Driver Acceptance of Distraction Mitigation Strategies: Focus Group and Simulator Studies

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ABSTRACT
Driver distraction is a major concern and has been shown to contribute to vehicular crashes. Therefore, investigating ways to mitigate distractions is very important. Driver acceptance of distraction mitigation strategies is crucial if these strategies are to be effective. Different driver distraction mitigation strategies were categorized in a taxonomy based on levels of automation, type of task being modulated by the strategy, and the strategy initiation. This taxonomy was further developed with focus groups that were conducted to investigate driver acceptance of the various mitigation strategies. The taxonomy guided a driving simulator experiment which evaluated how several mitigation strategies and presentation modalities affect driver acceptance. Older drivers accept strategies that directly guide their interaction with their non-driving activities more than middle-aged drivers. Regardless of age, all drivers prefer systems that alert the drivers in a visual mode rather than an auditory mode. The findings suggest that during system development, designers should consider the effects of age, presentation modality and the relation between false system adaptation, trust and system use.

INTRODUCTION

Driver distraction can be defined as the departure of driver attention from the driving task, which reduces safety. There are different definitions of these distracting tasks. Tasks defined by Wierwille (*1*) include manual only, visual only, visual primarily, and visual-manual and represent unique types of distraction. Ranney, Mazzae, Garrott, & Goodman (*2*) identified four components of driver distraction as visual, auditory, biomechanical, and cognitive. Any non-driving activity that the drivers engage in may involve one or more of these components, and conflicts between non-driving activities and driving are distractions. However, drivers are capable of actively managing the division of attention between these potentially conflicting activities. Both a driver's willingness to engage in a non-driving task and the attentional demands placed on the driver by that task, therefore, contribute to the potential for distraction.

In-vehicle technology that reduces driver distraction can be considered as a form of automation, and so recent reviews of automation and its effect on operator performance provide valuable insights that can highlight the advantages and disadvantages of various distraction mitigation strategies (*3-5*). Although distraction mitigation systems have great potential, these systems may also fail to provide expected benefits. Miscalibrated trust and the potential for misuse and disuse are among the many reasons for such failures. Many studies show that humans respond socially to technology and treat computers similarly to the way they would other human collaborators (*5, 6*). Trust is therefore a particularly important factor influencing reliance and the use of automation. As distrust may lead to the disuse of the automation, mistrust can lead to uncritical reliance on it, resulting in a failure to monitor the system's behavior properly and to recognize its limitations, thereby leading to misuse of the system (*7*).

Drivers' acceptance of the system is also a key issue and depends on ease of system use, ease of learning, perceived value, advocacy of the system, and driving performance (*8*). Acceptance interacts with trust and low levels of acceptance would lead to disuse and diminish its benefits. Therefore, driver acceptance of a distraction mitigating strategy should be assessed before the strategy is implemented in in-vehicle information systems (IVIS).

To further explore these issues, a taxonomy is needed that will systematically identify the dimensions of mitigation strategies and the relationships between the dimensions. This taxonomy, which was initially discussed in (*9*), was refined with focus group sessions that are discussed in this paper. Moreover, a driving simulator experiment was conducted to assess the acceptance of and trust on mitigation strategies defined with the final taxonomy. The objective of this study is to understand which distraction mitigation strategies drivers prefer and which ones they would accept, as well as to assess how age impacts acceptance.

CATEGORIZATION OF MITIGATION STRATEGIES

A preliminary taxonomy was developed based on three dimensions. The dimensions were the level of automation, initiation of a mitigation strategy, and the type of task that is being modulated by the strategy. These dimensions were considered critical for the development of mitigation strategies because different levels of these dimensions would impact drivers' response to and acceptance of distraction mitigation strategies. Because in-vehicle technology to reduce driver distraction is a form of automation, different levels of automation guide the effectiveness and acceptance of the strategies. Therefore, the mitigation strategies were categorized in terms of whether they are related to a high, moderate or low level of automation inspired by recent definitions for levels of automation (*3, 4*). They were then further categorized according to whether they address driving-related (e.g., steering, braking) or non-driving-related tasks (e.g., tuning the radio, talking on the cell phone) as defined by Ranney et al. (*2*). Driving-related and non-driving-related tasks compete for driver attention. Strategies that address driving-related tasks focus on the roadway environment and directly support driver control of the vehicle, whereas strategies for non-driving related tasks focus on modulating driver interaction with IVIS. Initiation of a strategy also guides the level of driver acceptance and strategy effectiveness. Within the previously defined categories, the mitigation strategies were subcategorized as driver initiated (i.e., where the driver is the locus of control) and system initiated (i.e., where the system is the locus of control). This initial taxonomy was presented to the focus group participants to help generate ideas to further develop the taxonomy as well as form hypothesis regarding how the various strategies might affect acceptance of mitigation strategies. The discussions of these focus groups are described in the next session.

