The Driver and the Instrument Panel

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Preface

This licentiate thesis in Industrial Design focusing on present day transportation research and was performed within the Optimized system Integration for safe Interaction In Vehicles (OPTIVe) project, financed by the Swedish Intelligent Vehicle Safety System (IVSS) research foundation and the Swedish Road Administration. Society is affected by the way our transportation system works. In one way or another use of the transportation system involves different levels of human involvement and control. The development of the transportation system also requires research from many different academic disciplines.

The issues of safety in transportation have focused on the roadway and the vehicle body. But transportation is more than that since the human role is an important part in the transportation process. Many of the real issues lie in human factors issues like cognitive workload and driver distraction. Understanding and applying research from these areas can facilitate improved usability and safety.

This thesis has been written with the hope that the layout, the theoretical introduction, and the language are understandable to readers from many different disciplines. Therefore it would be pertinent to start with a general introduction of the distraction risks involved in vehicle operation before delving into the theories and empirical studies and then ending with a general discussion and conclusions.
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Abstract

The trend today is to produce automobiles that have exciting systems which enhance the users’ driving experiences, however, the distraction potential of these systems has not fully been considered. Since there can be large differences in the driver’s level of distraction caused by visual overload due to individual and cultural characteristics. Therefore, three different markets were chosen due to their distinct vehicle and driving traditions and laws; China, Sweden and United States of America (US). The aim of this thesis, from an instrumentation design point of view, is to gain a better understanding of what information, and where information should be presented, in instrument panels to achieve low levels of distraction and, hence, decrease cognitive load, increase safety and functionality.

Studies undertaken in this thesis sought a user based solution. The questionnaire results showed that safety attributes were ranked before, quality, practicality, and attractiveness in automobiles. The number one concern for the Chinese market was safety features presented to them from HDD in the instrument panel, the Swedish market preferred the traditional features and placements, the US preferred safety features and those assisting in safe driving to be placed in the HUD. A high-fidelity driving simulator was used to study respondents of varied age and driving experience, of which drove through both rural and city traffic with speed limits ranging from 50 to 70 km/hour while responding to information presented in HUD, HDD, IF, and CS positions. All groups rated the HUD as a very good placement for information retrieval while driving, followed by HDD, IF, and CS respectively. The overall preferred placement was HUD as it also was the preferred position of serious failures and vehicle operation. The results from both studies showed that people wanted logical groupings of driver information placed in the vehicle so to reduce the risk of distraction.
Abbreviations

ABS    Anti-lock Braking System
ACC    Automatic Cruise Control
ADAS   Advanced Driver Assistance System
ANOVA  Analysis of Variance
BAC    Blood Alcohol Content
CB     Change Blindness
CD     Compact Disk
CS     Center Stack Display
DALI   Driver Activity Load Index
DI     Driver Information
GAD    Global Attention Demand
GPS    Global Positioning System
HDD    Head Down Display
HUD    Head Up Display
IB     Inattention Blindness
IF     Infotainment Display
LCD    Liquid Crystal Display
IV     Intelligent Vehicle
IVIS   Intelligent Vehicle Information System
IVT    In-Vehicle Technologies
MANOVA Multiple Analysis of Variance
MP3    MPEG-1 Audio layer 3
NHTSA  National Highway Traffic Safety Association
SPSS   Statistics Program for the Social Sciences
SUV    Sport Utility Vehicle
WHO    World Health Organization
US     United States of America
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1 Introduction

1.1 Background
The modern automobile is becoming more and more complex, therefore, vehicle system designers need to learn about and understand the complexity of the driving task and how the automobile systems should work together with the driver. A poorly designed system or an overly sensitive system can increase the drivers' chances to be distracted, therefore “a very good understanding of the driver’s psychology and behavioral habits is essential” (Vahidi & Eskandarian, 2003, p. 148). Driving demands high visual attention (Peacock & Karwowski, 1993; Schieber, 1994) and the task of driving requires functioning perceptual, cognitive, and motor skills (Blanco, Biever, Gallagher, & Dingus, 2006) in order to perform adequately. It is proposed that “empirical testing is needed to define how much information is too much as well as what types of decisions could be performed while still driving safely” (Blanco et al., 2006, p. 896). Therefore vehicles and their In-Vehicle Technologies (IVT) must be human centered (Bishop, 2005) and take into consideration how the visual attention is conducted, the level of cognitive load a driver faces, and how it should be maintained for safe driving because the driver workload concerns both primary and secondary tasks.

The problems of high cognitive load or high workload have been shown to be caused by increased visual clutter (Horrey & Wickens, 2004). It is also known that displays used to present visual information to the driver are more effective and less likely to be a distraction when the distance of the display is closer to the traffic scene (Wittmann et al., 2006). Research on the placements of Driver Information (DI) has shown that a Head-Up Display (HUD) in relation to Head-Down Displays (HDD) help decrease visual scanning (Liu & Wen, 2004), but these benefits can be reduced under conditions of high workload (Gish & Staplin, 1995. Wickens and Hollands (2000) posit that if the workload increases and the
drivers’ visual scanning is erratic then a better organization of the DI will help reduce the degrading effect of stress. Another note of importance is that the information and how it is presented needs be to easily understood and directly relate to the task or the responses that are be completed (Wickens & Hollands, 2000). This leads to the initial question of what is relevant DI in traffic, where it should be placed, and how it should be presented as to reduce distraction levels. According to Blanco et al. (2006) “A gap exists in the literature; empirical testing is needed to define how much information is too much while driving as well as what types of decisions could be performed while still driving safely” (p. 896).

To understand the problem one must first understand how safe driving is conducted and what can promote distraction. It is known that the act of driving consists of both primary and secondary tasks. The primary task consists of being focused on the road with the eyes only leaving the road to momentarily glance at mirrors and the speedometer. A secondary task comes into play when the driver does something in addition to that which is necessary for driving, like dialing a mobile phone or changing radio channels. When this happens the time watching the road is substantially reduced since the visual attention is divided between the road task and the onboard task (Wittmann et al., 2006). Since the level of risk while driving often varies in relation to the traffic, many drivers choose to complete secondary tasks in less demanding traffic situations in order to reduce the level of risk (Ranney et al., 2000). Each individual type of task calls for a certain level of workload and attentional demand which is associated with that type of task. Some tasks have a higher demand like the sending of a text message and others a lesser like lowering the radio’s volume. Often these tasks are completed while driving without any further complications. It would be logical to think that the lesser the cognitive workload the lower the risk of distraction and, hence, fewer traffic accidents but this may not always be the case.
There are many different DI systems available in modern automobiles and these contain warnings, messages, entertainment information, directional guidance, etc. which demand a certain amount of workload to use. As Schlegel (1993) stated that workload that is too excessive, too low, or that rapidly and unexpectedly changes encourages driver error and, depending on the situation, may result in an accident. These problems can occur in automobiles as a result of IVT’s. Too excessive workload can be a result from Intelligent Vehicle Information Systems (IVIS) and when improperly used in traffic can lead to a greater focus on the function itself than the traffic. The Advanced Driver Assistance Systems (ADAS) can promote a false sense of security which can lead to an over-trust in the system, so much, that the driver becomes overconfident and too relaxed, thus, having too low cognitive workload the driver cannot react quickly enough to unexpected traffic situations and even in some cases totally miss them. Rapid and unexpected changes of information which can result from too much information or simple messages and warnings that unexpectedly light up and/or are interpreted incorrectly can cause confusion and an increased workload, thus, also distracting the driver from the traffic scene. Hence, all these together in vehicle operation show that cognitive workload, driver distraction, and traffic safety are intrinsically intertwined (Patten, 2007).

Michael Goodman of the NHTSA says that at least “25 percent of (all) fatal crashes are distraction related” (Ashley, 2001, p. 53). A distraction can be caused by things from within and without the vehicle (Horberry, Anderson, Regan, Triggs, & Brown, 2006), e.g. appealing roadside advertisements, mobile phones, and even the radio or the CD player can lure the drivers’ focus from the traffic situation (Stutts, Reinfurt, Staplin, & Rodgman, 2001). What happens is that the drivers’ attention, originally focused on the task of driving, attends to something else. In vehicles of today are both IVIS and ADAS used to help prevent accidents
by both guiding the drivers and alerting them of possible hazards. These can be effective while certain problems have arisen from ADAS systems, e. g. Adaptive Cruise Control (ACC), which have allowed drivers to operate with smaller margins while being less focused on the roadway, thus, they end up taking more chances (Hoedemaeker & Brookhuis, 1998). The immediate problem is not the IVIS or ADAS or even the mobile phone themselves but the driver’s relation to it while driving in traffic. Therefore, understanding drivers’ perception, and awareness, of distraction effects may help drivers better manage the engagement and disengagement of in-vehicle activities.

