nav. system-Alter your route preference	3.74	2.25
Nav. system-Find an alternate route	3.50	2.00
Nav. system-Search for the nearest Starbucks	3.48	1.67
Non-tech tasks-Talk with a passenger	1.71	1.00
Non-tech tasks-Deal with children	2.97	2.57
Non-tech tasks-Find a radio station	1.86	1.63
Non-tech tasks-Adjust the loudness of a sound system	1.63	1.22
Non-tech tasks-Insert a CD, tape, or videotape	2.31	2.22
Non-tech tasks-Read a paper map	3.86	3.13
Non-tech tasks-Drink something cold	1.91	1.33
Non-tech tasks-Drink something hot	2.80	1.78
Non-tech tasks-Eat something sloppy (like a taco)	3.47	2.22
Non-tech tasks-Eat something neat (like a cookie)	1.88	1.22
Non-tech tasks-Turn up the temperature	1.37	1.25
Non-tech tasks-Check the speedometer	1.40	1.00

Table 2-1. Risk ratings for various in-vehicle tasks (1 = no risk; 5 = extreme risk)

A few comparisons of interest may be highlighted from Table 2-1. For the adult sample:

- PDA tasks as a group were viewed as the riskiest tasks to perform while driving a vehicle (mean = 4.31).
- Placing a cell phone call and having an extended conversation were seen as generally safe if done with care (3 on the rating scale).
- Having a brief "exchange of information" was seen as less risky than having an extended personal conversation.
- Talking on cell phones while driving is seen as having similar risk to dealing with children or drinking something hot.
- Looking up stored phone numbers and taking notes during conversations were rated the riskiest of the cell phone-related tasks.
- Non-technology related tasks ranged from having minimal risk (e.g., check the speedometer) to having substantial risk (e.g., read a paper map). Eating and drinking while driving are of particular interest because they are often compared with technology use in discussions of the problem of driver distraction. Participants made important distinctions within these categories. Drinking something cold or eating something neat (like a cookie) were not rated as very risky (each about 1.9 on the scale). However, drinking something hot was seen as riskier, and eating something sloppy (like a taco) riskier yet. Compared to cell phone use, eating something sloppy was rated riskier than extended conversation but not as risky as looking up a stored phone number.
- Navigation system tasks all had mean risk ratings in the relatively narrow range between a 3.22 and 3.96, but with large standard deviations, indicating a lack of good agreement among participants. The variation in answers may in part be due to the lack of navigation system experience exhibited by many of the participants (even though a number of participants also declined to provide a rating, due to lack of familiarity). Keying in a destination was rated the riskiest of all navigation system tasks.

The following points are highlighted regarding the teen group's risk ratings:

- No task was rated a 5 ("extreme risk") by any participant in the teen group. In contrast, about 20 percent of all ratings from the more mature participants were "5."
- The mean rating for the teen driver group was lower than the mean rating from more mature drivers for every task. The difference was especially pronounced for the communications technology-related tasks, where the group mean differences exceeded 1.0 rating scale units for 18 of the 20 tasks. In contrast, the difference exceeded 1.0 units for only 2 of the 12 non-technology tasks (drink something hot, eat something sloppy).
- The task rated riskiest by the teen drivers was searching for information on a PDA (mean = 4.0). The tasks rated least risky were talking with a passenger (mean = 1) and checking the speedometer (mean = 1).
- For teens, keying in a cell phone call and having an extended phone conversation were seen as having little risk and requiring only a little extra attention (2 on the rating scale).
- Having a brief exchange of information over the phone was rated by the teen drivers to have similar risk as finding a radio station.
- Having an extended phone conversation was rated by the teen drivers to have similar risk as inserting a CD, tape, or video.

- Both the teen and mature drivers saw reading a paper map as the riskiest non-technology related task.

Very similar risk ratings were collected from a larger participant sample in the on-road study (Section 3). Section 3.3.4 presents the formal statistical analyses.

2.5 Focus Group Summary

The focus groups brought out a number of significant points regarding driver decision-making about whether to engage in a task. Important individual differences in decision style were identified. While some drivers only engaged in in-vehicle technology use on a “by-exception” basis, others gave the decision minimal consideration or acted impulsively. Driving demand factors (roadway, traffic, maneuvers) appeared to be secondary to in-vehicle task motivations in the decision process. There was a general sense that roadway and driving factors were not considered carefully and little consideration was given to finding low-demand opportunities or to the impending demands of the up-road driving situation. Typical phone use tasks were generally seen as safe to do under most conditions and the level of risk of placing a call or engaging in extended conversation was seen as comparable to dealing with children or drinking a hot beverage. The use of personal time and resources, sociability, and “lifestyle” were important factors for phone users. There was a common admission of poor personal decision making and acknowledgement of episodes of “zoning out.”

Teenage drivers were distinct from more mature groups. Their attitudes about safety were more cavalier and their ratings of the risks of various tasks while driving were lower (sometimes much lower) than adult driver ratings. Although the sample was small (nine participants), it is of interest to note that despite their limited driving histories, every teen participant experienced a close call while using technology and five reported being in a crash. Teen driver decision making was described as more impulsive, and phone use was ubiquitous and seen as an element of life-style. The teens expressed confidence in their multitasking abilities and some relished the challenge of testing their ability to do multiple tasks while driving.

The findings of the focus group suggest various approaches for safety countermeasures for reducing the risks of driver distraction. The discussion of these implications is deferred to Section 4.3, where the findings of all aspects of the project are considered together.

Roadway Type	**Maneuver**	**Description**
Freeway	Proceeding on mainline	Driving along mainline lanes of a 4-lane (plus local lanes separated by barrier) suburban interstate highway, 55 mph speed limit
Freeway	Entrance/merge	Arterial road approach to freeway entrance ramp and merge lane
Freeway	Exit	Move to freeway exit lane and take off ramp
Arterial	Proceeding on mainline	Driving along in through lanes of 3-lane arterial in commercial area
Arterial	Unprotected left	Left turn from a left turn bay at an unprotected signalized intersection on the arterial
Arterial	Protected U-turn	U-turn on the arterial at an intersection with a left turn bay and protected signal phase (vehicle may have made maneuver during either protected or unprotected phase)
Arterial	Stopped at signal	Stopped for a red traffic signal on the arterial road
Parking lot	Exit to arterial	Approaching lot driveway to exit and turn right onto arterial road
Parking lot	Search for parking space	Drive up and down aisles of supermarket lot
Two-lane highway	Proceeding	Drive along two-lane highway with many curves and no shoulder, 35 mph speed limit
Residential	Proceeding	Drive on residential streets in a single family home community, little traffic

Table 3-3. Roadway locations at which ratings were obtained

Driving Location	Cell phone-Answer a call	Cell phone-Key in a call	Cell phone-Personal conversation	Cell phone-Enter text message	PDA-Look up stored phone number	PDA-Pick up & read message	PDA-Key & send e-mail	Navigation system-Key in a new destination	Navigation system-Call up a stored destination	Navigation system-Search for Starbucks	Non-technology-Search for and insert CD	Non-technology-Converse with passenger	Non-technology-Hot drink	Non-technology-Eat a taco
Freeway Mainline	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Freeway Entrance/Merge	X	X	X	X		X		X						
Freeway Exit	X	X				X		X						
Arterial Mainline	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Arterial U-Turn/Protected	X							X						
Arterial Left Turn/Unprotected	X					X								
Arterial Stopped at Signal	X	X				X		X						
Parking Lot - Inside	X	X	X			X		X	X		X	X	X	X
Parking Lot - Exit to Arterial	X	X				X					X			X
Minor 2 Lane/Winding	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Minor Local/Residential	X	X	X	X		X		X						

Table 3-4. Combinations of in-vehicle tasks and roadway locations included in the experiment

3.2.3 On-Road Driving Route

The 45-mile test route was located in Montgomery County, Maryland, and took between 60 and 90 minutes to complete. The route encompassed different road types: freeway, arterial, two-lane winding highway, residential street, and parking lot. Participants drove their own vehicles and were instructed to drive as they normally would, and were guided through the route by the experimenter.

In driving the route, the various locations for ratings were blocked into three distinct route segments: arterial (including parking lot), freeway (including arterial approach to freeway entrance), and minor road (two-lane highway and residential street). To control for effects of familiarity and experience, participants drove the test route in one of four randomly-assigned sequences: arterial – minor – freeway (AMF), freeway – minor – arterial (FMA), freeway – arterial – minor (FAM), and minor – arterial – freeway (MAF). The route within each segment of the trip remained constant.

3.2.4 Procedure

Sessions were conducted on weekdays, in mid-morning and afternoon, and timed to avoid periods of peak congestion. Traffic on the arterial road at these times was typically significant but not impeded; traffic on the freeway was moderate and free-flow. Most sessions took place in clear dry weather. Occasional participants encountered light rain during portions of their drive. Sessions were canceled if there was steady rain. Participants were instructed to bring their driver's license, proof of auto insurance, and in the case of teen participants, the completed parental consent form. All participants were also directed to have at least a half tank of fuel in their vehicles.

The participant met the experimenter at an office site in Rockville, Maryland. Upon the participant's arrival, the experimenter gave the participant a brief summary of the purpose of the study:

> "You will drive your own vehicle along a specified route with me in the back seat. At different times, I will ask you to verbally rate your willingness to complete certain tasks and the risk of completing those tasks, such as placing a phone call, at that point in time and location. You will not actually have to engage in any of these tasks while you are driving. Driving the test route will take about two hours to complete and the total session should not exceed 2.5 hours."

The participant then read and signed the informed consent form (see Appendix A). Next, the experimenter played an 11-minute training video which was used to clarify each in-vehicle task for the participant. The training examples included both carry-on (e.g., cell phone) and installed (e.g., navigation system) example devices. The video showed a model performing the tasks as a narrator described the actions being performed by the model. Participants were instructed to imagine performing tasks as they normally would, but to refer back to the video for tasks with which they were not familiar. So, for example, if a participant was unfamiliar with the task of entering a destination into a navigation system, the video showed the steps involved. If the participant was already familiar with this task, the video clarified certain aspects (e.g., the destination was not stored), but the participant was free to imagine use of his or her own personal system, which might differ in some ways from the product used in the video demonstration.

After the video was completed and the participant had the opportunity to ask questions, the experimenter outlined the details of the on-road procedure and thoroughly explained the rating scales. The participant and experimenter then initiated the drive session, which began with practice in using the rating scales. The experimenter sat in the rear seat on the passenger side, from where he or she read instructions and recorded the participant's ratings. On the way to the first test site, the experimenter guided the participant through five practice trials. Practice trials followed the same procedure as the study trials that followed. The experimenter provided feedback and questioned the participant to confirm his or her understanding of the procedure and his or her confidence in using the rating scales. Practice was extended until both the experimenter and participant felt confident in the ratings.