FOCUS GROUP

Focus groups have previously been used in transportation and other research to gain perspective and insights on an issue (*10*). Typically, focus groups are used as a part of large research programs and the data collected can be integrated with data from experiments, surveys, etc. However, the small number of participants limits the generalization to a larger population (*10, 11*). Nevertheless, the insight gained from this type of exploratory research is valuable in developing hypotheses and in formulating more precise research questions. Therefore, for this study, focus groups were performed to help develop the taxonomy which was then further investigated by a simulator experiment. 24 participants were recruited in two cities with different traffic conditions—Iowa City, IA (12 participants) and Seattle, WA (12 participants). Two focus groups were conducted in each city with participant age ranging from 22 to 64 ($\overline{X}$ =37.8, σ^2 =11.8). All participants were active drivers who drove daily.

All sessions were 4 hours long and followed a structured question path. The session began with introductions and explanations about why the group was assembled and what information was hoped to be garnered. To set the stage and educate participants about driver distraction, a brief overview of the different types of distraction were presented. Specifically, the visual only, visual manual, manual, and cognitive types of distraction were presented (*1, 2*). In addition, the sources of distraction were also listed: vehicle (e.g., radio), driver/passenger (e.g., passengers), and external (e.g., billboards). Finally, a 12-minute video on driver distraction, which provided concrete examples of the types of distractions, was presented. The general structure of the focus group then proceeded along the sequence of topics presented in the results section.

Results

Distractions that participants had previously experienced

The three major groups of distractions discussed were in-vehicle, external, and cognitive distractions. In terms of in-vehicle distractions, cell phone, changing CD's and tuning the radio were considered the worst distractions. External distractions included trying to follow road signs in an unknown area, or observing an unplanned activity (e.g., crash) or planned activity (e.g., lawn mowing). Primarily, cognitive distractions included driving while thinking about a non-driving situation. Regardless of the distraction type, most drivers indicated that they would continue to use their in-vehicle devices and perform other types of distracting activities unless there is a law that tells them otherwise. This indicates that drivers are most interested in systems that will allow them to continue their non-driving related tasks, and mitigation strategies that interfere with drivers' ability to perform non-driving tasks may not be well-accepted. Therefore, these considerations need to be incorporated into the taxonomy.

Realization of the potential danger of the distraction activity
Participants also identified how systems could help increase their driving performance. Examples include another vehicle's horn, and passengers who alerted the driver to "look out" or of upcoming turns. Road markings such as rumble strips were beneficial in alerting of a roadway departure. Other techniques that were considered beneficial include having the driver of the lead vehicle depress the brakes intermittently to warn of a closing gap in the lead and following vehicles. These distraction indicators can be translated into mitigation strategies which are driving related. For example, auditory collision warnings, which implement the *warning* strategy, may emulate a vehicle's horn. Similarly, seat vibration for roadway departure warnings may help mitigate driver distraction by augmenting cues drivers currently use.

Technologies to mitigate distraction
Generic technologies (e.g., eye-tracker, directional seat vibration, etc.) were presented to the participants to generate ideas for innovative technology solutions. Participants appeared to favor systems that can adapt to the driver's needs such as eye tracking and seat vibration devices. They felt that employing a device that could track eye position relative to eyes-on-road time would be helpful and an automatic seat and mirror adjustment for each individual driver would reduce the need for small adjustments during driving. Some drivers even favored ideas such as a co-pilot that would take over when an eye-tracking system senses droopy eyelids relative to fatigue, while other drivers did not like the idea of high levels of automation. These comments showed the need to tailor driver distraction mitigation strategies based on the adaptive needs of each individual. These needs may be realized in different levels of automation (such as high, moderate and low) tailored based on individual differences and the particular distraction level.