Traffic safety has long been, and still is, a great concern for automobile manufacturers, as Kopits and Cropper (2005) report, traffic accidents are expected to increase globally by 60% from 2000 to 2020. Hence, manufacturers are trying to build economical vehicles that at the same time maintain higher safety levels than previous models. Vehicle safety standards are regulated by governmental organizations but that does not always solve all the safety issue problems, sometimes misses do occur and go unnoticed until a problem arises when vehicles already are in traffic. One example of this was the Mercedes A-class Sedan, which passed all European safety tests, but when a Swedish magazine tested the cars agility to swerve around an unexpected road hazard a serious safety issue came up (Collin, 1997). The automobile was found to be unstable and rolled over, after that, DaimlerChrysler AG was quick to install stability systems in all A-class automobiles. This stability system, previously an expensive option, now became a standard item which was good for the consumer but also became an added cost for the manufacturer. Many customers’ assume that all new vehicles are safe, but this is obviously not always the case. More research needs to be conducted concerning the driver’s needs so that simple “misses” do not occur.
Another problem facing the automobile manufacturers today when trying to produce products for several different markets is an understanding of the specific market’s cultural characteristics. The failure to take into consideration cultural differences has been the account for many failures, that is, what works in one market may not work in another (Ricks, 1993). Each markets social structure, traditions, and even the availability of automobiles affect the way individuals perceive the automobile and its usage. This has lead to that different designs are used for different markets and has become of even more importance today since specific automobiles’ markets may include more than a single country, or culture, and since cultural norms and beliefs are powerful forces in shaping people’s perceptions, dispositions, and behaviors (Markus & Kitayama, 1991). An example of this is the 2008 Honda Civic in which the exterior has softer forms and more rounded body parts for the American market while the one sold on the European market has a much more aggressive design with sharper edges and another instrument panel layout designed to reach a younger customer (Honda Cars, n.d.).

### 1.2 Aim and research questions

The overall purpose of this thesis is to try to clarify how visual information should be presented to the driver to better fit the driver’s abilities in relation to visual demand and cognitive workload, as well as differences in this between different car markets.

To try to answer specific research questions are posed:

- What is the importance of attractiveness, practicality, quality, and safety in vehicles?
- How important are different warnings, driving information, and in-vehicle technologies?
- Where should different warnings, driving information, and in-vehicle technologies be placed?
1.3 Limitations
In this thesis are the respondents’ opinions and not their actual behavior studied. In the questionnaire were attitudes and beliefs of the factors not studied and which could reflect underlying attributes to the responses giving better knowledge of why the stated opinions were as such. The respondents were college students and lesser experienced drivers who might not be a true sample of the different markets in question. In the simulator study the focus was on the drivers’ ability to read warnings and messages presented from four different positions within the simulator but the simulator is not a true vehicle and thus the respondents may have not completed the study as naturally as they would have in a real automobile.

1.4 Research Approach
“Research is a discerning pursuit of the truth. Those who do research are looking for answers” (Hair Jr., Money, Samouel, & Page, 2007, p. 4). In defining the research problem one chooses methods that will be used in searching for answers and those methods often define how the answers will be interpreted. The research process this study has chosen to follow contains three phases, as shown in Figure 1. First the Decision Making Process began with what type of problem was to be studied. When that was decided the project moved to Phase 1 which consisted of Formulation, where the need was established, the problem was defined, a review of pertinent literature was conducted, and the objectives were developed. In Phase 2 the empirical research was executed, sampling methods were confirmed, data collection forms were designed, and data was collected, analyzed, and stored. In Phase 3 Analytical work was conducted, this included data analysis, interpretation of data, the identification of limitations, and the reporting of results.

For this thesis data gathering was conducted via relevant literature, books, articles, and reports, as well as interviews with experts, these were automotive
researchers, human factors experts, and relevant automobile designers, which is a method to increase reliability. Appropriate methods were used based upon the research goals there each method has its advantages and disadvantages. According to Yin (1997) a case study is well fitted for exploratory research, descriptive, or explanatory research, this method was used to find out the “how” or “why” necessary to defining the research problem. This method was conducted in conjunction with experts in the field of automotive safety, experts in human factors, and college students with the purpose of studying multiple sources as to triangulate the results and thus maintaining a high level of rigor.

![Decision Making Process](image)

Figure 1. The basic research process (Hair Jr. et al., 2007)

Both quantitative and qualitative methods were conducted to obtain data for this thesis. The biggest difference between the two methods is that quantitative
approach involves collecting numerical information from belief, opinions, attitudes, behavior, and lifestyles to general characteristics and background information while qualitative involves the recording of narrative information (Hair Jr. et al., 2007). The quantitative approach is best suited for collecting large numbers of data rather quickly from individuals either through observations or surveys. With this method several steps need to be considered, the design, validation by pre-testing, and the method of administration. While the advantages with quantitative methods are that they are easily distributed, standard questions can be used, mutually exclusive questions can be used, the researcher does not need to be present, and data analysis is used to find patterns which can be easily presented in tables and graphs. The drawbacks of this are that the outcomes are often exclusive, language is very important, there is a loss of researcher control, and if the respondents are not motivated then the results will be less accurate (Hair Jr. et al., 2007). The qualitative approach collects narrative data either through observations or interviews and is mostly interested in answering questions of what and how. In this approach the research is conducted through an intense contact with that which is studied, a holistic understanding is to be gained, attempts to capture “inside information” from the study, and try to explicate the ways people relate to their surroundings (Miles & Huberman, 1994). With this process a trained researcher needs to collect the data since asking correct questions and recording them correctly is essential. In the interview process the researcher speaks directly to the respondent, where they can ask open-ended questions, and followed up questions like: why, how, when, where, and who, to gain deeper understanding of the problem in focus (Hair Jr. et al., 2007). Disadvantages are that much more time is required, thus, adding to the costs, very little standardized instrumentation is used, most analysis is done with words, and the researcher is directly involved in the process which can influence the respondents answers (Miles & Huberman, 1994).
Based upon the needs produced from the case study a quantitative questionnaire was deemed most appropriate for this thesis. From those results was a mockup built in a driving simulator to test and compare the respondents’ answers with their actual behavior. This was used to verify the previous work and build a more robust study. A case study according to Yin (1997) using the qualitative method with structured interviews and observations along with a quantitative subjective workload questionnaire were used to gain insight on how the instrument panel could be developed for future automobiles. This was completed through observations and interviews. All these methods were used together to gain as complete picture as possible of the users so that in continuation, concepts can be built based upon their needs.
2 The Driving Task

2.1 Vision
Previous research has shown that the driving process is highly visual and that driving might depend on up to 90% of visual information (Peacock & Karwowski, 1993; Schieber, 1994) but this 90% has not been proven (Sivak, 1996). Studies in laboratory simulators have demonstrated that humans can perform adequately with only visual feedback, even when the visual feedback is distorted or inaccurate (MacAdam, 2003). The role vision plays in driving is indisputable, though, the exact proportion vision plays is uncertain and can even vary depending on the individual (Wallis, Chatziastros, Tresilian, & Tomasvic, 2007). Through visual channels and physical actions is the vehicle is steered by movements on the steering wheel and adjustments on the accelerator and brake pedals. While driving, the driver usually makes small adjustments timed to the vehicles speed in relation to the direction of travel. These adjustments do not, and are not exact in nature since maintaining the direction is done by many small movements. These movements produce a little overall effect on the cars direction yet keep it traveling in the correct direction. Grooves in the road, tire alignment, tire pressure, crosswinds, etc. are few of many factors that do not allow for an exact steering to work, but instead with small steering adjustments a vehicle can be efficiently controlled during travel (Wallis et al., 2007).

Drivers need visual information in order to attend to the driving environment and the act of driving requires the drivers’ visual awareness of the driving environment. This action of visual search which takes in important stimuli is called visual sampling (Wickens & Hollands, 2000). While driving the driver gazes towards the center-of-road, where most information necessary for the driver to keep the vehicle on the road and see road hinders is found. Drivers also look to the left and right of the vehicle for other possible hinders which could affect the drive, e.g. a child running out from behind a parked car to chase after a
loose ball. The driver needs also to attend to what is happening behind them, e.g. an emergency vehicle may need to drive past, or because another driver may have been inattentive to the situation and drove through, an intersection into oncoming traffic, and, finally, the vehicle or vehicles in front may stop abruptly due to one of many unexpected factors. The act of driving includes many uncertainties of which a driver needs to be prepared for. No one will ever be prepared for all the possible incidents that might occur while driving but the more experienced drivers have shown to be able to react quicker and make better decisions in these cases (MacAdam, 2003). Vision research shows that the gaze patterns of experienced drivers cover a greater area from left to right, thus, taking in more of the environment beside the road and, hence, are more in tune to changes on the road side. Lesser experienced drivers, on the other hand, spend more time gazing at the center of the road, in front of the car, and to a much lesser degree are alert for possible incidents. It has also been shown that experienced drivers look in specific places where possible incidents might come from, showing that they are not looking in a greater area just to look but are aware of what might, and sometimes do, happen (Horrey, Wickens, & Consalus, 2005).

### 2.2 Workload

One reason that human errors and inattention occur while driving is that the workload is either too much or too little (Kantowitz & Sorkin, 1983). An illustration on how too much workload negatively affects human task performance is found in Figure 2. The attentional resources can handle a certain amount of workload, this amount varies in individuals, and as the workload becomes more complex the individuals reserve capacity decreases until the individual becomes overloaded. When this occurs the level of performance will decrease. Inattention is defined as workload that is too excessive, too low, or that rapidly and unexpectedly change and encourages driver error and, depending on
the situation, may encourage an accident (Schlegel, 1993). In essence any level of workload that takes the drivers attention away from the act of driving is to be considered distracting.

![Graph showing relationship between workload, attention resources used, and task performance](image)

Figure 2. A schematic relationship in approximate terms, between workload, attention resources that are available and task performance (illustration adapted from Patten, 2007).

### 2.2.1 Inattentional Blindness and Change Blindness

There are two phenomena in the nature of visual awareness that do explain for some of the problems drivers face in traffic. One of these phenomena, called Inattentional Blindness (IB) (Cherry, 1953), occurs when observers fail to notice the presence of unattended stimuli, even when these stimuli are presented within an observer’s field of view and occupy the same location in space as attended and consciously perceived stimuli (e.g. a person can be so focused on watching several children play and never notice who or how many people walked by them). The second phenomena is Change Blindness (CB), which is the difficulty people have detecting changes to visual stimuli that occur across views,
sometimes even when the changing object is being attended (e.g. one could miss the change of colors on a web page when switching between two different pages) (Varakin, Levin, & Fidler, 2004).