Upon arrival at the test site, the experimenter began presenting the study trials. The experimenter had a list of tasks which included the location where each task should be presented. A description of the task was read to the participant as the vehicle was approaching the point where the rating was to be made. The experimenter then said "Now" when the vehicle actually reached the point where the rating was to be made. For some locations, the precise timing was not very critical (e.g., for driving along the mainline section of freeway). For other situations, such as approaching a freeway exit ramp or turning out of a parking lot onto a busy arterial, the timing was more critical and the point of saying "now" was more precisely defined. Participants were instructed to give their first impression and to answer quickly once the experimenter requested a rating. As an example, for the task of answering a cell phone call at the location of a freeway exit maneuver, as the exit area was being approached the experimenter would read "Your phone rings. You are not expecting a call. Your caller ID shows an unfamiliar number. Willingness to answer incoming call." As the vehicle moved to the exit lane, the experimenter would say "now." The participant would then immediately provide a rating (1 to 10) of his or her willingness to answer a call at that point. Then he or she would provide a second rating to indicate the risk involved in answering a call at that point. This procedure was used for all 81 combinations of in-vehicle tasks and locations. The experimenter recorded ratings on a data collection form. Three different versions of the data collection forms were prepared, differing in the order in which tasks were listed. The version of the data collection form to be used for each participant was determined randomly before the session.

After completing the test route and returning to the office site, the experimenter provided the participant with the take-home booklet. The participant was encouraged to complete the booklet as soon as possible so that he or she could accurately recall the driving situations and answer questions related to his or her ratings. The participant was given partial payment for his or her participation, the balance to be sent to him or her after he or she mailed back the completed questionnaire using a pre-addressed envelope.

relationships among the driving situations were similar for all four age groups. The main effects of age and gender, and their interaction, can be seen in Figures 3-1 (for willingness) and 3-2 (for risk). “Willingness” decreases with age and “risk” increases with age. Males rate higher willingness and lower risk than females. Gender effects are pronounced for willingness for the older group; gender effects are pronounced for risk for both the middle age and older groups. However, there is little effect of gender for the teenage and young driver groups.

Table 3-8 presents the mean ratings and standard deviations for all 81 situations in list form. For each situation, the table shows the group mean willingness rating, the standard deviation of the willingness ratings, the group mean risk rating, and the standard deviation of the risk ratings. The standard deviations, across the group of 88 participants, were generally in the range of 2 to 3 rating scale units, with the willingness ratings showing slightly larger standard deviations than the risk ratings. For willingness, the standard deviations ranged from 1.62 to 3.37, with a median of 2.78. For risk, the standard deviations ranged from 1.71 to 3.15, with a median of 2.51. For both willingness and risk ratings, the standard deviations were smallest for the four situations involving conversation with a passenger. For both willingness and risk ratings, the standard deviations were highest (i.e., agreement among participants was least) for the two situations that involved answering a cell phone call while dealing with a turning maneuver (unprotected left turn or protected U-turn).

The ratings for willingness to engage in a task and the risk of engaging in a task were very strongly related. The correlation of the group mean ratings for the 81 situations was -0.98 ($z = 20.3$; $p<0.0001$), meaning that high scores on one scale were related to low scores on the other. This is illustrated in the scatterplot of Figure 3-3. As seen in the scatterplot, none of the 81 points deviated substantially from the regression line. In other words, there was no case where the willingness to engage in a task was substantially greater or less than would be predicted based on how risky it was perceived to be. This strong linear relationship was true for each of the four age groups considered individually as well; the correlation coefficient exceeded 0.96 for every group. Although a positive correlation would certainly be predicted for these two sets of ratings, there is no *a priori* reason to assume such a strong linear relationship across the range of ratings. For example, there might have been an S-shaped function, where willingness was uniformly low when risk values exceeded some point and uniformly high when risk values fell below some point. The strong linear relationship across the range of ratings indicates that both willingness ratings and risk ratings provided similar information. It is possible that some or all participants viewed the concepts as identical. For example, willingness might be treated as the direct consequence of perceived risk, or perceived risk might have been directly influenced by a desire to make the perception compatible with behavior (cognitive dissonance). Based on this very strong correlation, the subsequent discussion of findings will focus on the ratings of willingness to engage in a task, recognizing that the risk ratings yield similar results. One exception is in the comparison of on-road versus booklet ratings, where there were some differences in the findings for willingness and risk; therefore both sets of data are provided in that section of the Findings.

SITUATION	Willingness Mean	Willingness SD	Risk Mean	Risk SD
Cell Phone/Answer call - freeway - mainline	6.79	3.08	4.22	2.49
Cell Phone/Answer call - freeway - entrance, merge	6.42	3.14	4.45	2.81
Cell Phone/Answer call - freeway - exit	6.07	3.14	5.00	2.88
Cell Phone/Answer call - arterial - mainline	7.13	2.83	3.92	2.53
Cell Phone/Answer call - arterial - left turn, unprotected	5.47	3.37	5.67	3.15
Cell Phone/Answer call - arterial – U-turn, protected	4.51	3.23	6.42	3.12
Cell Phone/Answer call - arterial - stopped at signal	8.06	2.87	2.39	2.08
Cell Phone/Answer call - parking lot - exit	7.03	2.98	4.09	2.81
Cell Phone/Answer call - parking lot - aisle	6.50	2.86	4.09	2.39
Cell Phone/Answer call - minor -– 2-lane proceeding	7.26	2.81	3.55	2.32
Cell Phone/Answer call - minor - residential	7.82	2.81	2.95	2.25
Cell Phone/Key in call - freeway - mainline	6.78	2.76	4.59	2.48
Cell Phone/Key in call - freeway - entrance, merge	5.33	3.02	5.59	2.69
Cell Phone/Key in call - freeway - exit	5.22	3.03	5.92	2.90
Cell Phone/Key in call - arterial - mainline	6.80	2.80	4.74	2.57
Cell Phone/Key in call - arterial - stopped at signal	8.11	2.70	2.66	2.11
Cell Phone/Key in call - parking lot - exit	6.27	3.17	4.50	2.94
Cell Phone/Key in call - parking lot - aisle	6.13	3.00	4.49	2.70
Cell Phone/Key in call - minor - 2-lane proceeding	7.01	2.70	4.15	2.29
Cell Phone/Key in call - minor - residential	7.41	2.89	3.41	2.46
Cell Phone/Pers.conversation - freeway - mainline	7.94	2.62	3.67	2.56
Cell Phone/Pers.conversation - freeway - entrance, merge	7.55	2.81	3.98	2.45
Cell Phone/Pers.conversation - arterial - mainline	8.05	2.54	3.43	2.40
Cell Phone/Pers.conversation - parking lot - exit	7.33	2.78	3.78	2.68
Cell Phone/Pers.conversation - minor - 2-lane proceeding	7.98	2.72	3.32	2.54
Cell Phone/Pers.conversation - minor - residential	8.57	2.32	2.63	2.19
Cell Phone/Enter text msg - freeway - mainline	3.44	2.34	7.07	2.26
Cell Phone/Enter text msg - freeway - entrance, merge	3.32	2.63	7.44	2.38
Cell Phone/Enter text msg - arterial - mainline	3.75	2.48	7.09	2.27
Cell Phone/Enter text msg - minor - 2-lane proceeding	3.92	2.60	6.68	2.49
Cell Phone/Enter text msg - minor - residential	4.83	2.94	5.48	2.82
PDA/Look up phone number - freeway - mainline	4.55	2.47	6.44	2.38
PDA/Look up phone number - arterial - mainline	4.49	2.43	6.10	2.42
PDA/Look up phone number - minor - 2-lane proceeding	4.74	2.69	6.26	2.49
PDA/Pick up & read msg - freeway - mainline	3.45	2.47	7.16	2.40
PDA/Pick up & read msg - freeway - entrance, merge	3.25	2.61	7.38	2.56
PDA/Pick up & read msg - freeway - exit	2.76	2.19	7.73	2.24
PDA/Pick up & read msg - arterial - mainline	3.75	2.48	6.89	2.45
PDA/Pick up & read msg - arterial – U-turn, protected	3.01	2.17	7.38	2.33
PDA/Pick up & read msg - arterial - stopped at signal	6.20	2.85	4.28	2.87
PDA/Pick up & read msg - parking lot - exit	4.00	2.75	6.11	2.79
PDA/Pick up & read msg - parking lot - aisle	4.05	2.72	6.09	2.66
PDA/Pick up & read msg - minor -– 2-lane proceeding	3.69	2.40	6.84	2.50
PDA/Pick up & read msg - minor - residential	4.74	2.84	5.69	2.83
PDA/Key & send e-mail - freeway - mainline	3.01	2.27	7.59	2.34

Table 3-8. Means and standard deviations of willingness and risk ratings

was greater willingness to engage in these tasks on the residential streets. On the freeway, the general ordering of the means was the same for all four in-vehicle tasks shown in the table: relative to mainline driving, there was less willingness to engage in the task when entering the freeway area from the arterial road. There was even less willingness when approaching an exit point while on the freeway. The magnitude of these differences was less for answering a cell phone call and picking up a PDA message than it was for placing a cell phone call or entering a destination in a navigation system. On the arterial road, there was greater willingness to engage in all four tasks when stopped at a traffic signal. There was less willingness when approaching the turning maneuver (left turn or U-turn).

Table 3-9 also includes two parking lot locations. One location is driving through the aisles of the lot, as when looking for a parking space. The other location is approaching the driveway of the lot, about to exit onto the arterial road. For the task of answering a cell phone, participants were about as willing to answer a call under either of these parking lot conditions as they were while driving on a freeway, arterial, or two-lane road. This was also the case for picking up a PDA message or entering a destination in a navigation system. However, there was less willingness to do these things in the parking lot as opposed to a residential street. In contrast to these other tasks, participants were somewhat less willing to place a call while in a lot than in the mainline driving situations.

In summary, driver willingness to engage in a task was greater on residential streets than on freeways, arterials, or two-lane roads, which did not differ much from one another. There was greater willingness to initiate a task when stopped for a signal, and less willingness when encountering a maneuver. However, in absolute terms, even during a maneuver, there was still substantial willingness to engage in the two cell phone activities. This was also the case for driving in a commercial parking lot.