Helpful passengers during distracted situations
Because people tend to respond socially to technology, reactions to technology can be similar to reactions to human collaborators (*5*). Therefore, if a system has characteristics of a helpful passenger, the driver may perceive the system to be more beneficial. Participants were asked to describe situations where passengers helped them drive better and what suggestions from passengers have been annoying. Focus group participants identified a helpful passenger as one who acts as 'a second set of eyes', who does not nag, who knows when to properly warn you of an impending danger. Offering conversation at the right times would classify a passenger as helpful, but talking constantly and during more visually demanding driving situations is not. The tone of a passenger's voice can also help the driver be more cautious in some situations. Recent research in the area of computer etiquette suggests that acceptance depends on more than the technical performance of the system (*12*). Distraction mitigating systems that carry these characteristics would have a higher likelihood of being accepted by the drivers.

Categorization, likes and dislikes of mitigation strategies
The participants were presented with the preliminary taxonomy and their perceptions and comments of the technologies when categorized into levels of automation, initiation of the strategy and type of task modulated by the strategy were requested. Drivers had different opinions regarding preferences for levels of automation. For example, some drivers preferred a

high level of automation (i.e. *intervening*) because this would remove the driver from all responsibilities related to distracting situations as well as for those with impairments (e.g., medical condition, alcohol and drug related) that may impact their driving abilities under certain scenarios. Concerns that drivers had with this strategy include the possibility of suboptimal responses based on current technology as well as individual driver's experience. They felt that there are always unexpected situations that automatic control cannot account for. Moderate levels of automation for the driving related task (i.e., *warning*) was deemed helpful in the driving task by enabling drivers to make better decisions if the presentation of the information was not annoying. In terms of non-driving related tasks, a low level of automation (i.e., *advising*) was also perceived to be helpful by all drivers. Participants felt that an *advising* strategy would enable drivers to be more aware of their driving behavior and how it can impact others. Some drivers generally had negative attitudes towards interruptions of their non-driving related tasks such as the interruption of their cell-phone conversation. On the other hand, the rest believed that rather than making the tasks easier to perform, the systems should prevent the drivers from engaging in non-driving activities. Clearly, acceptance of the system will play a key role in how drivers use the system as well as how satisfied they are in its performance. Therefore, the levels of trust and acceptance will need to be investigated in the next phase of the study.

FINAL TAXONOMY

The focus group helped improve the initial taxonomy and identify an area (driving related strategies that are driver initiated) that was not typically identified as a category that would mitigate the effects of distraction. The majority of research in mitigation strategies has centered on the driving related strategies that are system initiated (such as forward collision warning system, run off the road). Previous research in driver initiated systems (e.g., conventional cruise control, speed information at driver's request) typically did not center on mitigation strategies, but were viewed as convenient systems for drivers (*13*). However, the focus group suggests that perhaps these types of systems can be tailored to reduce the effect of driver distraction. Moreover, titles of some mitigation strategies were changed to reduce the ambiguity and/or negative connotations relating to some of the mitigation groups (i.e., *nagging* to *advising*). This new taxonomy is shown in Table 1 and further discussed in Donmez, Boyle, & Lee (*9*). A summary of each category is presented here.

Driving related strategies, system initiated

System initiated strategies under the category of driving related tasks aim to enhance safety by directing driver attention to the roadway as well as by directly controlling the vehicle. These strategies can be identified in terms of high (*intervening),* moderate (*warning*), and low (*informing*) automation. For example, in an *intervening* strategy, the system would take control of the vehicle and perform one or more driving related tasks during hazardous situations when the driver is too distracted to react in a timely manner. These systems would include co-pilot and automatic braking. The focus groups revealed that drivers have different preferences regarding this group of strategies. Some drivers liked the idea of high levels of automation whereas the rest preferred lower levels of automation. Regardless of preference all drivers were concerned about the system accuracy.

Driving Related Strategies, Driver Initiated
Based on the discussion of the focus group participants, some of the systems that were discussed did not fit into any of the existing categories. Therefore, the researchers developed this new category to facilitate other types of mitigation strategies as well as provide symmetry in taxonomy. This group of strategies mitigates distraction by having the driver activate or adjust system controls that relate to the driving task. The systems identified in this category can also be categorized into three levels of automation: *delegating* (high), *warning tailoring* (moderate), and *perception augmenting* (low). An example of *delegating* is driver's initiation of automatic vehicle control such as an adjustable headway setting for automatic braking. The low level of automation in this group, *perception augmenting*, provides driver information at the driver's request which helps reduce the driver's demand for locating necessary information (e.g., driver's speed, posted speed). Previous research showed that drivers generally like the comfort and convenience of the systems that fall in this group (*13*).