These two phenomena do also occur in traffic. IB occurs when a driver becomes so focused on the traffic that he/she misses noticing several exit signs and eventually misses the specific exit itself. The other phenomena, CB, could be when a driver stops to wait for a green light, looks inside the car away from the lights and traffic, looks up again to see a green light and vehicles in the left lane of them moving forward he/she presses the accelerator and crashes into the vehicle in front of him/her which was waiting for the light in their own lane to be given a green signal. In both cases the driver saw the traffic and the lights but due to inattention did not pay attention to what he/she actually needed to notice. Stutts et al. (2001) found out that at least in 5.4% of crashes where at least one driver was not able to drive from the accident scene did the driver look but did not see what caused the impending crash. These phenomena might occur even more often when the driver falls under an increased cognitive workload.

2.2.2 Inattention

Even when drivers are aware of certain dangerous situations they still do end up in accidents and this even happens to the most experienced ones. It may not happen often but it does occur and dangerous situations do occur much more often than do accidents. Drivers can find themselves in a situation where they maneuver away from the danger before an impending disaster occurs. What leads to these situations or “near misses” is interesting in that learning why they occur could help the understanding of them and, thus, this knowledge could be used to prevent future traffic accidents.
Based on an analysis of NHTSA crash data, “distraction” (attending to tasks other than driving, e.g., tuning the radio, speaking on a phone, looking at a billboard, etc.), “looked but did not see” (e.g., situations where the driver may be lost in thought or was not fully attentive to the surroundings, IB and CB), and situations where the driver was drowsy or fell asleep account for approximately 25% of police reported crashes (Ranney et al., 2000). Driver inattention is similar to driver distraction and there are four distinct categories of driver inattention; visual (e.g., looking away from the roadway), auditory (e.g., responding to a ringing mobile phone), biomechanical (e.g., manually adjusting the radio volume), and cognitive (e.g., being lost in thought) (Ranney et al., 2000). All of these can arise from either too little or too much workload or under normal workload conditions. In a study of North Carolina accident reports Wierwille and Tijerina (1996) found that where the drivers’ attention was diverted 55.5% of the crashes involved distraction from within the vehicle. In another study of crashes caused by distraction Stutts, et al., (2001) found that 11% of crashes occurred when the driver adjusted the entertainment system.

Knowing how and where to look for hazards is a learned ability rather than an innate ability (Groeger, 2000). And an understanding of the vehicles mechanical processes is not necessary for one to be a good driver. But instead the mental and physical processes that are involved have much to do with how the external driving environment is interpreted. Accident statistics show that experienced drivers are much less likely to be involved in an accident than novice drivers because they can better anticipate dangerous situations (Chapman & Underwood, 1998). It takes experience to learn how to drive in traffic, to learn how other drivers react, and how to be prepared for unexpected situations. As stated previously more experienced drivers have a larger gaze area and have learned to be prepared for different situations, thus, are able to react quicker. As Groeger (2000) states that drivers who anticipate hazards in traffic and react correctly to
them learn associations between different types of hazards and, thus, can anticipate other similar types of hazards in the future. Knowing how to predict hazards is what is learned from experience and, hence, an important factor which separates the more experienced from the inexperienced drivers.

2.2.3 Primary and Secondary Tasks
The task of driving a vehicle and all actions taken for proper navigating on the road, and through traffic, is considered the primary task, which includes the physical actions of pressing the accelerator, the brake pedal, if necessary the clutch pedal, the operation of the transmission, and steering the vehicle. These tasks are often conducted unconsciously since they are performed out of habit, e.g. experienced drivers do not need to think about how to shift nor when to shift, it has become an automatic behavior.

Secondary tasks are those which are not directly necessary for the vehicles navigation and may involve driving-related tasks (e.g., adjusting a mirror), tasks indirectly related to driving (e.g., navigation planning), or tasks unrelated to driving (e.g., talking, eating). These tasks are often not part of the natural driving responses and, therefore, do increase the potential for distraction. The workload or attentional demand associated with these tasks can vary even if it is an unconscious decision like to pick up a piece of paper from the floor of the vehicle. Decisions like this create additional demands on the driver. It is clear that drivers do conduct complex behavior that is potentially harmful. This is practiced and drivers know when they can take these chances by choosing opportunities that are conducive to their actions and level of experience in traffic. The drivers “willingness to engage” takes into consideration many factors, “including driver (e.g. experience), vehicle (e.g. display design), environmental (e.g. weather), situational (e.g. urgency) and task characteristics (e.g. ease of use)” (Ranney et al., 2000, p. 2). Drivers learn that they can conduct these types of secondary tasks.
while driving without harmful consequences. Drivers may engage in distracting activities simply because they may be overconfident in their skills and their ability to deal with distractions while behind the wheel (Wogalter & Mayhorn, 2005b). They learn to drive at high speeds on heavily trafficked roads without realizing that their behavior is potentially dangerous and that one mistake can have lifelong regrets. Lesch and Hancock (2004) suggest that drivers do not really have a totally correct picture of distraction and its effect on them while driving.

Distraction or cognitive overload can be defined as a general withdrawal of attention which manifests itself in both degraded vehicle control and degraded object and event detection. The first withdrawal of attention could relate to eyelid closer (fatigue) or glances away from the center of road. The second type of distraction is called “selective withdrawal of attention”. This is when “vehicle control (e.g. lane keeping, speed maintenance) remains largely unaffected but object and event detection is degraded” (Tijerina, 2000, p. 2). The underlying cause of this is when the drivers attention to thoughts not related to the primary task of driving helps them lose focus resulting in “visual scanning, restricted visual sampling of mirrors and road scene, fixating too close, and selective filtering of information based on expectations rather than the actual situation” (Tijerina, 2000, p. 2). Distraction occurs from both inside and outside the vehicle (Horberry et al., 2006). It can be advertisements that cause the driver to lose track of the traffic situation or pedestrians as well as the vehicles own controls. Not only are mobile phones cause for distraction, even the vehicles own radio, cassette, or CD player have been found to be major causes of accidents (Stutts et al., 2001). Another consideration is that young novice drivers with less driving experience have shown to be more likely to be distracted while driving (Horberry et al., 2006).
Over 25% of fatal crashes are related to the driver being distracted (Ashley, 2001). “Distraction was most likely to be involved in rear-end collisions in which the lead vehicle was stopped and in single vehicle crashes. Crashes in which the driver “looked but did not see” occurred most often at intersections and in lane-changing/merging situations” (Ranney et al., 2000, p. 3). It is well known that in-vehicle tasks do have a significant detrimental effect on driving performance, e.g. slowed response times or missed traffic events (Alm & Nilsson, 1995; Horrey & Wickens, 2006). Even though the problem is known, drivers continue to drive with degraded performance. They engage in distracting activities since they either do not understand that their performance is degraded (Wogalter & Mayhorn, 2005a) or that they do not know their own limitations in relation to the distraction effects (Horrey, Lesch, & Garabet, 2008; Lesch & Hancock, 2004). In a study to measure how drivers subjectively rate their performance against the actual effects Horrey et al. (2008) found that “drivers are not well-calibrated to the distracting effects” (p. 681) and in some cases the distracting effects were subjectively rated as less distracting as the distraction effects increased. Distraction can also have positive effects such as in monotonous traffic situations where driver boredom can be a problem. This is where certain levels of distraction could be necessary as to increase arousal, thus, helping the driver stay alert.
3 Safe Driving

3.1 In-vehicle Technologies
As new technologies began to be implemented in vehicles did new and chaotic tendencies become more prevalent in crash statistics, which could imply that these new technologies caused drivers to take their eyes and mind off the road (Tijerina, 1996). “The role of the driver is not adequately addressed when it comes to Intelligent Vehicle systems” (Bishop, 2005, p. 271) and they must be since they are inherently human-centered. There is a need to understand how drivers perceive and are aware of the effects of distraction so that high tech interventions can be used more accurately in mitigating distraction (Horrey et al., 2008). The number of cognitively demanding secondary tasks has greatly increased in the recent years, in the early 80’s the radio and cassette player were considered a distraction risk, in the 90’s CD players and navigation systems, and now more recently in the 00’s are warnings from many ADAS and IVIS, these have added to the number of demanding secondary tasks present in automobiles of today (Blanco, Hankey, & Chestnut, 2005) and little is still known about their potential for substantial cognitive demand (Blanco et al., 2006).

There are methods used to measure visual demand, e.g. eye-tracking equipment, and auditory demand, e.g. listening tests, while there is no valid measure for cognitive demand during visual tasks like driving. The amount of cognitive and visual demand a driver is faced with from secondary IVIS tasks is not certain, but the scientific community agrees that cognitive and visual demand do exist (Blanco et al., 2006). Some auditory tasks do cause drivers to become distracted and miss certain traffic situations (Richard et al., 2002) while others believe that the auditory demand for a task, i.e. dialing a phone call, would be much more if the driver had to physically press the buttons (Schreiner, Blanco, & Hankey, 2004a, 2004b). There are individual differences in drivers, where some choose to conduct secondary tasks while driving while others prefer not to. Some do not
feel comfortable making a phone call while driving or looking into the menu system of the MP3 player or changing the navigator settings, etc. whereas they would like to do it but choose not to since they feel unsafe doing it while driving. On the other hand, those who are more impulsive, showing greater tendencies to take risks, can and do take risks allowing themselves to be distracted while driving causing dangerous situations for themselves and others.