Comparing the 14 in-vehicle activities included in the experiment, there were substantial differences in the rated willingness to engage in these tasks. This can be seen graphically in Figure 3-4, for those tasks occurring during mainline driving on the various roadway types. Of all tasks, conversing with a passenger was the activity that drivers were most willing to do, with group mean ratings over 9 on the 10-point scale. Drivers were also quite willing to answer or place a cell phone call or engage in cell phone conversation, although there was clearly somewhat less willingness (and more perceived risk) than for passenger conversation. These phone activities were rated approximately equivalent to drinking something hot while driving. Participants were substantially less willing to engage in the other technology-related tasks. Text messaging on the cell phone and the various PDA tasks were rated low on willingness. Navigation system-related tasks were somewhat intermediate. It should be noted that about half the participants in the study were not personally familiar with the use of a navigation system (the effects of familiarity with the technologies are discussed below).

3.3.2 Effects of Familiarity with the Technology on On-Road Ratings

Participants differed in how familiar they were with the various technologies and in-vehicle tasks employed in this experiment. Although there was an initial training period, prior to data collection, to provide some familiarization with each activity, participants varied substantially in their real-world use of these products.

Table 3-10 shows the familiarity of participants with the in-vehicle technologies as a function of age group. Familiarity was determined from the ratings on the take-home questionnaire. For purposes of Table 3-10, familiarity ratings of 1 or 2 (on the 5-point scale) were treated as "unfamiliar," a rating of 3 was "somewhat familiar," and ratings of 4 or 5 were treated as "familiar." As the table shows, nearly every participant in the experiment (95%) considered themselves "familiar" with the use of a cell phone. In contrast, only 44 percent were familiar with a PDA and only 31 percent were familiar with a navigation system. About half of the participants were unfamiliar with a navigation system, and about a third unfamiliar with a PDA. Familiarity was related to age group. In this sample, teens were least familiar with navigation systems and PDAs. Older participants were less familiar with PDAs than young or middle age groups. Young drivers had somewhat less familiarity with navigation systems than the middle and older groups.

Table 3-11 is similar to Table 3-10, but the ratings are specifically for familiarity of use *while driving*. Most (89%) participants considered themselves familiar with using a cell phone while driving, although the percentage was somewhat lower for the teens (77%). Very few participants (14%) were familiar with using a PDA while driving; most (72%) were unfamiliar. This was true for all age groups. Most (69%) were also unfamiliar with the use of a navigation system while driving, although familiarity was somewhat higher (50% familiar or somewhat familiar) for the middle age group.

a phone call on an arterial road, it had a more moderate effect on willingness to enter a text message on an arterial road. This smaller effect may in part reflect a floor effect, since willingness was already rated quite low for this task. Rain had virtually no effect on willingness to answer a phone on a freeway.

- Peers: Peers in the presence of age peers, risk ratings were slightly lower for the two phone-related tasks and willingness was slightly higher. The reason for this is not known, but clearly participants were not viewing passenger presence as a factor that amplified risk. As the absence of a significant situation-by-age interaction implies, this finding was not attributable to any particular age group; the effect was similar for all ages.
- Child: The presence of a toddler passenger had virtually no effect on ratings related to answering a phone call on an arterial road. However, a toddler did result in some increased perceived risk and reluctance to engage in eating a messy food (taco).
- Night: Night conditions had no effect on the ratings for the single situation included (keying in a phone message on an arterial).
- Congestion: Congestion had little effect on the willingness to engage in reading PDA messages on a freeway. However, it did result in more reluctance to key in a phone call on an arterial.
- Construction: The presence of a construction zone with a lane drop resulted in increased risk and decreased willingness for keying in a navigation system destination.
- Boredom and Fatigue: Under long boring driving conditions, participants indicated that keying in a phone call decreased risk and they were more willing to engage in the task than when not bored. Presumably this reflects a feeling that this activity might contribute to alertness. Under conditions of fatigue, there was also a somewhat greater willingness to answer a phone during freeway driving. However, fatigue led to less willingness to use a navigation system search feature.
- Urgency: Urgency had little effect on willingness or risk ratings.

Looking across the 15 situations, no obvious systematic patterns are evident. Participants saw some factors as negative under some conditions but not others. In some cases, the added factor actually increased the willingness to engage in the task. Only a few situations resulted in a substantial decrease in willingness to engage in a task. The most dramatic case was for keying in a phone call on an arterial road during heavy rain. The second largest shift in the willingness ratings was in the opposite direction: participants were more willing to key in a phone call during a freeway drive when the situation described them as bored during a long, familiar trip.

Tables 3-14 and 3-15 present the findings as difference scores that show the shift in rated willingness and risk as a result of the added factor. Each entry is the difference of the rating with the factor present minus the rating with the factor absent. Therefore positive numbers indicate an increase in willingness (or risk) when the additional factor is included and negative numbers indicate a decrease in willingness (or risk) when the factor is included. The table presents these difference scores for each age group, as well as for all participants. As noted earlier for Table 3-13, the magnitude of the effects of the added factor is generally similar, though of course opposite direction, for the willingness ratings and the risk ratings. This is even the case for those situations on the arterial road, thus again alleviating the concern from the benchmarking comparison.

The means, across all fifteen situations, show that there were age differences in the degree of shift in willingness (and complementary shifts in risk). The shift toward less willingness was greatest for the middle and old groups and least for the teenage group. Comparing the age groups for various situations in Table 3-14, a few differences stand out. Middle and older participants were more reluctant to key in a phone call on an arterial road under conditions of rain. Teenage and young drivers showed very substantial increases in willingness to key in a phone call when bored (shifts of 1.73 and 1.77 rating scale units); the middle and older groups showed only modest shifts in their mean ratings (0.36 rating scale units). Substantial age differences were also seen in the shift in willingness to eat a messy food (taco) when there was a child passenger in the car. Older participants showed much greater reluctance (shift of -1.82 units), young and middle age drivers showed less dramatic but still substantial shifts (-1.05, -0.73 units), while teenage drivers showed virtually no effect. The added factors of congestion and construction had a greater effect on middle and older groups.

3.3.4 General Ratings of Task and Location Factors

The ratings of willingness and risk presented so far have all been based on participant judgments about specific situations, defined by the combination of a particular driving maneuver, roadway location, and in-vehicle activity. The take-home booklet also asked participants more general risk ratings for a set of 32 in-vehicle tasks and a set of 10 general driving tasks.

Table 3-16 presents the mean risk ratings for each of the 32 in-vehicle tasks, for all participants and for each age group. Ratings were made on a 10-point scale, where 1 = “No additional risk beyond my normal driving” and 10 = “Very likely I would be involved in an accident.” A task-by-age group ANOVA was conducted on these data. The ANOVA indicates that there is a significant main effect for both the in-vehicle task ($F(31, 2562) = 195.32$, $p<0.0001$) and the age group ($F(3, 2562) = 5.83$, $p<0.0006$), as well as a statistically significant interaction of these factors ($F(93, 2562) = 2.29$, $p<0.0001$). Risk ratings increased with age (4.41, 4.48, 4.91, and 5.68, for the teen, young, middle, and older groups, respectively). The ratings in Table 17 are ordered from the lowest rated (least risk) activity to the highest rated (most risk) activity, based on the mean for all participants. While most of the lowest risk tasks do not involve the use of communication technologies, some non-technology tasks, such as map use or note taking, were rated among the riskier activities. In general, tasks involving cell phone use were not rated as risky as tasks involving navigation system use, which in turn were not rated as risky as PDA. Nearly all PDA-related tasks were seen as quite risky while driving (mean ratings of 7.51 to 8.93 on the 10-point scale). The general risk ratings shown in Table 3-16 are generally similar in order and magnitude to the situation-specific on-road ratings (Table 3-7). However, they are somewhat more extreme in that the lowest-rated tasks tend to be rated even lower in the general ratings and the highest rated tasks tend to be rated even higher. Probably the most noteworthy difference is for the task of answering a cell phone. The general rating of this task was 2.64. This was somewhat lower than the on-road rating on a minor residential street (2.95) and more substantially different than the ratings on the freeway (4.22), arterial (3.92), and two-lane highway (3.55). However, the general pattern of ratings for the set of in-vehicle tasks is quite similar for the general booklet ratings and the on-road ratings.

Table 3-21 summarizes the stated reasons for the general ratings associated with the most risky general tasks and general driving situations (Part 3 of the booklet). The upper portion of the table shows the predominant reasons for risky in-vehicle tasks and the lower portion shows the predominant reasons for risky driving situations. The table shows the proportion of participants who cited a particular reason at least once. Data are shown for the entire group of participants as well as for each age group separately. For in-vehicle tasks, the most commonly cited reason was that the in-vehicle task took attention away from the driving task. While this was the most frequently cited reason for all age groups, it was cited by about half-again more teens and young participants (61%) than middle and older participants (42%). The second most frequently cited reason was that the visual requirements interfered with monitoring the road. About a third of participants explicitly indicated this answer. About a fourth of participants mentioned the physical requirements of interacting with the task. While the various age groups were similar in the frequency of citing the various factors, the major exception was that teenage drivers were much more likely (36%) to cite the length of the task (versus about 14% for the other age groups).

For the general ratings of driving situations, merging or otherwise interacting with other traffic was the most frequently cited reason, followed by the high speed of traffic and the behavior of other drivers. In general, reasons related in some way to traffic characteristics (interaction, speed, predictability, volume) were much more predominant than reasons related to roadway features (such as maneuver demands, sight distance, roadside hazards, pedestrians). Young, but not teenage, drivers cited the behavior of other drivers much more frequently than the other age groups. Teenage drivers cited merging traffic and opposing traffic more frequently. Older drivers differed in citing the difficulty of visual and temporal judgments more often. This was the most frequently cited reason by the older group.

Table 3-22 summarizes the stated reasons for the on-road ratings for the selected set of eight situations (specific in-vehicle task at a specific roadway/maneuver location). Unlike the explanations for the most risky general tasks and driving situations, above, these explanations dealt with situations that the participant may, or may not, have considered among the more risky. Therefore stated reasons might address why risk was perceived as low as well as why it might be perceived as high. The table shows the percentage of all participants who cited a particular reason at least once among the set of situations. It also shows the mean number of citations per participant, for those who cited it at all. The data are summarized at three different levels of categorization of the answers. At the broadest level, reasons were sorted into three categories: factors related to task execution; factors related to the driving environment; and factors related to task motivation. Within each of these broad categories, a set of more specific subcategories was defined. For example, factors related to task execution included attention, the need to take hands off the steering wheel, duration of the in-vehicle task, and so forth. Finally, for each of these subcategories, there is a more specific reason. Often these specific reasons are opposite in direction. For example, the factor of “difficulty of the task” could refer to the fact that the task was easy to perform or to the fact that the task was difficult to perform.