Non-Driving Related Strategies, System Initiated
System initiated, non-driving related strategies builds upon the idea that when the driving performance is or will be significantly deteriorated, the system would take action and change the nature of the non-driving related task that the driver is engaged in. The three levels of automation for this group include *locking and interrupting* (high), *prioritizing and filtering* (moderate), and *advising* (low). *Locking* discontinues the non-driving activities and locks out the system that is associated with the distracting activities while *advising* gives drivers feedback regarding the degree to which they are engaged in a non-driving task. These systems have not been studied as much as the other categories. However, findings from the focus group indicate that there are perceived benefits in further investigating these systems.

Non-Driving Related Strategies, Driver Initiated
The driver initiated strategies rely on the driver to modulate their non-driving tasks according to their subjective degree of distraction. The three levels of automation for this group include *controls presetting* (high), *place-keeping* (moderate), and *demand minimizing* (low). For example, if the visual demands on the road increases drivers tend to glance at an in-vehicle display more, with shorter duration glance times and larger times between the glances to keep their driving safe (*14*). Therefore, as the time interval between each glance increases, the need for keeping the place of the driver at the non-driving related task also increases (*place keeping*). Some focus group participants indicated that this group of strategies may lose their effectiveness if these systems were too easy to use. As an example, if they feel that hands free cell phones allows them to minimize task demands (*demand minimizing*), they may feel more comfortable using it more and therefore their likelihood to get distracted would increase. This issue should be considered in system design to ensure effectiveness of mitigation strategies.

SIMULATOR EXPERIMENT

The importance of user acceptance of a mitigation strategy was identified in the focus groups. Because the non-driving related category represents an area which is a growing concern with advanced technologies, acceptance issues related to non-driving related tasks appear to merit further research. Moreover, of the categories presented above, the majority of previous research has focused on driving-related strategies such as *intervening* (automatic braking systems), *warning* (collision warning systems), *informing* (speed indicator), *delegating* (adaptive cruise control), *warning tailoring* (adjustable warnings) and *perception augmenting* (speed indication with driver request). Of the non-driving-related strategies, only *demand minimizing* has been investigated as a potential means of reducing distraction (*15*). The strategies that clearly merit further investigation include non-driving-related strategies such as *locking & interrupting, place keeping, prioritizing & filtering, controls pre-setting* and *advising*. Two strategies from these were therefore chosen for further investigation. Strategies tested were *advising* and *locking* which represent the extreme ends of automation under the non-driving related, system initiated category. The system initiated category was chosen because the driver initiated strategies depend highly on the subjective distraction level of the driver and do not promise as high effectiveness. It is also important to consider the impacts of automation level therefore strategies tested represent two extreme ends of automation.

Methodology

A sample of 28 drivers was presented with a system to mitigate distraction both in visual and auditory format in a fixed based driving simulator. 16 middle age (Range: 35 to 55; $\overline{X}$ =45, σ^2 = 4.27) and 12 old age group drivers (Range: 65 to 75; $\overline{X}$ = 69, σ^2 = 3.26), who are potential initial purchasers of these systems, were recruited for participation. As their importance was expressed in the focus groups, both visual and auditory formats were tested. The visual secondary task was presented to the drivers on a 7-inch LCD mounted on the dashboard (approximately 18 degrees viewing angle). Auditory messages used in the secondary task were converted into .wav audio files through the Ultra Hal Text-to-Speech Reader, Version 1.0, created by Zabaware, Inc.

All scenarios took place on 2-lane rural roads. The participant was instructed to drive at a comfortable speed which was not above the speed limit of 45 mph and to follow the lead vehicle which periodically braked at a mild rate of deceleration (0.2 g) for 5 seconds. There were 12 braking events in each driving scenario. Half of the braking events were on curves and the other half were on the straight sections of the drive. Moreover, to make the scenario more realistic different radius curves were used; half of the curves were 400 meter radius (3 left turn, 3 right turn) and the other half were 200 meter radius (3 left turn, 3 right turn). The braking events and the radius of curves were randomized through the drives.

The secondary task was based on the working memory span task defined by Baddeley, Logie, & Nimmo-Smith (*16*), and was displayed to the participant via a peripheral display for the visual task and by a synthetic voice for the auditory task. The secondary task required the participant to determine if a short sentence was meaningful or not (response by pushing steering wheel buttons) and then to recall the subjects of three consecutive sentences (verbal response). For example “the policeman ate the apple” is meaningful and its subject is “policeman”, whereas “the apple ate the policeman” is not meaningful and its subject is “apple”. The button-press and verbal recall tasks provided a controlled exposure to the visual, auditory, motor, and cognitive distraction associated with in-vehicle information system interaction and was similar to the tasks used in other driver distraction studies (*17*).