Automobile manufacturers are constantly working on improving the driver environment. Many of the new systems present warnings or information for hazards. In these cases, conflicts can occur in that a warning is not correctly understood. The goal of warnings is to increase safety in that drivers interpret them correctly and carry out the prescribed actions correctly (Wogalter & Mayhorn, 2005a). In vehicles only a few decades ago were only simple warnings needed, unlike today where convenience systems, safety systems, productivity systems, and traffic-assist systems are all used in vehicles (Bishop, 2005) to improve safety and convenience. And for these “to be effective, it must motivate individuals to comply with its directives” (Dejoy, 1999). Presenting content that is understandable and motivates its users to comply is the goal of technology-based warning systems and many of the ADAS and IVIS information systems should be combined to support the entire warning process for driving (Wogalter & Mayhorn, 2005b). This means that already in the design phase, system compatibility should be included, which allows systems to communicate with each other, thus, not being separate, independent systems. There has to be systems which cooperate in presenting necessary relevant warnings and/or information to the driver at the relevant place in time (Buuchholz, 2004). As Volvo did with the built-in mobile phone, in that the phone would not ring when the car was making more abrupt maneuvers, i.e. in a round about or while making evasive maneuvers in traffic, so that the driver would not be distracted in more cognitively demanding situations. This was also one of first attempts made
by a manufacturer to reduce distractions from the automobile’s systems itself. At a more simple level are drivers able to personalize the vehicles systems by themselves but more advanced systems are on the way and for these to be safe and functional more specific information about the driver’s limitations and capabilities are is needed (Wogalter & Mayhorn, 2005b). Thus a system can, knowing what the driver prefers, predict actions preparing the systems for possible responses, giving the driver cognitive support, this includes the radio all the way to advanced accident prevention systems (Liu & Wen, 2004; Nakamura et al., 2005).

Daimler-Benz chief of research Klaus-Dieter Vohringer stated that “every second road accident can be prevented if vehicles are equipped with suitable assistance systems” and he added “there’s a business case for investing in safety systems” (Hoffman, 2002, p. 1). Aside from the fact that safety sells cars technological helps are added to vehicles as to reduce accidents. Affordable computing and sensor technologies have made new applications possible which has allowed the usage in traffic and in the automobile environment (Bishop, 2005; Hoffman, 2002). “Technology based warning systems offer improved information accessibility because they can deliver information at the points of time when it is needed” (Wogalter & Mayhorn, 2005b, p. 526). Technology can be used to attract people’s attention better through colors and animated symbols (Wogalter & Leonard, 1999) but the best feature is that specific warnings can be more dynamic and tailored for a specific user with a specific task (Essa, 1999). The NHTSA (2007) has become concerned about what is being made available to the driver both from automotive manufacturers and aftermarket manufacturers in that they sell and promote items that make greater amounts of information and functionality available to the driver without carefully taking into consideration how it could effect the cognitive capabilities of the driver and, hence, traffic safety (Ranney et al., 2000).
3.1.1 Intelligent Vehicles

Intelligent Vehicle Technologies (IVT)’s are designed to assist drivers by presenting real-time information regarding routes, delays, congestion, and warnings of potential hazards (May, Ross, & Osman, 2005). According to Bishop (2005) driving a vehicle consists of four basic functions: monitoring, perception, judgment, and action. The benefit with IVT functions is that they do not waiver in their monitoring nor hesitate in their reaction. IVT systems are defined as “…systems that sense the driving environment and provide information or vehicle control to assist the driver in optimal vehicle operation” (Bishop, 2005, p. 3). Today these items are considered to be antilock braking, traction control, etc. but it is much more than that. Systems that assist in braking, throttle control, and steering as well as systems that monitor the driver so that he/she can be best prepared for the traffic situation without being distracted by secondary tasks or boredom. Both IVIS and ADAS systems are an example of IVT’s of which an example is found on the instrument panel and windscreen in Figure 3.

Figure 3. An example of an automobile with IVIS and ADAS systems installed in the dashboard and windshield (Siemens VDO, 2006).
3.1.2 Pros and Cons with Respect to IVT’s

The long term goal of IVT systems is to make a vehicle function autonomously in traffic. Advanced driver safety systems otherwise known as ADAS, on the other hand, are active safety measures that are designed to increase road safety, road capacity, and attenuate environmental load in traffic (Wiethoff, Oei, Penttinen, Anttila, & Marchau, 2002). The systems available today are basically stand-alone but will be fully integrated by the end of the decade and ADAS will see broader usage from 2010 to 2020, giving new opportunities for road and traffic interaction (Bishop, 2005). This would include collision warning systems that take into account weather and road conditions when warning the driver, e.g. giving more time to brake in slippery conditions than in normal dry conditions. Around 2020 should vehicle to vehicle interaction become more mainstream, allowing vehicles to communicate and cooperate in traffic and the onboard systems will detect developing crash situations and take proper steps to avoid crashes (Bishop, 2005).

Intelligent Vehicle Information Systems (IVIS) can be called “convenience systems” which are other support systems than those which is directly related to driving, i.e. navigation helps and other support as to reduce the stress of driving. These systems are not “legally” safety systems (Bishop, 2005). However, there is concern over their potential to distract drivers and reduce driving performance as well as increase accidents even more (Engström, Johansson, & Östlund, 2005; Goodman et al., 1997; Goodman, Tijerina, Bents, & Wierwille, 1999; Tijerina, Johnston, Parmer, Winterbottom, & Goodman, 2000). That’s why they are not marked as safety systems. The weight of burden is upon the drivers themselves to perform safely, to decide when to do secondary tasks, and how to use these advanced functions as driving support. Some studies have shown that IVIS tasks create a greater attention demand for the driver and are more cognitively demanding than conventional secondary tasks in the vehicle due to additional decision making demands involved in the driving process (Blanco et al., 2006).
Even when the driver desires to maintain safe driving it is not always sufficient to prevent distraction since the driver can still become more focused upon what is happening in the vehicle than in the traffic.

This has lead to the ADAS safety systems which have the function of actively assisting the driver in avoiding accidents by providing information about current and upcoming traffic situations and helping the driver to take proper actions. Even some driver assistance systems may occasionally demand the driver’s attention (Harms & Patten, 2003). These systems can vary from adaptive headlights which adjust to the type of driving, i.e. illuminating for turns or bends in the road, night vision, animal warning, to crash prevention from the front, back, and sides, which are measures designed to warn, steer, and brake. Warnings for impaired drivers, i.e. drowsiness, and road surface monitoring will help stop unnecessary driver errors due to inattention. Precrash systems determine that a crash is inevitable and prepare the vehicle and assist the driver to minimize physical damage to the car and it’s occupants. Even external speed control functions are included so that the speed maintains the governmental defined speed limits, which would work with satellite positioning in conjunction with digital maps. These can even adjust to the time of day and weather conditions (Blanco et al., 2006). Regardless of type, IVT’s require drivers to sometimes divide their attention between in-vehicle information and the driving environment. The impact of these devices on attention may depend both on the design and on the function of such systems. It is possible that minor physical differences between devices with similar functions effect the driver’s attention differently, and methods sensitive for measuring such differences would produce valuable information for safer IVT design useful to authorities, users and producers of IVT’s (Harms & Patten, 2003).
Concerning automobiles and the crash protection that they provide Kopf states in Blythe and Curtis (2004) that “the fatality reducing potential of passive safety measures is almost exhausted. Therefore, active safety measures such as ADAS seem to be the only means of reducing the number of accidents” (p. 2). Knowing that 25 to 50% of all accidents involve driver inattention (NHTSA, 1997; Ranney et al., 2000; Sussman et al., 1985; Wang et al., 1996) this will become a research area of even greater interest.

3.2 Display placement
It is known that the human eye has a peripheral field of view of approximately 210°, however the central field of view, foveal vision, is only 2° (Miura, 1990). The eyes’ ability to notice changes in the environment decreases as the distance from the fovea increases and the foveal acuity decreases by a factor of three beyond a 15° parafoveal eccentricity of the central field of view. This means that displays beyond the 15° are much more difficult to notice and are not clearly seen. Two important factors need to be understood concerning vision, the first is that within approximately 15° from the central field of view are eye movements executed most efficiently, and secondly, there seems to be a border at 30° for the vertical meridian and 35° for the horizontal meridian mark in which peripheral information can be detected most accurately. The limits for detecting objects above the line of sight is 50° and below the line of sight is 70° (Diffrient, Tilley, & Harman, 1981) (Figure 4). This means that a person is required to rapidly move their eyes, beyond that which is most efficiently seen, to scan the road scene and the instrument panel for other information while driving. Since head movements can be limited for varying reasons there are some important signals in the vehicle compartment and in the traffic scene which are missed due to lack of proper visual scanning.
Traditionally primary DI has been presented in the HDD, which is found roughly from 20° to 25° below the center of the drivers’ line of sight. This means that the HDD is found within the peripheral vision but the driver needs to turn his/her head to see and read the information. For small amounts of information, this is quickly done, i.e., vehicle speed, and quickly interpreted and the driver can return to scanning the traffic scene. The HUD location, which is found from about 10° to 15° below the center line of sight, presents information closer to the parafoveal eccentricity there the driver can quickly look at the information without glancing away from the traffic scene. The Infotainment display (IF) location can also be placed higher up on the dashboard, closer to 15° below the line of sight and about 30° towards center of the vehicle, and can be used to present more complex information at a level the driver can read while keeping foveal acuity of the traffic scene. Finally, the Center-Stack display (CS) location is furthest from the line of sight, roughly 30° to the center of the automobile from the driver and more than 25° below the line of sight. Attending to this placement requires a total loss of vision to the road scene (Wittmann et al., 2006).
Since the 1980’s vehicle manufacturers have been looking for different solutions to the ever increasing amount of information being presented to the driver (Bishop, 2005). The placements being used are typically the HDD, IF, CS, and with a few exceptions the HUD. Different vehicle manufacturers have experimented with other placements, e.g. in the middle of the dashboard just below the windshield, which are higher up and closer to the line of sight. And some have chosen to split up information presentation to separate areas, while others have chosen to concentrate information in the HDD area. In some cases even the radio, CD, Mp3 player, etc. have been moved to the HDD, an area which was typically used for primary DI. Menus presenting more detailed vehicle information and driver helps are also typically found in the HDD. The HUD has been tested but found to be too expensive for most automobiles and thus have been limited to more exclusive models (Head up price, 2006). Automobile manufacturers who choose to use IF and CS displays for varied information presentation spread out the amount of data presented to the driver over a greater area, separating primary and secondary tasks, which may be good but it also places greater requirements on the driver’s visual scanning.