It should also be noted that while the on-road experiment could place the driver in the actual driving situation, it could not reproduce the range of motivational factors that might influence decisions. Thus the participant might be told in the situation description that they are hungry (in the eating situation) or that they are in a hurry, but the actual motivation did not exist.

Although task execution factors were the most-cited category, the most frequently cited specific factor was the amount of traffic. This factor was cited by 83 percent of participants, and they averaged 3.2 citations per participant. Light traffic was cited as a decision factor somewhat more often than heavy traffic for this set of situations. Within the task execution factors, sufficiency of attention and visual distraction were cited by the most participants (66%, 61%) and were cited more frequently as well (2.6 times, by those who cited the factor at all). Speed and curvature were both cited by slightly more than half of the participants.

Table 3-23 shows the frequency of various citations for each of the eight situations included. Whereas Table 3-22 summarized the number of citations of various factors across all eight scenarios, Table 3-23 breaks out the major findings for each individual scenario. For each situation, the table shows the percent of participants who cited reasons within each of the three general categories of task execution, task environment, and motivation. The table also lists within each of these categories those particular reasons that were cited by at least 15 percent of the participants. For example, for the first row of the table (for the scenario where the driver is engaged in cell phone conversation while merging onto a freeway), 62 percent of all participants cited some form of "task execution" factor. Of the subcategories of "task execution" factors, two were cited by at least 15 percent of the participants: "attention" (cited by 23%) and "difficulty of task" (cited by 15%). The situation in which the driver was stopped at a traffic signal (for the task of picking up and reading a PDA message) was clearly very different from the others, which all occurred while the vehicle was in motion.

Motivation factors were the least cited for all other situations, but the most cited for this situation. That was primarily due to the reason of "immediacy" (64%), and within this category, the subcategory of "stopped" (61%). This reason might equally well have been included as an "environment" factor as a motivation factor. Excluding this "stopped" situation, task execution factors were cited by a clear majority of participants (67-79%), except for the residential street situation (49%). Task environment factors were very frequently cited for the residential road and two-lane winding road situations (78%, 73%), and cited by about half the participants for the other five situations (excluding the "stopped" situation). The amount of traffic was frequently cited for all seven situations in which the vehicle was moving. For motivational factors (excluding the "stopped" situation), there were few cases where any one individual factor was frequently cited. One exception was for the text messaging task, where a number of participants expressed opposition to any performance of this task in an automobile. Overall, 18 percent of participants mentioned this for one or both of the scenarios that included entering a text message. However the frequency of citing this varied with age (teen = 5%, young = 18%, middle = 23%, old = 27%).The other exception was for the residential road navigation system use, where the importance of the task was mentioned by 15 percent of participants.

In general, the citation rates for various factors were similar among the age groups. A few noteworthy differences among age groups were observed. Teenage drivers cited road curvature

3.3.6 Driver Behavior and Decision Making

The final portion of the take-home booklet collected information on driving behavior and decision making style. Seven questions dealt with the intensity or aggressiveness of one's driving. Three questions dealt with perceived ability and desire for multitasking while driving. Six questions dealt with how impulsive or deliberate the person was in his or her general decision making. Each participant was given a score for each of these attributes, by summing the participant's rated level of agreement (5-point scale) with each question (with the scale adjusted where necessary so that higher numbers indicated more of the attribute). Thus for "driving intensity," a range of scores from 7 to 35 was possible; for "driving multitasking," a range from 3 to 15 was possible; and for "deliberativeness," a range from 6 to 30 was possible.

Figure 3-8 plots the cumulative relative frequency of "driving intensity" scores. The figure shows the cumulative percentage for the entire group of participants, and also for each of the four age groups. Figure 3-9 shows comparable data for the "driving multitasking" scores and Figure 3-10 shows comparable data for the "deliberateness" scores. The teen and young age groups showed a much greater tendency toward intense, aggressive driving styles. The median score for the teen group was 19.0 and for the young group 20.0. In contrast, the median for the middle age group was 15.4 and for the older group 14.7. Only 17 percent of middle age participants, and 5 percent of older participants, had scores higher than the median (20) for the young group. Age was also related to the multitasking scores. The young group had the highest median score (11.0), the teen and middle age groups has medians of 9.0 and 9.29, respectively, while the older group had a much lower median of 6.2. While almost no older participants had a multitasking score over 10, half of the young group had scores of 12 or more out of the maximum of 15. Older participants appear averse to having to multitask while driving; young drivers (even more so than teens in these data) appear to enjoy the challenge of multitasking. For decision style, middle and older groups reported more deliberative and less impulsive decision making. Median scores for the teen and young groups (21.0, 20.9) were lower than for the middle and older groups (23.5, 22.8). Teens and young participants had many more scores toward the lower ("impulsive") end of the scale. Over a fourth of the teens (27.4%) and 18.2 percent of the young group had scores of 20 or lower; this contrasts with only 9.3 percent of middle age participants and none of the older participants. At the other ("deliberative") end of the scale, 46 percent of the middle age group and 41 percent of the older group had scores of 25 to 30 (the maximum possible). In contrast, only 9 percent of teens and 5 percent of young participants had scores this high. In summary, then, teen and young groups reported more aggressive driving styles, more tendency to multitask, and less deliberative decision making styles. For driving intensity and multitasking, the young group appeared somewhat more extreme than the teenage group.

Three in-vehicle technologies were included in this experiment: cell phones, PDAs, and navigation systems. Cell phone use is of particular interest because it is widespread and has been studied most frequently in driver performance experiments and crash analyses. Participants saw very little risk involved in cell phone conversation and were quite willing to engage in phone conversation under all circumstances included in the experiment. In the on-road portion of the study, only conversation with a passenger was viewed as less risky than personal conversation on the phone. While participants rated on-road willingness somewhat lower for the common cell phone tasks of answering a call or keying in a call, ratings were still quite high (>6.0) for most situations. Even in the worst case (answering a call while making a U-turn at an arterial intersection), willingness ratings were still around mid-scale (4.51). On the road, answering a cell phone call was rated as comparable to drinking something hot. Keying in a call was generally rated slightly more risky than answering a call. Similarly, participants were slightly less willing to key in a call than to answer a call. Both of these tasks were seen as less risky than locating a CD and inserting it into the CD player. In contrast, keying in a text message by cell phone was seen as quite risky, comparable to PDA use. Thus the on-road data indicate that participants had very little reluctance to engage in phone conversation and saw minimal risk in it. Placing or receiving calls were seen as somewhat riskier, but the participants had relatively little reluctance to engage under most conditions.

The discussion in the focus groups had suggested that drivers may be relatively insensitive to roadway and traffic factors in their decision making. In the on-road study, there was also some suggestion that task attributes had a stronger influence than roadway and environment attributes. This was indicated by several findings. Considering the matrix of on-road scenarios in Table 3-4, there was typically a greater range of scores within the rows of the matrix (i.e., from task to task) than in the columns (i.e., from site to site). General risk ratings for the various in-vehicle tasks (Table 3-16) were more variable and extreme than general risk ratings for the roadway situations (Table 3-22), although it should be noted that the scale anchors are differently defined. General ratings for various in-vehicle tasks correlated more strongly with on-road ratings than did general ratings for driving locations. In reviewing the reasons why participants rated on-road situations as they did, factors related to task execution were cited more often than factors related to the driving situation, although the difference was only about 15 percent. Although the range of tasks and driving situations included in the experiment was reasonably representative, the detailed findings are specific to the set of scenarios evaluated. Thus in these findings we have the suggestion, though not conclusively, that in-vehicle task factors tend to influence willingness and risk judgments more strongly than do the driving situation factors.

Individual driver attributes – particularly age group, general driving style, and driving multitasking – were related to the general willingness to engage in potentially distracting activities. These factors are themselves interrelated, so there is some ambiguity in interpreting them. However, it seems apparent from these findings that the willingness to engage in in-vehicle technology use is related to broader risk taking tendencies. The on-road study also found a very strong (negative) linear relationship between the stated willingness to engage in a task and the perceived risk of engaging in the task.

location as independent factors for the full set of 81 situations. However, this sort of analysis was possible for a subset of the data.

A variety of factors can influence a person's decision about whether to engage in a potentially distracting task. Some factors relate to the distracting task and some relate to the driving situation. Both of these categories of factors could be manipulated directly in the on-road experiment. However, other factors are also important that were not easily controlled. The focus groups identified these as including personal time control, cost considerations, social aspects, mental state, and motivations specific to the task (e.g., is a phone call expected or unexpected). While the experimental method attempted to control for motivational factors to some degree, the decision making by participants did not really include manipulation of some of these important factors. The on-road experiment, then, focused on how the willingness to engage in an activity was influenced by task and roadway factors, and to some extent, driver factors. It was not an attempt to quantify the actual likelihood of engaging in a distracting activity, which is strongly influenced by additional factors beyond experimental control. It may also be noted that the experimenter was present in the vehicle. While this would likely influence drivers actual engagement in the task, it is unknown how it might influence the judgments made in this experiment. Interaction between the driver and the experimenter was kept minimal during the data collection portion of the drive, other than communicating the task scenarios and providing route guidance. It is conceivable that this interaction could influence judgments about passenger conversation tasks.

The on-road data were supplemented by additional data from a take-home booklet. The booklet had participants rate additional situations, including factors not manipulated on the road (e.g., weather, congestion). All participants returned their booklets. Five "benchmark" situations were included that were in common for the on-road and booklet ratings. The two sets of ratings were in reasonably good agreement, although not identical, and there was a statistically significant, although not large, interaction of the rating mode (on-road or booklet) with the driving situation. Since the on-road ratings were made in real time in the actual driving context, these were assumed to be the more valid judgments. However, the presence of a significant interaction term raises some concern over the interpretation of the ratings. The take-home booklets also asked participants to explain the reasons underlying some of their on-road ratings. This required some recall of the on-road situation. Participants were asked to fill in the booklets as soon as convenient, and most did so quickly. While this makes the assumption of good recall reasonable, the validity of these stated reasons is not known. They may or may not differ from reasons that might have been given at the actual moment of the decision. Participants were not asked for underlying reasons while they were driving because there was a concern that forcing this type of analytic explanation might actually alter the way drivers rate the situations. Also, the procedure was already demanding and time consuming, so that adding additional aspects to the task might have compromised the procedure. Nonetheless, the retrospective judgments made later in the booklets may be different from what would have been obtained at the time of the rating. It may also be possible to collect richer subjective data on *why* the participant made a particular rating if an in-depth interview were conducted at the time of the judgment. While the explanations provided in the take-home booklets were informative, they were generally not greatly detailed. The procedure of the on-road experiment emphasized the inclusion of a range of driving conditions and tasks, and quantitative judgments of willingness, and so placed correspondingly

regarding distracting in-vehicle activities. This work provides a basis for more refined research that may follow up on the findings. While there now have been literally hundreds of studies of the effects of potential distracters on driving *performance* (e.g., see the extensive bibliography of Goodman, Barker, and Monk, 2005, on wireless communication devices alone), there is no comparable base of knowledge regarding driver *decisions* about these tasks. There have been important recent instrumented vehicle studies (e.g., Stutts et al., 2003; Dingus et al., 2006) and surveys (e.g., Royal, 2003) that may shed light on the types of activities drivers engage in and the frequency with which they do so. However, these tell us little about the decision process itself and the observed types and rates of behaviors may not generalize well to various driver populations and may not reflect emerging products and technologies. There have been some focus group efforts that addressed people's perceptions regarding cell phones or other technology use (e.g., Brinberg & Dingus, 2002), but these have not had the depth of focus specifically on the driver decision making process as did the current project. In order to help structure the findings and issues stemming from this initial work on driver willingness to engage in in-vehicle tasks, a descriptive model of driver decision making was developed to serve as a framework. This conceptual model is provided in Section 4.2.