The experiment was a 2^4 repeated measures design with day and run as repeated measures. There were two levels for each of the four independent factors: age (middle/old), mitigation strategy (advising/locking), secondary task (visual/auditory), and system adaptation (true/false). Age was a between subjects factor and the latter three were within subjects factors.

Two distraction mitigation strategies were implemented in the system to either advise the driver to discontinue the non-driving related task (*advising*) or to lock out the interaction with the system completely (*locking*). Both of the strategies were mapped to the driving events that require appropriate response from the driver. These two events were the lead vehicle braking and the curve entry ahead. Curve entry ahead refers to the road section consisting of two seconds long drive straight section before the curve and three seconds long drive section of the curve. The participant was told that the system would take actions when the driver has to give attention to the roadway, specifically when the lead vehicle was braking or there was a curve ahead. The mitigation strategies were implemented between scenarios. That is, each mitigation strategy was tested with a separate experimental drive.

For the visual secondary task, *advising* was implemented with a red bezel around the screen. The red bezel illuminated whenever there was a lead vehicle braking or curve entry ahead (5 seconds for both conditions). With the *advising*, the driver was still able to interact with the system. The *locking* strategy blanked the screen and illuminated the red bezel. The red bezel and the lockout remained in effect until the triggering condition was over (i.e. lead vehicle braking or curve entry). For the auditory secondary task, *advising* was implemented with a periodic clicking noise (1 Hz) whenever there was a lead vehicle braking or curve entry ahead. With *advising*, the driver was still able to interact with the system. The *locking* strategy stopped the task message presentation and presented the periodic clicking noise to the driver. The lockout remained in effect until the triggering condition was over. There were separate experimental drives for each level of the secondary task (visual/auditory).

The system adaptation (true, false) was implemented between days with the order of presentation counterbalanced between the days. That is, a random half of the participants began with the true system adaptation on the first day whereas the other half received the false adaptation on the first day. True system adaptation refers to the system properly adapting to the environment or driver state. False system adaptation occurs when the system fails to adapt appropriately, producing both false alarms (i.e., takes action when it is not supposed to) as well as misses (i.e., not taking action when it was supposed to). These two types of imperfections within false adaptation might affect the driver acceptance, trust, and use of the system and should be further explored. However, for this initial investigation, the effects of the misses and false alarms within the false adaptation condition are not differentiated. For the purpose of creating an unreliable system, both of these imperfection types were implemented together under the condition of false system adaptation to form a 50% reliability rate. The duration of alarms (*advising* and *locking*) were equal for each scenario drive.

Acceptance and Trust Measures

An acceptance questionnaire based on Van Der Laan, Heino, & De Waard (*18*) was given to the participants after each drive. The questionnaire composed of nine questions investigating two dimensions of acceptance: usefulness and satisfying. Before analysis, the acceptance questionnaire was recoded to fall along a scale of -2 to +2 (-2 representing lowest level of acceptance and +2 representing the highest). These numbers were then averaged to obtain the usefulness score and the satisfying score. Additional acceptance questionnaires were also filled out by the participants. These questionnaires aimed to assess the acceptance of the *advising* and *locking* strategies if they were embedded in current IVIS features (radio, cell phone, email).

Because trust is an important attitude that may guide the reliance on a system (*5*), a system trust questionnaire was also given to the participants which was based on Wiese (*19*). The questionnaire included the questions of 'I trust the safety system' and 'the performance of the safety system enhanced my driving'. A -2 to +2 scale was used to code the responses (-2:

strongly disagree, +2: strongly agree). The overall trust score was obtained by averaging the responses for these two questions.

Results

Acceptance with proposed mitigation strategies

There were some interesting differences between the middle-aged and older participants in the simulator study. Older participants perceived the systems to be more useful ($t(26.5) = 3.07$, $p<0.005$) and were more satisfied ($t(26.7) = 3.35$, $p<0.005$) with the system than the middle aged group (Figure 1). These drivers tend to accept non-driving related, system initiated mitigation strategies more than middle aged drivers. However, regardless of age group, visual based strategies were perceived to be more satisfying ($t(159) = 6.39$, $p<0.0001$) and more useful ($t(157) = 4.63$, $p<0.0001$) than the auditory based strategies. These finding also support the insights gained by the focus group regarding the preferred display modality. Focus group participants preferred visual compared to auditory based strategies.