Figure 5. Visual of HUD, HDD, IF, and CS locations in an automobile.
In a typical vehicle can IVIS and ADAS information be found in the HDD which, in some cases has resulted in many individual functions being found in the HDD alone, whereas some manufacturers chose to use the IF display and give the driver up to 700 functions like in the BMW i-Drive (Cobb, 2002; Summerskill, Porter, & Burnett, 2004). An example of a vehicle interior with the four locations is in found in Figure 5.

Several studies have shown that the HUD position is a viable alternative for information placement in airplanes (Wickens & Hollands, 2000) as well as in automobiles (Liu & Wen, 2004; Wittmann et al., 2006) but according to Tufano (1997) airplane research can not be directly accepted for automobiles due to the inherent differences in the visual background. Vehicle traffic presents different demands, since the traffic scene is much more complex than airplane traffic while in flight. Even though the HUD opens up new possibilities, because it reduces the number, and duration of, drivers’ sight deviations from the road. Thereby the drivers can receive information without taking their eyes off the road (Dingus, 1989; P. Green, 1999). While distraction problems found in airplane HUD’s, where imposed images distracted the pilots from noticing changes in the external environment (Wickens, 2005), do not seem to present the same problem for automobiles since the main focus of driving is upon the traffic scene not the instruments like in airplanes. Ward and Parkes (1994) did observe that the HUD required a higher mental effort from the drivers and a higher cognitive load while similar studies have been conducted resulting in reduced workload, decreased response times, more consistent speed, and increased driving comfort (Liu & Wen, 2004; Nakamura et al., 2005). One thing that needs to be considered is that certain types of information cannot be done away with since they are primary for driving, so the safest presentation method for information needs to be tested and implemented.
A dilemma the automobile industry is facing is how to expand the ways visual information can be presented to the driver without increasing cognitive load and, at the same time, increase safety in traffic. A distribution of multiple displays will require more visual scanning time in the automobile and increase the chances for driver distraction. Tsimhoni and Green (2001) amongst others showed that driving is effected negatively when paying attention to a secondary task and Wittmann et al. (2006) posits that “road control can still be maintained when the distance of the display to the line of sight outside is not too great” (p. 188). Therefore, “…car manufacturers should carefully consider the placement of onboard displays for the presentation of visual information in the car” (p. 196).

The literature shows that positions up front and center could be good placements for information comprehension and maintaining distraction levels in automobiles, however, there are other placements available and being used. It is possible that several placements can be targeted, as a way to separate tasks, or levels of tasks, to help the driver keep a better mental image of the driving environment and the systems overall relevance to the primary driving task. The placements and the types of systems/information presentations should be tested for what is appropriate, safe, and acceptable to the driver.
4 Cultures and Car Markets

4.1 Traffic Accidents
The number of automobiles in the world has increased greatly and it has become a symbol of success for “any aspiring person from Boston to Belgrade to Beijing” (Newman & Kenworthy, 2007, p. 67) which has led to a great increase of automobiles in most countries. Kopits and Cropper (2005) show that there will be a 66% increase in traffic fatalities worldwide from 2000 to 2020, with the greatest proportion of this increase to be found being in developing countries. In 1970 there were about 200 million automobiles worldwide, 850 million in 2006, and by 2030 this number is expected to increase to 1.6 billion (Newman & Kenworthy, 2007). World Health Organization (WHO) (2008) records show that 1.19 million people died in road traffic accidents in 2002. Mathers and Loncar (2006) predict a 51% increase by 2020, somewhat lower than Kopits and Croppers (2005) but, nonetheless, they both agree that traffic fatalities are a worldwide problem. If developing countries follow the same historic trends that high income countries have then a country like India will not see the death toll decline until 2042.

In China it was estimated that 680 people die daily in traffic, in comparison to the US, which had eight times the number of vehicles with only 118 fatalities per day (Brown, 2004). Over 20% of all the worlds’ traffic fatalities occur in China, a country with a low vehicle density of 1.4% (National Bureau of Statistics of China, 2006) while the US had a vehicle density of 86% (Bureau of Transportation Statistics, 2008). On the other hand Sweden, had less traffic fatalities than both China and the US, with 49/M as opposed to US 147/M, and China 192/M (Bureau of Transportation Statistics, 2008; CARE project data, 2005; National Bureau of Statistics of China, 2006; NHTSA, 2007).
It is, though, difficult to compare the costs of traffic fatalities relating to, for instance, China by just presenting financial figures. Another way to look at it is to see how it effects the population in general. In China are traffic accidents the second largest cause of death for Chinese children, this number is 2.5 times greater than Europe and 2.6 times greater than in the US (Xinhuanet, 2004). Progress is being made to reduce traffic accidents through road engineering, vehicle construction, driver education, and even through legislation. Roads are being built to separate traffic as to reduce head-on crashes, automobiles are being built with better occupant protection and advanced crash warning systems, drivers are being educated of the risks involved with driving and how to lower them, and laws are implemented to reduce dangers in traffic, i.e. hand held mobile phone conversations are not allowed while driving, and increased punishment for breaking traffic laws has been implemented.

4.2 Values and Norms
The automobile market is an international market, thus, it is important for automobile manufacturers to gain an understanding of the pertinent markets when designing and building automobiles for those. The failure to take cultural differences into account has been the cause of many business failures (Ricks, 1993). Aaker and Maheswaran (1997) expressed a need for cross-cultural studies in order to understand the processes in which cultural differences effect attitudes and behavioral actions. The sought after cultural factors need to be understood through studying the local customs and their social norms to find out what needs are to be focused on, as well as, how products should be introduced into the market. However, it is not always true that an immediate positive response is needed when introducing new products, a controversial introduction producing negative responses can also be most appropriate, stimulating and producing sales for the product (Leach & Liu, 1998). While cultural values are shared beliefs, desirable end states or behaviors, transcend specific situations, guide selection or
evaluation of behavior, and events are ordered by relative importance (Schwartz & Bilsky, 1987). It is important to know that cultural values are beliefs about behaviors and goals specific groups, or societies, understand to be important and they also help determine the consumer value (Leach & Liu, 1998).

In addition to holding cultural values, societies utilize cultural norms to regulate behavior amongst their members. These norms are rules and behaviors that are approved by one’s group or society (Fisher & Ackerman, 1998). Unlike cultural values, cultural norms are context specific, because they specify what group members should, or ought to do, within a specific situation or role (Berry, 1993; Cialdini, Kallgren, & Reno, 1991; Fisher & Ackerman, 1998). It has been demonstrated that similar advertisements produce different effects in different cultures (Han & Shavitt, 1994). Advertisements that appeal to individualistic benefits are more persuasive in the US than in Korea, while advertisements appealing to the collective family or group are more appealing in Korea than in the US. This means that attitudes towards differentiation and uniqueness tend to be more favorable for members of individualistic cultures, while attitudes toward building relationships and maintaining connections tend to be more favorable for members of collectivistic cultures (Aaker & Maheswaran, 1997). Research has shown that in highly individualistic countries individuals are seen as separate entities and they can leave social groups as they please and behave according to their own social preferences. While in highly collectivist cultures are individuals identified as members in a group, of which they cannot freely leave and behave against to the group norms (Bagozzi, Wong, Abe, & Bergami, 2000; Morris & Peng, 1994).

In trying to understand cultural differences we need to understand that consumers from different cultures may purchase similar products and services but this does not necessarily imply that the culture’s influence on product/service
purchase and use are similar. People may utilize the same product and service features for very different reasons (Aaker & Maheswaran, 1997; Bagozzi & Dholakia, 1999). Consequently, cultural diversity remains a highly influential factor in international business (Overby, Woodruff, & Gardial, 2005) and since national cultures “dwarf” the differences between regions and within-national groups it is important to study them (Schwartz & Ros, 1995; Smith & Bond, 1993; Smith & Schwartz, 1997) since national culture has been shown to significantly influence consumer decision making (Briley, Morris, & Simonson, 2000), intentions (Bagozzi et al., 2000), persuasion (Aaker, 2000), and product attribute importance (Tse, Wong, & Tan, 1988).