Sections 2.0 and 3.0 of this report presented extensive findings from the focus groups and on-road study. In this section, selected findings are highlighted and summarized.

General Willingness to Engage in Tasks

The focus group discussions, on-road ratings, and general task ratings were all in agreement in indicating that most drivers had relatively little reluctance about cell phone use under most driving conditions. Of course, it should be kept in mind that the study only included people who had access to cell phones, and typically other technologies, while in their vehicles. Participants did not rate basic cell phone tasks – dialing, answering, and conversing – as highly risky. While the actual risk associated with phone use remains controversial and difficult to quantify, there is evidence of interference with certain driving performance measures. Although participants in the focus groups and on-road study rated extended cell phone conversation as somewhat riskier than simply conversing with a passenger, they were still very willing to converse on the phone. For the on-road experiment, this was true under virtually all driving conditions studied. Placing or receiving calls was seen as somewhat riskier, but again there was only moderate reluctance to do these tasks under almost any condition. In the on-road ratings, only conversation with a passenger was viewed as less risky than personal conversation on the phone. While participants rated on-road willingness somewhat lower on the 10-point scale for the common cell phone tasks of answering a call or keying in a call, ratings were still quite high (>6.0) for most situations. Even in the worst case (answering a call while making a U-turn at an arterial intersection), willingness ratings were still around mid-scale (4.51). In general, cell phone tasks were rated as less risky, and people were more willing to do them than tasks related to the other two in-vehicle technologies in this study: PDAs and navigation systems.

Figure 4-1 graphically portrays the mean general task ratings of risk for cell phone tasks and non-technology tasks. These data are from the take-home portion of the on-road experiment. The judgments were very similar to the ratings made during the focus groups (r=0.95).

described in Section 3.2.4. Except when the vehicle was stopped or in low speed situations (parking lot, residential road), the group on-road mean willingness to pick up a PDA message or key in and send a PDA message was quite low (rating < 4.0). There was moderate willingness to look up a stored number on a PDA. General task ratings from the booklets confirmed this finding of high perceived risk for PDA tasks, with highest-rated risk for the tasks of opening/reading an e-mail and keying in/sending an e-mail (as well as tasks of scheduling a meeting and searching the internet).

Navigation system tasks were generally rated intermediate between cell phone tasks and PDA tasks. It should be kept in mind that close to half of the participants indicated that they were unfamiliar with navigation system use. Although some familiarity was provided by the training video prior to data collection (see Section 3.2.4), ratings for many participants will be more speculative than for cell phone use. Participants indicated greater willingness to call up a destination than to key in a destination or use a search feature. General task risk ratings from the booklet had similar results. The general task ratings also included the task of reading a paper map while driving. This was seen as quite risky (6.9), rated comparable to keying in a new destination and considerably more risky that reading an electronic map display (5.5).

Motivational, Task, and Driving Factors in Decisions

The factors that influence whether or not a driver decides to engage in a task may be broadly characterized as motivational factors, in-vehicle task factors, or driving factors. The discussions in the focus groups seemed to place greatest emphasis on motivational factors and surprisingly little attention was given to driving factors. While the on-road study did not manipulate motivational factors to a large degree, it did include a range of task factors and driving factors. Again, driving factors seemed to be of lesser concern, with the findings suggesting that task attributes had a stronger influence than roadway and environment attributes. This was indicated by several findings of the experiment (discussed in Section 3.4). Taken together, the focus groups and on-road study suggest, though not conclusively, that the characteristics of the in-vehicle task seem to influence driver judgments more strongly than the characteristics of the driving situation. It also appeared that drivers give little consideration to the upcoming roadway and traffic situations and the likely demands. There does not seem to be much process of planning for the best opportunity to execute a task.

The study revealed a range of important motives to engage in an in-vehicle task. Some motives are externally driven by events (e.g., phone rings, navigation help is needed) while others are internal to the driver (e.g., socializing). Some motives are driving-related (e.g., need to find an address) and some are unrelated to driving (e.g., desire to utilize otherwise unproductive time on the road). Some motives are specific to the content of the communication (e.g., call a business client) while others are non-specific (e.g., want to use up remaining minutes on phone plan). Clearly important to many drivers were control over personal time, desire to socialize, enjoyment of technology use, efficient use of resources and costs, and even a more general attitude about a “wired” lifestyle. Non-communication-specific, non-driving motives were a major point of discussion in the focus groups. Such motives may not appear to be very essential or urgent to an outside observer, but they are often a major element in prompting potentially distracting behaviors.

When considering the in-vehicle task attributes that were important for driver decisions, the focus group discussion and the take-home booklet responses agreed in emphasizing visual attention demands. Physical demand requirements and to some extent, general attentional demands, were also raised. Other potentially important task attributes received little or no consideration. The take-home booklet recorded the participants' stated reasons for ratings in two places. In one section, the participants were provided with the on-road rating they made for eight different situations and asked to explain why they rated the situation as they did. In another section, the participants rated the general risk associated with each of 32 in-vehicle tasks and each of ten driving conditions. Then for the three tasks they rated most risky and the two driving situations they rated most risky, they were asked to explain why these were seen as most risky. In providing explanations of *why* they rated situations as they did, the predominant task-related reasons given by participants had to do with the amount of visual attention required by the task and the direction of visual attention away from the road. Other commonly cited task factors included physical requirements (e.g., hands off steering wheel), task complexity, and difficulty.

While the written answers in the booklets provided useful general findings, they did not result in deeper insights into the decision process. Various reports in the technical literature have pointed to the potential importance of a number of task attributes that are not really addressed by the data. For example, these include: the ability to decompose the task into discrete subtasks ("chunking"); potential for "cognitive capture"; ability to self-monitor the level of distraction (awareness); potential for incidents/errors (e.g., drops, spills, mis-entries) and the demands of error-recovery; and driver control over task initiation and pacing. It would be useful to have some feature-based taxonomy of tasks or a feature-based model of task demand. One could then link driving performance measures (e.g., path tracking, hazard awareness) and driver willingness to engage to various task characteristics. Such taxonomies and models do not exist, although there have various calls for research to develop them (e.g., Westat, 2000) and there are figure-of-merit models that incorporate at least some task elements (e.g., DEMAND model, Hankey, Dingus, Hanowski, Wierwille, & Andrews, 2000). There have been some studies of crash records and naturalistic driver behavior that have resulted in "taxonomies" of distracting activities (e.g., Stutts et al., 2003; Wierwille & Tijerina, 1996). However, these are actually hierarchically organized lists of distracters (e.g., vehicle interior source of distraction>dash/console>radio). They are not structured around task attributes. It would be revealing to map driver willingness to engage in a task to task attributes, and to identify differences for a similar mapping of driver performance to task attributes. That might reveal task factors that drivers under-appreciate or over-value. However, an adequate basis for doing so with the data of the present experiment is not available.

Planning, Preparation, Anticipation

Drivers may be able to anticipate certain in-vehicle activities and prepare for them in a manner that will limit later distraction. The focus group discussion found a variety of pre-trip preparations for technology use. This seemed particularly so for those who conducted business from their vehicles (e.g., real estate agents, sales people, consultants). They tended to place cell phones, PDAs, papers and notebooks, in accessible places. Some put on earpieces. Navigation system owners sometimes pre-programmed new destinations (in addition to frequently used

occur. In referring to this as a “working model,” the intent is to recognize that the present project represents an initial step in understanding driver decision making about distracting tasks. Very little literature exists on this topic. Refinements are to be expected as further research is done on this topic.

Figure 4-2 presents this conceptual model diagrammatically. The model can be viewed as having three general phases. At the top of the diagram are the “pre-trip factors” that may influence decisions. These include such things as expectancies about device needs (e.g., am I expecting a phone call?), preparations for device use (e.g., placement of the phone, pre-programming navigation destinations), and on-going activities that are already in progress when the driver begins the trip (e.g., having a phone conversation, eating something).

The middle portion of the diagram deals with the immediate decision process about whether to initiate some in-vehicle task, given the existence of some current motivation to engage in the activity. The diagram shows this as having four sub-steps: motivation, evaluation factors, integration, and decision to initiate. It shows the various factors that feed into the perceptions of opportunity, risk, and incentive, which together produce a decision. Also included in the diagram as decision factors are “social norms, responsibility,” reflecting the acceptability of the behavior, and “decision style.” The decision style box is meant to reflect the importance of individual differences as revealed in the focus groups and self-ratings of the on-road study.

The lower portion of the diagram addresses what happens after the in-vehicle activity has been initiated. There is a process of adapting driving behavior (e.g., increasing headway), dynamically sharing attention between driving and other tasks, monitoring one’s driving performance, and monitoring the status of the in-vehicle task. If there is a perceived problem with either driving performance or execution of the task, a decision is made about how to proceed. This decision could be to continue the in-vehicle task as planned anyway, suspend or terminate the in-vehicle task, modify the relative priorities of vehicle control and in-vehicle tasks, or modify the way the task is to be done (e.g., ask a passenger to handle something or switch to voice input).

Following is further clarification about the meaning of each of the elements of the diagram in Figure 4-2.

<u>Pre-trip factors</u>

The descriptive model begins with a set of pre-trip factors. These are conditions that come into effect prior to the actual drive. Three sets of considerations are shown:

1. <u>Pre-trip expectancies</u>: Drivers come to the trip with expectancies about likely characteristics of the trip (e.g., traffic, route familiarity), the likelihood of initiating some in-vehicle task along the way (e.g., placing a call, needing to program a destination), and the possibility of receiving communications of various degrees of urgency (e.g., calls from family members, business communications). This covers questions the driver might pose, such as: Who might contact me and why? Will I want to contact anyone or consult any information during the trip? What will the trip characteristics be like (e.g., trip length, road types, weather, traffic)?