System Trust

Older participants trusted the systems more than the middle aged participants ($t(26.8) = 3.14$, $p<0.005$, $\overline{X}_{middle\ age}$: -0.028, $\overline{X}_{old\ age}$: 0.622). As expected, systems that were 100% reliable resulted in higher trust than the 50% reliable systems ($t(27.2) = 2.48$, $p<0.05$, $\overline{X}_{100\%\ reliable}$: 0.38, $\overline{X}_{50\%\ reliable}$: 0.11). The system accuracy was also revealed as an important issue from the focus group findings and the experimental data support that system accuracy would guide trust in the systems.

Predicting trust based on acceptance levels

Pearson correlation coefficients for three variables, level of trust in the driver distraction mitigation strategy, usefulness, and satisfying, were investigated. As the level of usefulness increased, so did the driver's level of trust ($p<0.0001$). This was also true for the level of satisfying. Drivers who were more satisfied with the strategy also perceived an increase in level of trust ($p<0.0001$). The relationship between usefulness and trust ($\rho = 0.731$) was stronger than the relationship between "satisfying and trust" ($\rho = 0.629$). This indicates that a useful system is more important with respect to trust than a system that provides immediate satisfaction. But because satisfaction is also strongly correlated with trust, this factor should not be dismissed.

Preferences for proposed mitigation strategies in the presence of various IVIS systems

After driving in the simulator and experiencing the various mitigation strategies, drivers rated their acceptance of these strategies as applied to current and likely in-vehicle information systems. Participants were asked to assess the preferences for these strategies given current technology including cellular phones, voice activated e-mail messages, and radio controls. These available in-vehicle systems were evaluated in order to allow participant to provide subjective preferences and relate what they observed in the simulator to something they were more familiar with. The older participants perceived the strategies embedded in IVIS to be more useful ($t(165) = 2.17$, $p<0.05$) and more satisfactory ($t(160) = 2.14$, $p<0.05$) than the middle aged group (Figure 2). In general, all participants were more satisfied with the operation of a visual *advising* strategy (such as a red bezel) on their radio when compared to an auditory *locking* strategy in a cell phone ($t(160) = -3.35$, $p<0.001$) or email ($t(160) = -2.28$, $p<0.05$). Therefore, a visual based alert which does not lock the IVIS task appears to be more accepted by drivers than an auditory alert which does. This implies that driver's perceived importance in the secondary task plays a key role in the strategy acceptance.

Relationship between the Focus Group and Simulator Results
The focus groups revealed that the level of automation had an impact on the acceptance of driving related strategies. More specifically, some drivers preferred the ability to maintain control of their vehicle and were not accepting of high level of automation. The experimental data did not show such an effect between the levels of automation for the non-driving related strategies. However, the experiment revealed that older drivers accepted the strategies more than middle aged drivers. The experimental data also supported the focus group finding on display modality. Auditory based systems were shown to be less accepted than the visual based systems. Therefore, designers may want to mitigate distractions by visual alerts when appropriate. Another focus group finding supported by the experiment was the concerns on system accuracy. Low levels of system reliability resulted in lower levels of trust. Trust was also found to be positively correlated with acceptance measures. Of the two acceptance measures usefulness had a greater impact on trust. This is an important issue because the trust in a system would guide the proper use by the drivers. Systems designers should aim to achieve high levels of reliability as well as acceptance before incorporating mitigation strategies in the vehicle.

GENERAL DISCUSSION

Cognitive distraction is an important consideration when designing mitigation strategies which relates to the mental distractions that can occur while driving (i.e., lost in thought) and may significantly degrade safety (*20*). Even though many focus group participants indicate that they have been cognitively distracted while driving, they do not want to give up their in-vehicle devices unless laws were in place. Therefore, research in non-driving related strategies that will help mitigate the impact from these in-vehicle devices appears to be of great value.