4.3 Consumer Behavior

Studies have found significant differences in color perceptions between consumers in China, South Korea, Japan, and the US (Jacobs, Keown, Worthley, & Kyung-Il, 1991) and these perceptions can substantially affect how consumers value a product (Leichtling, 2005). Color has shown to rank among the top three considerations, along with price and quality, in the purchase of an automobile (Grossman & Wisenblit, 1999). This is also true in cognitive differences in a study by Choong and Salvendy (1998), where US and Chinese respondents showed significant differences in their comprehension of icon displays. The US respondents performed better with textual and combined modes compared to the pictorial mode while the Chinese performed better in pictorial and combined modes, compared with the textual mode, and these differences in part relate to the way these cultures reason. The Westerners are relatively analytic and the Chinese relatively holistic in the way they categorize (Ji, Zhang, & Nisbett, 2004). It is also known that people may utilize the same product and service features for very different reasons, e.g. in Europe certain products sell well in many countries but the motives are varied (Aaker & Maheswaran, 1997; Bagozzi
& Dholakia, 1999). Consequently, cultural diversity remains a highly influential factor in international business (Overby et al., 2005).

However, determining what motivates the consumers and how they value products can be a challenge (Wilson, 2003), and this becomes even more complex and challenging when considering multiple, international markets. Even though the phenomenon is recognized internationally, its effect on peoples perceptions and their behavior may vary in different cultures (Overby et al., 2005). The organizations who respond appropriately to the needs of the markets will have a significant advantage, e.g. when they plan globally but adapt to local conditions (Kefalas, 1998; Tai & Wong, 1998).

Four general tools are traditionally understood to be used in influencing consumer behavior; advertising, pricing, physical distribution and display of product, and the product itself (Alba & Hutchinson, 2007). As DaimlerChrysler AG understands that safety sells cars (Hoffman, 2002), meaning that specific qualities of the product itself, i.e. safety, help sell automobiles. But that may not be enough to compete with other automobile models, advertisements need to be used, they often tell a story, creating an image, describing the product to the prospective customers, thus informing them and influencing them, with hopes of making the automobile more attractive than the competing models. A recent analysis of Canadian automobile advertisements showed that advertisers used four key themes to improve sales: performance, price, lifestyle, and safety (Rudin-Brown et al., 2008). These themes have been found effective and, thus, are being used to influence consumer behavior. Since advertising is often quickly forgotten are advertisements repeated often to help imprint themselves in the consumer’s memory (Alba & Hutchinson, 2007). Not only does the manufacturer need to remind the consumer of their products as to influence their buying they also include the price as a way to reinforce the idea that they are selling a product
with high consumer value. Consumer value is the buyers’ perceptions of value in relation to the perceived cost, that is, the benefits they receive in relation to the sacrifice they perceive by paying the price (Monroe, 1990). Therefore, pricing is an important factor to consumers even though an automobile may be priced low, that in itself it may not be deemed as attractive to the potential buyer, but when an attractive brand is coupled to the product along with the price consumers perceive it as having a higher consumer value. As it is known brand names in themselves do exert considerable influence on consumer decision-making (Keller, 2008). Availability, and presentation, of the automobile in showrooms has an effect on consumer demand, there even limited numbers, and a luxurious display can also influence the prospective buyer to believe that the model is rare in quantity and an exclusive item available for the privileged few. These factors coupled with an expensive price tag allow the customer to feel more exclusive if they were to own such a model, thus, they get what they perceive as an automobile with a high consumer value.
5  Attractiveness, Practicality, Quality, and Safety in Vehicles

5.1 Introduction
The automobile industry is an international industry where culture and cultural differences are often taken into consideration upon entering new markets. In this study culture is defined as a group’s characteristic way of perceiving the man-made part of its environment (Triandis, 1972). In trying to understand cultural differences we need to understand that consumers from different markets may purchase the same, or similar, products and services but this does not necessarily imply that the social and cultural influences to why those products and services are purchased are similar. People may utilize the same product and service features for very different reasons (Aaker & Maheswaran, 1997; Bagozzi & Dholakia, 1999). Consequently, cultural diversity remains a highly influential factor in international business (Overby et al., 2005). This chapter seeks to understand the consumers’ perceptions of the importance of attractiveness, practicality, quality, and safety when buying a new vehicle. To gain an understanding of the role different cultures play in these perceptions were three diverse markets studied.

5.2 Method
5.2.1 Respondents
Data was gathered from students and drivers from China (165), Sweden (138), and US (70). The Swedish and US respondents were college students attending universities in urban areas; Luleå, Sweden and West Palm Beach, FL, and the Chinese were lesser experienced drivers from the urban area of Beijing, China. Most of the respondents were between 20 and 25 years of age. In all the cases were the respondents first asked if they were willing to help in the study and in all cases were the students compliant while 165 of 175 approached Chinese respondents agreed to complete the questionnaire. 25 were removed from the original sample because they did not complete all the questions.
College students were chosen as respondents since they have been shown to maintain the same values as the general population (Schwartz, 2006). College students tend to be, because of their age, lesser experienced drivers and more likely to buy a new automobile than their peers since they are more likely to work in higher paying jobs after graduation, as well as are more likely to accept new and different ideas, for instance, in the vehicle environment. Attempts were made to reach Chinese college students with some driving experience but Chinese college students did not have drivers’ licenses nor were their knowledge of automobiles acceptable for this test. Therefore were less experienced drivers recruited since they would be more like their Western counterparts.

5.2.2 Material

The questionnaires were given, and answered, in the respondents native language to, thus, reach the respondents native cultural mindset (Whorf, 1956; Witkowski & Brown, 1982). Back-translation as prescribed by Werner and Campbell (1970) was used to test the questions for correctness in the Swedish version. The Chinese questionnaire was translated from English through an iterative parallel translation process by several bilingual researchers. The different versions were compared and a final version was completed using agreed upon results. The Swedish and US questionnaires contained five items that were to be ranked from 1 (most important) to 5 (least important). These were; feels safe, practicality, feeling of quality, exterior design, and interior design. Both interior and exterior design concerned the physical look of the vehicle and both the Swedish and the US respondents rating resulted in both of these variables having similar scores. The Chinese questionnaire was produced with only an attractive variable due to conflicts in translation therefore was the decision made to combine the interior and exterior design responses together into an attractive variable. The Friedman test was used in the ranking of variables and the Kruskal-Wallis test was used to compare the variables between the countries.
5.2.3 Procedure
The Swedish questionnaires were given to randomly chosen university teachers in randomly chosen fields of study to administer in the classroom. The American questionnaires were given to professors at an American university where students were administered the questionnaire in the classroom. Chinese researchers recruited less experienced Chinese drivers in Beijing, China.

5.3 Results
5.3.1 Respondents
In this study 165 (61% females) drivers represented the market of China, 128 college students (27% females) the market of Sweden, and 70 college students (71% females) represented the market of US (Table 1). The average age of the Chinese respondents was 33 (females 21-57 and males 22-51), of the Swedish 22 (females 19-35 and males 18-65), and of the US 23 (females 16-69 and males 18-69). Of the Chinese respondents 98.8% (98.0% females and 100% males) had a driver’s license, of the Swedish 82.0% (75% females and 83.3% males), and of the US 95.7% (98.4% females and 92.9% males) had a driver’s license. The Swedish respondents had the least amount of driving experience with females having 3.3 years of experience and males 3.7, followed by the Chinese 4.7 and 7.0 years, respectively for females and males, while the US had the most driving experience with females having 5.4 years and males 9.1 years of experience.

Table 1. Sociodemographics distributed over markets and gender.

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<thead>
<tr>
<th>Age(M) (Range)</th>
<th>CHINA</th>
<th>SWEDEN</th>
<th>US</th>
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<tbody>
<tr>
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<td>Males (n=65)</td>
<td>Females (n=35)</td>
<td>Males (n=93)</td>
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<td>32 (21-57)</td>
<td>33 (22-31)</td>
<td>22 (19-35)</td>
<td>22 (18-65)</td>
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<tr>
<td>Driver’s License (%)</td>
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<td>98 (98)</td>
<td>65 (100)</td>
<td>27 (77)</td>
<td>78 (84)</td>
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<tr>
<td>Years of Exp. (M) (Range)</td>
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<tr>
<td>4.7 (0-13)</td>
<td>7.0 (1-22)</td>
<td>3.3 (0-17)</td>
<td>3.7 (0-40)</td>
</tr>
</tbody>
</table>
5.3.2 Importance

When the respondents were asked to rank the importance of attractiveness, practicality, quality, and safety in order of importance when deciding to buy a new private vehicle from 1 (most important) to 5 (least important) all three groups chose safety as either the most or second most important item (Table 2).

Table 2. Importance of Attractiveness, Practicality, Quality, and Safety distributed over markets and gender.

<table>
<thead>
<tr>
<th></th>
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<td></td>
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<td>3</td>
<td>3</td>
<td>4</td>
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<tr>
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<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Quality</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Safety</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Chinese respondents significantly ranked safety as most important followed by practicality, attractiveness and quality $\chi^2(3, N=165)=144.76, p=.000$, Swedish respondents significantly gave quality most importance followed by safety, practicality, and attractiveness $\chi^2(3, N=118)=20.07, p=.000$, and the US respondents significantly chose safety as most important followed by quality, practicality, and attractiveness $\chi^2(3, N=64)=8.81, p=.032$. The Chinese female respondents significantly ranked safety as most important followed by practicality, attractiveness, and quality $\chi^2(3, N=100)=103.34, p=.000$, the Swedish significantly ranked safety as most important followed by quality, attractiveness, and practicality $\chi^2(3, N=34)=10.87, p=.012$, and the US female respondents ranked safety as most important followed by quality, practicality, and attractiveness $\chi^2(3, N=47)=6.97, p=.073$. On the other hand, the Chinese male respondents significantly ranked safety as most important followed by practical, attractiveness, and quality $\chi^2(3, N=65)=44.42, p=.000$, the Swedish significantly ranked
quality as most important followed by practicality, safety, and attractiveness \( \chi^2(3, N=84) = 27.18, p = .000 \), and the US male respondents practicality as most important followed by safety, quality, and attractiveness \( \chi^2(3, N=17) = 3.14, p = .370 \). Safety was most important for all females and for the Chinese, while quality was most important for the Swedish males and practicality for the US males. Safety showed significant differences between the countries \( \chi^2(2, N=348) = 61.61, p = .000 \) there China rated it as most important, USA second most important, and Sweden third. Practicality was significant \( \chi^2(2, N=353) = 18.57, p = .000 \) in that China rated it as most important, followed by USA and Sweden, respectively. Quality was significant \( \chi^2(2, N=363) = 46.67, p = .000 \) in that Sweden rated it as most important followed by US and China, respectively, while attractiveness showed no significant differences.