2. Pre-trip preparations: These are things the driver might do to prepare in advance for in-vehicle tasks. It includes the placement of devices within reach, the activation of devices, putting on an earpiece, preprogramming devices, and placement of ancillary materials (e.g., papers, notepads, datebooks, pens).
3. On-going device use and other activities. This refers to activities that are already in progress when the driver enters the vehicle to begin the trip. Examples include on-going phone conversations, e-mail exchanges, eating or drinking, and tending to children.

Motivation to Engage in In-Vehicle Task

The en route portion of the decision model begins with the motivation to engage in some in-vehicle task. The motivation might be due to an external event (e.g., phone rings) or an internally-generated need (e.g., need to check one's schedule). It is the point where the driver "wants" to do something. What follows is then a process of evaluating whether and how to do that task.

Findings: User Motivations	User Interface - Need for Warnings	User Interface-Interface Attributes	Interactive Control - Function Lock-out	Interactive Control - Driver Assist	Education and Training - Safety Campaigns	Education and Training - Driver or User Training or Licensing
People seek to maximize use of personal time, productivity. Driving time is seen as "wasted" time that can be utilized.					Campaigns might focus on perceptions of value, responsibility for risk to others (your time but not your road); alcohol parallel (responsible use, social norms).	
Social interaction is an important motivation for some users.	Cautionary message if conversation is longer than some criterion.			Consider whether parameters of dialog and speech might indicate nature of conversation and/or risk of distraction.	Educate regarding risks, appropriateness; some types of personal conversation might be particularly distracting; alcohol parallel (responsible use, social norms).	
Findings: Decision Making	**User Interface - Need for Warnings**	**User Interface-Interface Attributes**	**Interactive Control - Function Lock-out**	**Interactive Control - Driver Assist**	**Education and Training - Safety Campaigns**	**Education and Training - Driver or User Training or Licensing**
Some drivers choose to engage in device use on a use-by-exception basis and others choose on a refrain-by-exception basis.				Give driver feedback regarding current or impending demand.	Pick your spots, think first.	
Rated willingness to engage in a task is very strongly correlated with the perceived risk of engaging in the task.					Modify perceived risk of doing tasks.	
Decisions about using technologies while driving relate to a person's more general decision-making style. Some people act impulsively and others are very deliberate.				Adapt algorithms to the particular driver's behavior.	Make it a choice.	Self-assessment and awareness (e.g., scales).

Table 4-1. Possible countermeasures to address concerns from project findings (continued)

Suggestions for Warnings

Suggestions related to driver warnings are generally based on findings about the factors that drivers fail to appreciate in their decision making. The visual demand of a task is no doubt a critical safety factor, but it is also one that drivers appear to appreciate. Although warnings about long-duration glances are likely to be redundant with driver awareness of the risk, the importance of this factor and the driver's appreciation of it suggest that some level of non-informative warnings will be tolerated and the situation should be warned. Other task attributes are less well-appreciated by drivers and therefore warnings may be more informative to them. Users may be warned at the initiation of high demand tasks, particularly under already demanding conditions. Researchers have suggested some potentially important task attributes related to distraction, such as the ability to segregate the task into discrete "chunks," user control over temporal aspects (onset, pacing), the phenomenon of "cognitive capture" (mental absorption in the task to the point of loss of situational awareness), the ability of the driver to self-monitor task demands or driving degradation, and the likelihood of in-vehicle task errors and incidents and the demands of addressing these. Unfortunately, the field does not yet have an accepted taxonomy of in-vehicle tasks related to workload or distraction. The relative importance of various task attributes remains to be specified and the degree to which drivers under-appreciate particular aspects is unclear.

The project findings suggest that drivers give relatively little attention to immediate or impending roadway and traffic demands. To the extent a system can detect or anticipate the driving task demands, a warning can be given if the driver initiates an in-vehicle activity at an inappropriate time. Roadway and traffic conditions may be sensed from vehicle-based sensors. Road and traffic attributes for immediate and up-road locations may be derived from GIS sources or transmissions from traffic centers. The driver's likely path could be projected based on navigation system entries or driver past history or models of traffic flow at the site. Although the sophistication with which a system might define driving task demands is speculative, any warning that can promote better appreciation of high-demand conditions may help address an important limitation of much driver decision making.

Another opportunity for warning is to caution drivers if a phone conversation (or other communication) meets criteria that suggest it is unsafe or inappropriate. For example, if a conversation exceeds a certain duration, a cautionary message could be provided. However, one difficulty for any warning or interactive control system in dealing with cell phone use is that the phone is likely to be a carry-on, rather than integrated within the vehicle. Therefore some form of remote sensing, or user cooperation, would be required.

The suggestions above are all for "active" warnings that are provided when certain circumstances exist. There are also fixed warnings that appear as on-product labels, routine messages on display screens, or within ancillary materials, such as user manuals or quick guides. For example, navigation devices typically provide a cautionary message on the start-up screen, warning about the risks of use while driving (Llaneras & Singer, 2002). Cell phones typically include warnings within the instructional material that accompanies the product. Device users appear to have little awareness of specific warning messages that appear on or accompany the device or in the display. In general, product warnings are often necessary but of limited effectiveness. There are various things that can be done to improve the ability of a warning to capture attention, appear credible and meaningful, and promote user compliance. Manufacturers and distributors of devices or vehicles might consider available guidance to improve the effectiveness of their fixed warnings (e.g., Singer, Balliro, & Lerner, 2003). However, the literature on warning labels makes it clear that such warnings are generally of limited effectiveness and should not be viewed as the primary means of addressing safety concerns (e.g., Wogalter, DeJoy, & Laughery, 1999).

Suggestions for Interface Attributes

Certain attributes of the user interface can be designed to reduce the demand for visual fixations. Reducing visual demand is an obvious design objective and is consistent with user's perceptions about the importance of this factor. Visual demand can be influenced by the visual display, input requirements (visual and motor), display location, menu structures, amount and type of information, and so forth. There exist numerous standards, guidelines, and research recommendations for vehicle displays and controls and for ITS applications (e.g., Campbell, Carney, & Kantowitz, 1998; SAE, 2004) which will not be discussed here, but which designers should consider in developing the user interface. However, we will highlight a few specific interface features that emerged as potentially important in this study. First, greater use of voice technology is promising. Voice messages and speech recognition not only reduce the amount of visual search required to obtain information and input a response, but also have the further benefit of not requiring the driver to remove a hand from the steering wheel. Particularly for teen drivers, there were self-reports of steering with one's knees while doing other tasks, so voice input could be especially helpful for this target group. Participants in this project's focus groups were generally reluctant to consider voice input even when they recognized the option. They were not very confident of the technology, although it was not clear to what extent this was based on personal experience with current technology, experience with older technology, or simply by assumption. In any case, more effort is required to have users take advantage of voice. Speech-based technology may also be helpful in addressing the safety concern of drivers trying to take notes during phone conversation (e.g., writing down an address). Perhaps voice recording, with a voice-to-text output for later use, might be helpful. Improved tactile or auditory feedback from input responses may also reduce visual demands. Focus group participants specifically mentioned the layout of keypads and the tactile feedback from the keys as influencing this demand. Perhaps speech feedback might also be useful (e.g., a voice echo of a key entry). The design of the interaction required for manual inputs can also reduce visual demand. For example, it may be better to selected functions by repeated presses of a single key rather than through individual keys. Another point where visual demand can be reduced is in the caller ID display of cell phones (and by analogy, the identification of the communicating party on other sorts of communications). Phone users indicated that their decision about whether or not to answer a cell phone while driving depended on who the caller was; therefore they checked the caller ID while driving, then answered the phone (or not). If the caller ID display is too small, low contrast, or subject to glare, it may require excessive visual attention.

Other aspects of the interface have to do with the structure of the task. Certain features of the task may be important determinants of distraction but the self-report findings suggest little consideration of such factors when drivers make their decisions. These factors were already alluded to in the discussion of warning countermeasures, and include subtask chunking, pacing, and input errors. Since drivers may fail to adequately consider such factors, it is important to keep the demands limited. The task should be designed to minimize perceived urgency in the procedure, by allowing ample time for inputs, having natural “break points” in the sequence, and retaining memory for sufficient periods. Recovery from errors may also require excessive visual attention. Errors may include things such as mis-entry of a character, dropping something (e.g., a phone or a stylus), or making a navigational mistake. The task should be designed to reduce the likelihood of an error and also to minimize what is required in correcting the error. Drivers are unlikely to consider various sorts of potential errors in their decision making yet such errors could be important contributors to crashes.

Drivers should be informed if there is some unsolicited (automated) change in telematic or vehicle functions. For example, if some function is locked out because the system senses there is high driver demand, the driver needs to understand that the function is unavailable. The very reason for implementing a lock-out is that the driver may decide to engage in the task. If the driver attempts to do this and the function is not working as anticipated, there may be even greater distraction as the driver attempts to understand and “fix” the situation. The user interface must therefore provide a simple and effective means of indicating this lock-out status. The display, whether visual or auditory, must not in itself contribute to distraction during what is already, by definition, a demanding period. Also, the driver should be made aware of the termination of a lockout period, particularly if there was an attempt to perform the task during the lockout.

Some in-vehicle devices may offer the user a variety of options for displays, modes of use, special features, or pre-programming. For example, route guidance systems may offer displays in either map or turn-by-turn list modes, cell phones may be programmed to have distinct rings for selected callers, or devices may be operable in voice interactive mode. Users may not take advantage of these features or even be aware of them. One implication of this is that careful thought should go into selection of the default mode (if the user takes no selective action). The default should be designed for minimum workload and distraction for typical users and particularly for novice users. This is not necessarily the case, as evidenced by recent reviews of navigation systems (Llaneras & Singer, 2002). Also, the devices or their displays may do little to make it evident to the user that there are options. Better designs could make the users more aware of opportunities to modify the task to reduce interference with driving.

Focus group participants indicated that they had difficulty coping with call waiting while driving. There does not appear to be objective data on driver performance in this task, in the present project or other published research. The issue is interesting because the focus group participants were all active cell phone users and presumably quite familiar with this function. Why can these people handle call waiting well in other contexts, but report getting “befuddled” when trying to do this while driving? Since receiving another call while engaged in a current call is presumably fairly common, it would seem important to better understand whether this is a real safety concern and what aspect of the task causes the difficulty. It may be possible to better design the call waiting task so that it does not interfere with driving as much. As with various other suggestions for improved design, however, this could also lead to greater phone use while driving and the net benefits may be unclear.