The experimental data showed that there are some major differences among the old and middle aged drivers that may have an impact on the type of mitigation strategy that is designed. The older drivers perceive the non-driving related, system initiated mitigation strategies to be more useful and satisfying when compared to the middle aged drivers. Middle aged drivers accept such strategies less because they get annoyed with the interventions in their non-driving related activities. Moreover, previous research showed that drivers are usually critical of systems that intervene in their driving, whereas systems that offer recommendations and provide information are deemed considerably more acceptable (*21*). Some focus group participants were more concerned about the ability to remain in control of their vehicle and were not as content with a high level of automation, while others liked the idea of complete automation. Therefore, when developing systems to reduce distraction, the acceptance of these systems by different driver groups should also be considered. For example, the drivers may have the ability to tailor the system based on their individual preferences. The experiment also showed that trust is positively correlated with perceived usefulness of the strategy as well as how satisfied the drivers are with the strategy. Usefulness is quantified to have a larger impact than satisfying and therefore plays a more important role in trust.

Focus groups suggested that mitigation strategies presented in the auditory format can be very annoying. The experiment verified this finding. The auditory based mitigation strategies were accepted less than the visual based strategies. Therefore, when appropriate, warnings should be conveyed visually rather than as a sound alert. However, in some situations an auditory warning may be more effective than a visual one, and a tradeoff between effectiveness and acceptance would develop. In an imminent danger the system should aim for higher effectiveness. Another point that was frequently pointed out in the focus group discussions was the system accuracy. False alarms and false system adaptations contribute to drivers' response to and acceptance of the system, which may in turn influence system effectiveness (*22*). Drivers believed that the mitigation strategies should be as accurate as possible. Experiments showed that the system trust depends on the accuracy. Low system reliability resulted in less trust. Because distrust undermines reliance and the benefits of a system (*5*), accuracy is very important for mitigation strategy effectiveness. However, not all false positive alarms are harmful. Such alarms can be used to train novice drivers, and are also needed to generate driver familiarity with the system. If the first time the driver receives a warning is in a true collision situation, the driver may not respond to it in the amount of time available. False positive alarms may also lead to more cautious driving and thereby result in reduced false alarm rates (*22*). Thus, for a mitigation strategy to be effective, an acceptable false alarm rate should be established.

CONCLUSION

Focus group and driving simulator studies were conducted to investigate whether strategies incorporated in IVIS to mitigate distraction will be accepted by drivers and thereby reduce the number of crashes and fatalities that occur each year. The insights gained from the focus group helped develop a taxonomy of distraction mitigation strategies. Two mitigation strategies from this taxonomy were evaluated in a simulator experiment. The results showed that older drivers accept system initiated strategies that modulate IVIS interaction more than the middle aged drivers. Therefore, when designing systems for middle aged drivers, maintaining driver control of the IVIS interactions may be necessary if the system is to be accepted. Moreover, regardless of age, all drivers perceive auditory based alerts to be more annoying than visual ones. In order to increase driver acceptance of an alert, designers should consider visual rather than auditory alerts. Another issue that was revealed in the focus group discussions and was later quantified by the experimental results is the adverse effects of system inaccuracy. Low system reliability results in low level of trust which guides proper system use. Therefore, to ensure acceptance and effectiveness of a mitigation strategy it is important to maintain high system reliability.

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TABLE 1 Final Taxonomy of Distraction Mitigation Strategies

LEVEL OF AUTOMATION	**DRIVING RELATED STRATEGIES**		**NON DRIVING RELATED STRATEGIES**	
	System Initiated	***Driver Initiated***	***System Initiated***	***Driver Initiated***
High	Intervening	Delegating	Locking & Interrupting	Controls Presetting
Moderate	Warning	Warning Tailoring	Prioritizing & Filtering	Place-keeping
Low	Informing	Perception Augmenting	Advising	Demand Minimizing