5.4 Discussion

5.4.1 Attractiveness
Attractiveness received the lowest overall score. In relation to safety, quality and practicality an attractive automobile was of least importance to the US and Swedish respondents. In both markets there are many makes and models to choose from. In general, the majority of automobiles are relatively attractive, manufacturers spend much money and effort on designing an attractive automobile that sticks out, and is able to stand out on its own looks. Hence, a vehicle that does not contain dynamic features will quickly be forgotten as being monotone or boring.

In general, all major automobile manufacturers sell their models in China but only a small percent of the population can afford a European or American vehicle. While there are many other makes to choose from there is a demand for more economical automobiles in China and more and more are becoming economically capable to buy a new vehicle, but since cost is often the foremost deciding factor in which vehicle will be purchased, attractiveness might fall behind
in the list of priorities. The Chinese placed *attractiveness* next to last, before *quality*. Considering the Chinese factors involved in owning an automobile such as poor roadways, over crowded roads, and low traffic safety, it is probable to assume that *safety* and *practicality* are definitely more urgent issues for new car buyers. It is possible that for both the females and males an *attractive* and high *quality* automobile is not even considered as a possibility since there may be other factors that have not been touched upon like insurance costs or the possibility of customizing the vehicle with aftermarket products.

The Swedish females ranked *attractiveness* as third, before *practicality*, and after *safety* and *quality*. This order can be the result of how people see and use their cars, possibly the Swedish females perceive the automobile’s looks as more interesting, being an expression of themselves and their interests. The respondents of this study are younger (19-35 years old) and also students, thus, they are more likely to be single, and, hence, have different needs compared with a family that has children concerning items of *practicality*. In this case a station wagon would not be needed but instead a small economical car would be more appealing. The males, however, ranked *attractiveness* as least important of the four factors. One could discuss, “what is attractive” or “what makes something attractive”, maybe *quality* and *practicality* are also seen as attractive? But when placed in the grouping with the other factors, *attractiveness* should take an individual roll separate from the others promoting physical *attractiveness* and not *practicality*, *quality*, or *safety*. It is possible that the other factors can make the vehicle more or less attractive depending on how well the vehicle fulfills the consumer’s demands in declining order. Both the US females and males and the Swedish males ranked *attractiveness* as least important. This, taking in consideration the factors order of importance, in relation to other items shows that buyers in a market with many choices, good roads, relatively safe traffic, etc. do also rate *attractiveness* behind *safety*, *practicality* and *quality*. Just like the Swedish
respondents the US place more importance on how the vehicle protects them (safety) and helps them (practicality and quality) than that of good looks or attractiveness.

5.4.2 Practicality

The US males ranked practicality as most important while the Chinese and Swedish males ranked it as the second most important, for the females the Chinese ranked it as second, the US as third, and the Swedish females as fourth (last). Practicality can be interpreted as how versatile the automobile is or how easy it is to use for many different tasks. All three markets have conditions that are unique in relation to the others; in the US people usually own more than one vehicle and drive long distances to and from work, the Chinese have limited vehicles and poor roadways, and the Swedish usually own only one automobile and do not travel much since fuel is expensive and the public transportation system is convenient. In the US market pick-ups are popular since few other vehicles have more storage/transport area, nor do they have the versatility of transporting basically everything from lumber to garbage, and rarely do people travel with more than one passenger. In Sweden pick-ups are not seen as practical since they are not fuel efficient and do not have enough passenger space. The Swedish solution to a pick-up is a station wagon with a trailer attachment. Whereas in China practical vehicles are those that are fuel efficient, small, and maneuverable in traffic. Swedish drivers have consistently bought station wagons, last year both Swedish manufacturers together lead all vehicle sales, and 15% of all new sales were station wagons (Bil Sweden, 2008). It is possible that the Swedish respondents’ understanding of practically was based upon fuel efficiency in relation with transportation of several individuals.

Both the female and male respondents from China ranked practicality as second, which could relate to their traffic situation where the roads are over crowded.
Thus those who consider buying a new automobile would look at what is practical for their family’s use, due to their social structure (Schwartz & Ros, 1995), before other items like quality and attractiveness. A possible explanation to why US males ranked practicality as first and second might be related to the choices of larger vehicles in America. Large vehicles are practical in transporting people and things. The pick-up is the most sold vehicle in the US and they are popular because of their transport practicality, but are not quite as practical for those who are not interested in moving larger items or for those who live in urban areas. The cultural norms have influenced people to buy the larger SUV’s and pick-ups because they are large, and because they are large, they are practical and represent safety on the road.

5.4.3 Quality
The Swedish male respondents ranked quality as most important, the US as third while the Chinese ranked it as least important. These perspectives can give insight on the automobile culture in each respective market. The automobile manufacturers in all three countries have adapted to different market conditions; the Chinese market has over 100 domestic manufacturers of which few maintain European/American vehicle safety standards, the automobiles are generally smaller, lighter, and cheaper in relation to their European counterparts, and the demand for automobiles has doubled in the past 10 years and is expected to double again in a few years, creating a vacuum for cheap automobiles. The Swedish market has two small domestic automobile manufacturers, their products are known for a high level of safety and quality, and due to this they are somewhat larger and heavier than the average European automobile (Spanish Automobile Association, 2008; Swedish Institute, 2006). The US market is the world’s largest automobile market, many European and Asian manufacturers market their products there, and the US has three very large domestic and several smaller automobile manufacturers. Automobile owners have traditionally owned
larger vehicles, i.e. pick-up trucks, SUV’s, and large automobiles aside with a second automobile that is more economical.

According to the literature and crash statistics, China needs to reduce the numbers of traffic fatalities, update the road network, enforce traffic laws, and provide cheap automobiles for the skyrocketing demand (Godfrey, 2006; Huang, Zhang, Roetting, & Melton, 2006). Those things are certainly of greater concern to the individual than automobile quality. When primary concerns for safety and automobile availability are met, like they have been in Sweden, and the US, then quality would also become a more important factor for the Chinese respondents.

The Swedish male respondents ranked quality as most important. As earlier stated Sweden leads safety statistics, the road network is up to date, and Sweden has one of the oldest automobile parks in Europe (Spanish Automobile Association, 2008) which reflects that the owners must take great care of their vehicles. Vehicles that are not properly maintained do not last and to be able to have the oldest automobile park in Europe the owners do understand the importance of maintenance, as well as, place a high value in the automobiles so that they will take good care of them. Swedish produced automobiles have traditionally held a high level of quality and parts have been relatively cheap and the automobiles have been easy for private owners to maintain. The female’s ranked quality second to safety, showing that they also appreciated quality in automobiles, and, thus, possibly understanding the importance maintenance plays in vehicle upkeep.

SUV’s and pick-ups have been popular in the US market. Even so, the trend to buy vehicles that are somewhat lighter, more economical and longer lasting has become more important. That is the type of vehicle is what the Japanese manufacturers have been building and selling, which has allowed them to gain a
strong foothold on the US market. Quality in the details has been lacking from US produced vehicles although many options and accessories are found in the vehicles. The females placed quality second while the males placed it as third. Quality can be interpreted as low in maintenance or is both low in maintenance and has a “feeling of quality” throughout the whole vehicle even in the details. Along with the “feeling of quality” low maintenance is probably a great concern for US vehicle owners.

5.4.4 Safety
Safety was ranked highest by all females and the Chinese males, the US males ranked it as second and the Swedish male respondents ranked it as third. This shows that safety is an important issue to be dealt with in automobile design for especially females. These results are also consistent with Nordfærn and Rundmo’s (2008) findings “the majority of the published literature indicates that males estimate lower traffic risk than females” (p. 3). Research also seems to support the fact that those who live in environments that are safer do show lower levels of perceived risk and place a lower demand on safety features (Nordfærn and Rundmo, 2008), which is in accordance with the males results where the Chinese showed the greatest need and the US perceived the need for safety as greater than the Swedish males did. This reflected the respective traffic safety levels in each country.

Since traffic fatalities are a great concern for the WHO, the World Bank, and many national governments and organizations (Kopits & Cropper, 2005), it would be reasonable to think that on an individual level people are also concerned about traffic safety. As previously stated, in China are road accidents a major problem, and there seems to be a conflict of interest for the Chinese people in that the social norms promote unsafe driving behavior (Zhang, Huang, Roetting, Wang, & Wie, 2006) while at the same time people are greatly
concerned for their own safety (Xinhuanet, 2004). On top of that a simple lifesaver like using a seatbelt is low, from as little as 7 to 65% depending on when and where the control was completed (Stevenson, Yu, Ying, Hendrie, Ivers, Li, et al., 2007).

The Swedish male respondents ranked safety third while the females ranked it as first. The Swedish do lead the world in traffic safety (WHO, 2008), safety requirements for drivers are high and the vehicles are regularly inspected for safety (CARE project data, 2005). This could help explain why the male respondents ranked quality as first, in that they may have felt satisfied with the level of safety that is maintained in Sweden.