Another user interface problem relates to the finding that drivers often do not prepare in advance for likely en route tasks that they may choose to engage in. Cell phones may not be within easy reach. Materials that might be required for communications (particularly for business-related messages) may be difficult to access. Earphones may not be easily found. Phone numbers or e-mails that may be contacted are not pre-programmed (speed dialing). Likely destinations may not be entered in a navigation system. To some extent, pre-trip preparation might be influenced by design factors. Storage areas on the device or fitted to the vehicle might encourage better placement of items. Displays or procedures that make pre-programming more attractive to the user (simpler, faster, more evident) might encourage pre-trip preparation.

Some complex tasks that drivers choose to engage in could be done more easily by passengers. For example, entering destinations into a navigation system or reading an e-mail could be accomplished by a passenger in a "co-pilot" role. Some focus group discussants reported doing this regularly. Device interfaces may be designed so that they can be seen and used by passengers, giving the driver an alternative to a yes-or-no decision about whether to engage in the task.

Suggestions for Function Lock-Out

Lock-out functions essentially take the decision about whether to engage in a task away from the driver. They may be especially helpful for those situations that drivers do not take adequately into account in their evaluations or for those drivers who choose to act in a risky manner. When employing a lock-out feature, it will be important for drivers to clearly understand how and why the system acts as it does. Otherwise, drivers may attempt to "fix" or override the system or user acceptance may be poor. Therefore the functioning of the system and informational displays should promote a valid "mental model" of the system for the user.

Since drivers do not seem particularly sensitive to the roadway situation when making their decisions, lock-out functions ideally would take the current and projected roadway demand into account. The current situation could include traffic interactions using vehicle-based sensing, such as proximity to other vehicles, time to contact measures, speed, and maneuvers (e.g., turning). Systems may also be able to project impending roadway demands using GIS data, information transmitted from traffic control centers, or planned route (based on navigation system input or driver history). Drivers do not seem particularly sensitive to certain driving transitions so sensing of this in lock-out systems may also be helpful. Examples include exiting from parking lots and other driveways or moving into freeway exits.

The tasks drivers choose to engage in may cause distraction not just from the overall visual or cognitive demand of the tasks, but also because of occasional "incidents." People may not be sensitive to the possibility of these events. These may include critical events such as errors in entry, drops or spills of items, "cognitive capture," or distraction by other in-vehicle or external activities. It would be helpful if a lock-out system could recognize such incidents.

Drivers may be reluctant to terminate communications (phone conversations or text messaging) once they have committed to engaging in the task. Therefore it might be useful if a lock-out system automatically put the other party "on hold" during critical periods. The system could provide an automated message to the other party indicating that the communication is temporarily suspended until the driving demand subsides. It has been speculated that one reason that cell phone conversations are more disruptive of driving than conversations with vehicle passengers is that passengers adapt their speech behavior to the traffic situation and the driver's actions. Cell phone parties cannot do this. An automated phone hold might therefore help address this limitation.

Responding to incoming phone calls or other messages may have an undue sense of urgency for some drivers and some research suggests that a high proportion of cell phone-related crashes are associated with responding to a call (e.g., Goodman, Bents, Tijerina, Wierwille, Lerner, & Benel, 1997). One strategy may be to lock out all incoming messages unless by exception. Only communications from pre-selected parties would be permitted through. This could limit the number of calls or text messages and also simplify the driver decision process (eliminating the common step of checking caller ID).

Passengers may be a factor in driver decision making and also in the extent to which a task is potentially distracting. Passengers may influence the situation in various ways. For young (particularly teen) drivers, passengers appear to be a very significant risk factor (e.g., Williams, 2001) and in themselves may constitute a basis for locking out some tasks. On the other hand, for some functions, passengers can serve as "co-pilots" and make it possible to conduct a task even when the driver is otherwise engaged. For example, a passenger may enter a destination into a navigation system. Therefore a lock-out system may act differently if a passenger is sensed.

Because some drivers enjoy multitasking, and may actually seek challenging situations, it would be helpful if a lock-out system could recognize when the driver is engaged in non-driving related activities. This could be based on driver posture (leaning, turning), gaze, hand position (and hands-off-wheel), device activation (e.g., phone use), or other actions (eating, drinking, reading) identified through image analysis or other means of detection.

Teenage drivers are a particular concern, given their greater willingness to engage, lower perceived risk, confidence and enjoyment of multitasking, more intense driving styles, and generally poorer crash avoidance behavior. Systems that can recognize the individual driver could adjust the lock-out criteria if a teen driver was present. Some tasks could be locked out simply on the basis of the driver; for example, teens appear more likely than others to use text messaging, and it may be reasonable to simply preclude this. Some tasks could be locked out under certain higher-risk conditions, such as with passengers present or in inclement weather. Other lock-outs for teens could be based on sensing likely inappropriate device use, such as extended phone conversations.

This study found a positive relationship between an intense, aggressive driving style and the willingness to engage in distracting tasks. Therefore a lock-out system might take into account the user's driving style. This determination could be based on measures taken during the current trip or on historic driving data (particularly if the system recognizes individual drivers). This could preclude the most risk-prone drivers from engaging in an inappropriate task and might also have the benefit of motivating less aggressive driving in order to relax lock-out criteria.

Suggestions for Driver Assist

Driver assist systems dynamically adapt the driving task and/or the possibilities for conducting other activities based on an assessment of current or predicted conditions. Therefore it is not surprising that a number of the recommendations for driver assist systems are related to suggestions already made for driver warnings and function lockouts.

A key recommendation is that driver assist systems should go well beyond driver looking behavior (eye off road, glance duration, visual task demand) in their algorithms. Visual search is a key factor related to distraction and to degraded driving performance, but it is also one for which drivers appear to have good appreciation and which they already may factor into their decision-making. Visual demand must be incorporated into driver assist systems because it is important and because it is consistent with driver perceptions of distraction (hence is important for system credibility). However, additional significant benefits in driver assist systems may be achieved by incorporating those factors that drivers do *not* take into account well. These have been mentioned previously for other countermeasure approaches and include:

- Immediate and predictable upcoming demands of the driving task. These include roadway characteristics, traffic conditions, road user interactions, planned maneuvers, and transitions from one type of driving situation to another.
- Features of the in-vehicle task that may have an important relationship to distraction. These features may include user control over temporal aspects, ability to break up the task into discrete subtasks (chunking), perceived urgency, cognitive capture, driver ability to monitor distraction (self-awareness), probability of errors/incidents, and the demands of recovery from errors/incidents.

As discussed earlier, immediate and projected driving task demand information might come from vehicle-based sensors, GPS/GIS, information transmitted from traffic control centers, and inferred driver intent based on navigation system input or driving history. The ability to categorize in-vehicle tasks based on their distraction potential is not very mature, but it still may be worthwhile to attempt some means of including those task factors to which drivers appear to be insensitive.

“Cognitive capture” may be a particularly interesting phenomenon to incorporate into evaluation if it can be appropriately defined and measured. Focus group participants acknowledged finding themselves in “zombie-like” states, so this certainly has a subjective reality.

Because users appear reluctant to terminate an ongoing task, driver assist systems may do well to place more emphasis on predicting demand and discouraging task initiation in the first place. Drivers do not seem to give much consideration to likely uproad demands.

Since in-vehicle devices may have various modes of use and display options, a driver assist system ideally will take into account how the driver is using the device. For example, navigation map displays may be more demanding than simple turn-by-turn lists, and lists may be more demanding than voice. Destination input will be more demanding for keying in a new destination than recalling a pre-programmed destination. Driver assist algorithms could consider how a device is being used and what options regarding display or function are in effect.

As discussed earlier under the topic of function lock-outs, some drivers knowingly choose to place themselves in demanding situations and some seek out this challenge. Therefore it would be useful if a driver assist system could recognize when the driver is engaged in ancillary activities related to the in-vehicle task (e.g., taking notes, looking for items) or engaged in other unrelated tasks (e.g., eating, drinking, use of entertainment system, attending to children). Involvement in such activities might be detectable through driver posture, hands-off-wheel, eye glance patterns, reaching/hand location, or more sophisticated image analysis.

A driver assist system should take ambient lighting into account. Participants reported difficulty with some common cell phone tasks at night and glare has also been described as a problem. Light conditions obviously could also affect the demand of the driving task. Yet the rated willingness to engage in a task (keying in a cell phone call) was not affected by light conditions (although this is based on a single “what-if” scenario in the take-home booklet). Since night conditions may influence both the demands of the driving task and the distraction potential of in-vehicle activities, this factor would appear to merit consideration in driver assist strategies.

While cell phone conversations are a common activity, not all conversations are equally distracting. Focus group participants noted this, as related to the emotional intensity of the conversation, the ability to “zone out” during extended casual conversation, and the demands of certain business communications. However, there is little indication that drivers take the type of conversation into account when making there decisions to engage in a task. In fact, one might speculate that the very types of conversations that are most interfering may also be the ones that appear most personally significant to the phone user and they may be most reluctant to defer. Therefore it might be advantageous if a driver assist system could recognize conversation that has high distraction potential. There may be parameters of speech and dialog that reflect this. For example, an evaluation might consider speech rate, voice volume/volume changes, acoustic indicators of stress, duration of speech episodes, length of the conversation, and so forth. The potential for practical benefits of speech and dialog analysis in this application are not clear and would require a careful evaluation of the technical literatures on this subject.

If a system is capable of recognizing the individual driver, driver assist algorithms could be adapted to individual behavior. This was discussed previously for function lock outs, as related to poor decision making by those with aggressive driving styles or teen drivers. The point may be more generally applied to the criteria for driver assist functions in general.

A final point has to do with the trade-off between minimizing driving risks and maintaining good user acceptance. Drivers generally do not seek to minimize workload and maximize safety but rather try to keep these at acceptable levels. For many common tasks, including cell phone use, there is little reluctance to engage in use of most functions under most driving conditions. Driver assist systems that adopt much stricter goals than does the driver may face user acceptance problems. The findings of the on-road study regarding the willingness of people to engage in various tasks under various conditions may prove helpful when considering system safety criteria.

Suggestions for Safety Campaigns

Public educations campaigns might be useful in addressing some of the problems of poor driver decision making about engaging in in-vehicle tasks. The suggestions that follow relate particular findings to possible public education themes.