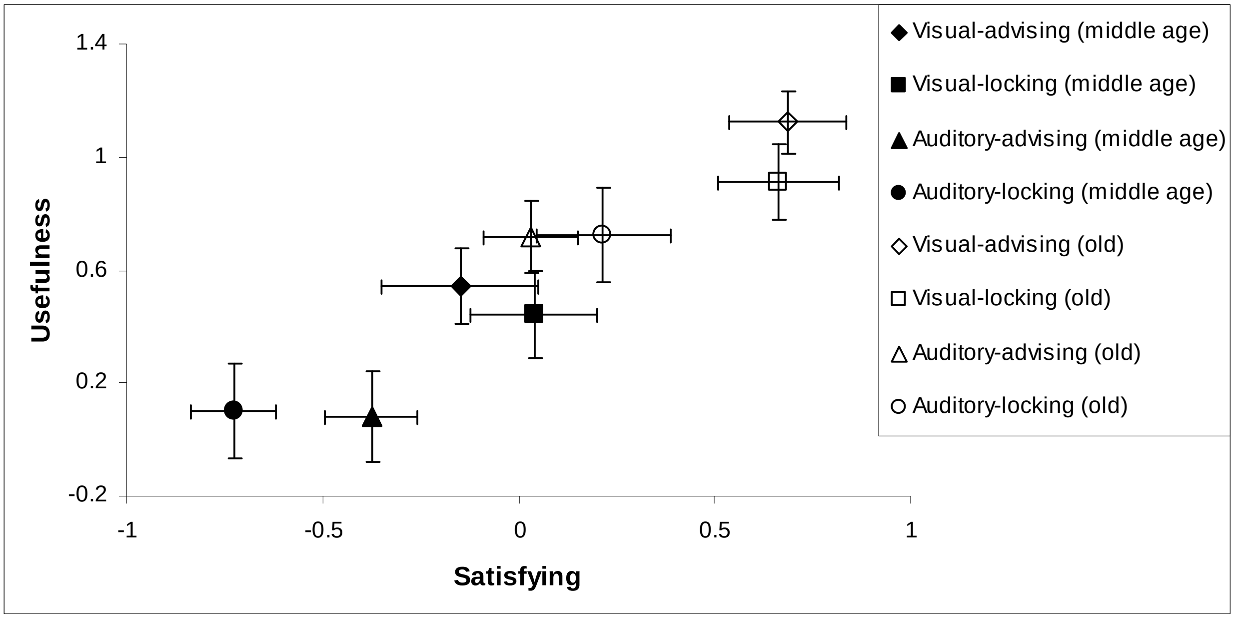

FIGURE 1 Acceptance of Mitigation Strategies by Age Group and Presentation Modality

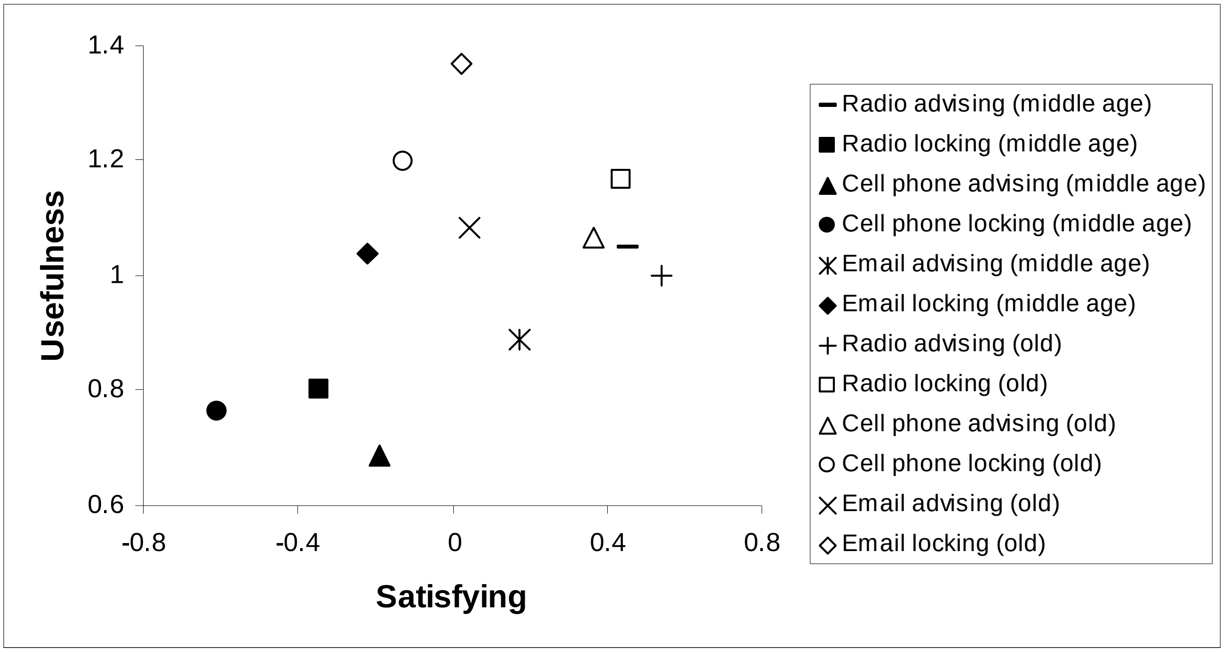

FIGURE 2 Acceptance of Mitigation Strategies Embedded in Current IVIS