Various findings related to the failure of many drivers to be selective in their choice of time or place for engaging in tasks. Drivers appear to give inadequate consideration to current driving and traffic conditions and even less to anticipated demands even shortly ahead (e.g., leaving a parking lot). Many focus group participants described their decision making as “impulsive” or as “lifestyle.” While some described a “use-by-exception” strategy, others employed a “refrain-by-exception” style. A safety campaign might be addressed at getting drivers to recognize device use as a conscious choice and that engaging in in-vehicle activities should be deliberate. Campaigns might be constructed around concepts such as “pick your spot,” “make it a choice,” “don’t just do it,” or similar ideas. Many focus group participants readily acknowledged this lack of deliberate choice in their behavior. Therefore there may be an opportunity to promote self-acknowledgement of this and foster more deliberate planning and choice.

Drivers appear to be sensitive to the visual attention demands of in-vehicle tasks and take this into account in their decision making. An education effort could inform the public of the need to consider more than just what takes their eyes off the road. Other task attributes to consider include how long the task will take, whether it can be conveniently suspended or terminated if the demand of the driving task gets high, whether it can draw the driver into a non-aware state (cognitive capture), whether there are difficult timing demands or urgency, whether items (e.g., phone, earpiece, notes) are reachable and conveniently situated, and whether there may be disruptive incidents (e.g., dropped items, mis-entries).

Drivers are relatively insensitive to roadway and traffic conditions in their decisions and need to have greater awareness of the important factors. This relates to the need to make a deliberate choice (“pick your spot”) discussed above. It may also be useful to make explicit the kinds of roadway factors that could lead to difficulties in dealing with distracting tasks. The driver should anticipate maneuvers (turns, merges), changes in speed or congestion, demanding roadway geometry, work zones, entering traffic, pedestrians, and so forth.

The focus groups suggested that a very considerable aspect of decision making relates to factors that are unrelated to driving and safety. These may be inappropriate concerns in the roadway environment. People feel that their time is their own to use as they wish and that driving time is “wasted” time. Their decisions may be driven by details of their phone service, such as when minutes are least expensive, roaming charges, locations where reception is poor, or whether there are minutes remaining on a service plan.

Some users are motivated by a desire for sociability. Decisions should be driven by the safety of engaging in the task at a particular time, not by personal considerations of service costs, sociability, or personal time use. This is a matter of responsibility to other road users and in this sense may be parallel to the issue of responsible alcohol use. Perhaps one can find parallels to successful drink-driving campaigns. The general point is that these personal considerations put other road users at risk. The message is, it may be your time, but it's not your road. "Impaired driving" for personal motives is not acceptable on public roads. Safety considerations need to be given greater priority in decisions about engaging in a task than minor personal motives. In addressing this message, it may prove difficult to shift personal utility of these various motivational factors through educational efforts. However, alcohol-related efforts may point to ways to influence the public acceptability of these actions and the need to take personal responsibility.

An interesting aspect of the focus groups was that many people readily admitted to poor decision making, to "zoning out" while engaged in tasks, and to incidents of poor driving. People acknowledged the absurdity of trying to fill every minute with some activity, even while driving. There was often a rather sheepish aspect to these admissions. If drivers are aware of making poor choices, and admit it, perhaps this is something that can be built upon. People may readily criticize the stupid actions of the "other" driver, but when engaged in real discussion, admit to their own poor choices. Perhaps a safety campaign based around the concept of "admit it!" could be used as a basis fostering a greater sense of responsibility for one's actions.

The on-road experiment found a very strong negative correlation between the perceived risk of engaging in some activity and the driver's rated willingness to engage in that activity. While the existence of this relationship is not a surprise, that strength and consistency of it is. The correlation coefficient was $r = -0.98$ and there were very few cases where a task deviated substantially from the regression line. In other words, perceived risk (or more accurately, its inverse) and stated willingness were essentially the same thing to these research participants. This implies that anything that influences the perceived risk of some in-vehicle activity should directly impact the likelihood of a driver deciding to engage in that activity. Therefore information campaigns that promote awareness of the risks of engaging in in-vehicle activities may promote better decision making. One specific target may be cell phone use, since research participants indicated little reluctance to place or receive calls under almost any condition. Some drivers are also extremely confident in their ability to multitask in general, so information related to this risk may also be useful.

Relating the risks of certain in-vehicle tasks to other recognized hazards (which may be less acceptable to drivers) could be useful, but there is limited objective data to compare various risks. Some studies of cell phone use have compared the degradation of performance to some level of alcohol impairment. Strayer, Drews, & Crouch (2006), for example, found in a study of simulated driving that drivers using cell phones had elevated crash risks similar to those of drivers with blood alcohol concentrations of approximately .08 g/dL, though the specific impairments of each group differed. While there may be difficulties in directly comparing the risks associated with various impairments, to the extent that general comparisons are supported by data, such comparisons may provide a means to influence driver risk perception of in-vehicle activities.

One interesting note regarding risk perception is that it may be influenced by having a child on board. This was raised in the focus groups but only seen to a limited degree in the take-home booklet scenario ratings. There were two rating scenarios where a toddler was present while the driver was said to be driving on an arterial road; one involved answering a cell phone call and the other involved eating something messy. Risk was rated higher (and willingness lower) with the toddler present for the eating task, but there was little effect for the phone answering task. To the extent having a young child present influences the driver's sense of risk, there may be a basis for a message to make your decisions about distracting tasks as though "the baby is in the car with you."

Drivers may have the capability of modifying or redefining some tasks and educational campaigns might highlight these options. For example, some tasks can be handed off to the passenger, in a "co-pilot" role. In the same way a passenger would normally read a map for the driver, the passenger could answer or place calls, deal with the navigation system, and so forth. Drivers could more often use voice messaging as an alternative to answering a call and this could be encouraged. Pre-programming is relevant for a variety of tasks, such as destination entry, speed dialing, or assigning distinct rings to particular callers. Another option to redefine the task is to realize that the task can be completed before driving. This is particularly evident in the willingness of drivers to initiate a call or other activity when they enter their vehicles, and then continue the task as they try to exit a parking area and merge into traffic on a major road. Information campaigns might be aimed at particular examples ("let the passenger do it;" "finish before you start") or at the general point that the driver has ways to handle tasks that can reduce the risk of distraction.

Teen drivers would appear to be a key target audience for educational campaigns. Teens stand out from more mature drivers in a variety of ways. They are more willing multitaskers, with considerable confidence in their abilities to do things while driving and with enjoyment in challenging their skills. They appear to have relatively high levels of cell phone use and see this as an important component of their lifestyle. They appear more likely than other drivers to engage in text messaging. Across the full range of in-vehicle activities, they tend to see less risk and have greater willingness to engage in tasks. They are more impulsive in their decision making. For these reasons, it would seem reasonable to have safety educational campaigns targeted specifically to teen audiences, with teen-appropriate messages.

All of the above suggestions for safety messages were directed at the vehicle driver. It may also be reasonable to educate the passenger. This is particularly the case for teenagers, where passenger presence is a clear risk factor and where the driver may not make use of passengers as helpers. Passengers (even teens too young to drive) could be the targets of a "be a good co-pilot" campaign. This might address not contributing to distraction at critical times, helping the driver with key tasks (e.g., phone use, navigation system use, entertainment system use), and "speaking up" if the driver appears distracted or risk-prone.

Suggestions for Driver or User Training or Licensing

Many users of in-vehicle devices have a poor awareness of various display options, functions, and shortcuts. Even if aware of these, the user may not appreciate the benefits or understand how to implement the option. Examples include programming cell phone rings for specific callers, speed dialing, voice messaging, speech input and output, navigation display options, and pre-programming of likely destinations. It should not be assumed that users are aware of or appreciate all of the safety-relevant features that a device may afford. Manufacturers, distributors, and retailers of devices and/or vehicles need to make the options and their distraction-related safety benefits more evident. This could be done through design of the device, design of the display, marketing materials, user manuals and quick guides, point-of-sale demonstrations, and training. Training options include self-training material, such as videos, CDs, interactive web sites, or workbooks. It may be possible to promote these ideas at cell phone and telephone messaging industry group meetings.

Some focus group participants indicated that the cell phone call waiting function was difficult to cope with while driving. Ideally, then, drivers would not use this function and rather allow a voice messaging system record the message. However, if drivers do persist in responding to all calls, it might be useful to promote training and practice in using the call waiting function. If it is well-practiced it may be less disruptive.

Device users appear to have little awareness of specific on-product messages that appear on the device or in the display. Warnings should be explicitly pointed out in training, demonstrations, or on product-related materials.

Many drivers appear to have limited appreciation of the effects of cell phone use on their driving performance and are very confident in their ability to multitask while driving. Therefore their decision making does not reflect proper respect for the potential for driver distraction. It might be useful to provide people with some sort of demonstration or feedback regarding degradation of their driving performance while engaged in certain tasks. This could be in the form of a driving simulator or some other demonstration tool that would show the user performance effects with and without the distracting task. This could be made available to the public at venues such as shopping malls or fairs. It could also be incorporated as part of driver training or in remediation courses for traffic offenders. The demonstration device and associated scenarios and tasks would have to be carefully designed to reliably show effects, whether on overt driving, glance distributions, or hazard detection.

Drivers appear to be relatively insensitive to roadway features and show poor anticipation of the demands of upcoming features, traffic, and maneuvers. This seems to be an important limitation in driver decision making that could be addressed through training. Drivers should learn to give careful consideration to driving demands and should understand the factors that may make it difficult to conduct in-vehicle tasks. A key issue is how to provide this training. It could be incorporated into more general driver training and might also be incorporated with any training materials or procedures for particular in-vehicle devices.

A number of participants in the focus groups acknowledged being very impulsive in their decision making and giving minimal thought as to whether to engage in some task. They just "do it." Perhaps some sort of simple self-rating scale could be developed and distributed, to provide drivers with feedback about whether they have a dangerous decision style. Improved self-awareness about this tendency might help promote more conscience consideration in decision making.

Some driver decision making about in-vehicle tasks actually should take place prior to the trip. In many cases, drivers apparently fail to do this. Users can be trained, perhaps through checklists or other aids, to recognize what can be done prior to a trip and the best way to do these

The on-road experiment found a strong relationship of driving style with willingness to engage in in-vehicle tasks. Drivers who self-reported an aggressive, intense driving style also were substantially more willing to engage in potentially distracting activities. This suggests a public safety concern over device use by drivers who already pose a greater crash threat. Therefore it might be reasonable to consider sanctions against cell phone or other device use by motorists convicted of serious driving offenses.

Older drivers reported greater reluctance to engage in in-vehicle activities. This may be an entirely appropriate example of self-regulation of driving practices. However, it might be argued that older drivers may benefit from the use of some devices, such as navigation systems. In that case, some form of skill training would be useful to assure competent use and guidance in good decision making.

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