In the US are crashes and traffic fatalities, high with over 5.9 million crashes and 42 000 traffic fatalities a year (Bureau of Transportation Statistics, 2008). These levels are much lower than in China but 200% higher than in Sweden, which could partly explain why both the US female and male respondents ranked safety as first and second, respectively. In relation to China, US drivers do think and drive safer, but in relation to Sweden the US has lower safety standards (Huang et al., 2006; WHO, 2008). E.g. seatbelt usage is not mandatory in all states. Mandatory seatbelt laws would help reduce a magnitude of injuries and fatalities. Another example is the Blood Alcohol Level (BAC) limit for drivers, e.g. Sweden has 0.02% , at that level no driver shows noticeable impairment, on the other hand, the US has 0.08%, at which any driver would be impaired in; reflexes, reasoning, depth perception, distance acuity, peripheral vision, and glare recovery (Worldwide Drink Driving Limits, 2008). Also, in this case as with China it seems that the US social norms and the traffic safety needs do conflict with each other.
6 Warnings, Driving Information, and In-Vehicle Technologies

6.1 Introduction
Warnings, Driving Information, and In-Vehicle Technologies are together called Driver Information (DI). That is information which is presented to the driver while driving for both tactical planning and increased comfort. There are certain aspects that need to be considered for increased traffic safety since the amount of both safety and comfort items will increase in coming vehicles. In vehicle operation are traffic safety, driver distraction, and cognitive workload are intrinsically intertwined (Patten, 2007). Cognitive workload is the term defined by the relationship between resource supply and workload on a driver. When the mental resources can not take care of the demands placed on it then it is called cognitive overload (Reason, 2002; Wickens & Hollands, 2000). Such as, too much visual information presented to the driver or confusing information, e.g. unclear warnings, has showed to cause overload and, hence, reduce the driver’s ability to perform safely.

Research has been conducted to produce relevant warnings for the International Standards Organization and this continues as the number of safety systems increase (Campbell et al., 2004). According to Wogalter et al., (1999) the research on warnings has been driven by an increased interest in safety, the concern for legal implications where the lack of, or an improper warning, could determine the outcome of a lawsuit, and from national governmental and standards organizations worldwide that mandate them. In designing and developing warnings it is important to choose the correct object of study as well as the correct user (Frantz, Rhoades, & Lehto, 1999). The concern for mental overload from warnings has been considered over a longer period of time and warnings are being added in vehicles and icons are being tested for understandability but perceptions of the importance of each specific warning and
its placement in the driving compartment seems to have had lesser importance in research.

Information necessary for vehicle operation is called DI and needs to be monitored while driving in traffic. Speed limits need to be followed and the fuel level needs to be monitored so that one does not find oneself in a rural area without fuel stations when the fuel level is low. This information is defined as the status of functions necessary for good, safe, and enjoyable operation of the vehicle. Before the 1970's DI included gauges like oil pressure, water temperature, fuel level, tachometer, along with a few other additional items depending on the type of vehicle. In addition to items like the speedometer was radio and tape cassette player included. In modern vehicles the amount of information presented to the driver has increased greatly and includes not only those basic functions but also entertainment system, climate control system, trip computer, seatbelt reminder, which door is ajar, which light is malfunctioning, etc. There might be a need to reduce the distraction risk from information presented to the driver thus this study was conducted to find out what drivers perceive as important DI and where they would like it to be placed in the vehicle.

IVT’s include both IVIS and ADAS systems which are designed to assist drivers by presenting real-time information, warnings of potential hazards (May et al., 2005) and to increase road safety (Wiethoff et al., 2002). The benefit with IVT’s is that they do not waiver in their monitoring nor hesitate in their reaction and they are defined as “systems that sense the driving environment and provide information or vehicle control to assist the driver in optimal vehicle operation” (Bishop, 2005, p. 3). Concerning automobiles and the crash protection that they provide, active safety measures seem to be the only means of reducing the number of accidents (Blythe & Curtis, 2004). Knowing that up to 50% of all
accidents involve driver inattention (NHTSA, 1997; Ranney et al., 2000; Sussman et al., 1985; Wang et al., 1996) there functions become a research area of even greater interest.

A dilemma the automobile industry is facing today is how to expand the ways visual information can be presented to the driver without increasing the cognitive workload which, in turn, increases the chances for distraction. The point of departure in this study is the user and his/her level of understanding and perception of what is needed concerning DI in automobiles today. Moreover, also to find out whether this differs between cultures or countries. Hence, drivers from three different automobile markets were inquired about what DI presented to them via the instrument panel actually are of importance as well as where they would prefer them to be placed in the driving compartment.

6.2 Method

6.2.1 Respondents
Data was gathered from respondents from China, Sweden, and US. The Chinese respondents, except for one, were licensed drivers from Beijing. Very few college students in China own a drivers’ license while instead 58 taxi drivers and 119 private vehicle owners were approached, and all the taxi drivers and 109 private owners accepted to participate in the study. The Swedish and US respondents were college students attending universities in the cities of Luleå and West Palm Beach, FL. They were approached by their course leaders and all complied to participate in the study, which resulted in 142 respondents from Sweden and 89 from US.

6.2.2 Material
A selection of information based upon warnings, driving information, and IVT’s were used in the questionnaire. Those were based upon a pilot study and
industry experts’ recommendations. The pilot study was conducted on several groups of students from varied backgrounds. The main warning types were Mechanical Failure, Reminder, and Operational Failure and each of these three included several specific warnings. Mechanical Failure included high motor temperature, ABS failure, electrical failure, charging system failure, and airbag not in function. Reminder included low fuel level, low oil pressure, low tire pressure, service engine, door ajar, poor driving conditions, and low washer fluid. Operational Failure included parking brake engaged, motor stall, and malfunctioning light. The main driving information types were Support Information, Safety, and Comfort and each of these three included specific driving information. Support Information included speedometer, fuel level, oil pressure level, tachometer, and trip computer. Safety included door ajar, malfunctioning light, and seatbelt reminder. Comfort included clock, scrollable menu, cruise control, climate control status, entertainment system, outside temperature, and phone status. The main IVT types were Driver Efficiency, Driver Assistance, and Advanced Help and each of these three included several specific IVT’s. Driver Efficiency included image of road in poor weather, navigator, excessive speed indicator, shift light for economy driving, and shift light for sport driving. Driver Assistance included lane change helps, parking helps, ACC, image of road hinders, external speed control, and video of passengers. Advanced Help included adjustable display, advanced options, econo-meter, and advanced menu.

The questionnaires were given, and answered, in the respondents native language to, thus, reach the respondents native cultural mindset (Whorf, 1956; Witkowski & Brown, 1982). Back-translation as prescribed by Werner and Campbell (1970) was used to test the questions for correctness in the Swedish version. The Chinese questionnaire was translated from English through an iterative parallel translation process by several bilingual researchers. The different versions were compared and a final version was completed using agreed upon results.
6.2.3 Procedure

An introduction to the questionnaire included the project description and its purpose. It also ensured the respondents of confidentiality. The respondents were asked to “imagine yourself in the act of buying a new private vehicle” and rate the level of importance to statements concerning given information on graphical scales ranging from 1 “not at all true” to 7 “very true”. Each statement had a text explaining what type of warning, driving information, and IVT it was. The warnings had in addition to the text also an ISO standard warning icon to help explain the specific warnings being used. A complementary question asked the respondents to choose, out of four placements, where they would prefer that the information in question should be placed (Figure 6). The choices were a HUD on the windshield, a HDD behind the steering wheel on the dashboard, an IF to the right of the steering wheel on the dashboard above the traditional placement of the radio and climate controls, or in the CS, the area between the driver and the passenger, typically where the radio and climate controls are found.

Figure 6. The vehicle interior shown to the respondents.

It was also stated that the respondents were to “Remember that information placed in the windshield (HUD) is transparent and would not impair your vision”. In the factor analysis section were all the components categorized according to the characteristics that each component represented for each respective group’s
responses. The sociodemographic questions included sex, age, civil status, level of income, driving license ownership, and driving experience.

6.3 Results

6.3.1 Respondents
In this study 167 (60% females) drivers represented the market of China, 142 college students (28% females) the market of Sweden, and 89 college students (69% females) represented the market of US (Table 3). The average age of the Chinese respondents was 33 (females 21-57 and males 22-51), of the Swedish 22 (females 19-35 and males 18-65), and of the US 23 (females 16-69 and males 18-69). Of the Chinese respondents 98.8% (98.0% females and 100% males) had a driver’s license, of the Swedish 81.0% (75% females and 83.3% males), and of the US 96.6% (98.4% females and 92.9% males) had a driver’s license. The Swedish respondents had the least amount of driving experience with females having 3.3 years of experience and males 3.6, followed by the Chinese 4.7 and 7.0 years, respectively for females and males, while the US had the most driving experience with females having 5.2 years and males 8.2 years of experience.

Table 3. Sociodemographics distributed over markets and gender.

<table>
<thead>
<tr>
<th></th>
<th>CHINA</th>
<th>SWEDEN</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females (n=101)</td>
<td>Males (n=66)</td>
<td>Females (n=40)</td>
</tr>
<tr>
<td>Age (M) (Range)</td>
<td>32 (21-57)</td>
<td>33 (22-51)</td>
<td>22 (19-35)</td>
</tr>
<tr>
<td>Driver’s License (%)</td>
<td>99 (98)</td>
<td>66 (100)</td>
<td>30 (75)</td>
</tr>
<tr>
<td>Years of Exp.(M) (Range)</td>
<td>4.7 (1-13)</td>
<td>7.0 (1-22)</td>
<td>3.3 (1-17)</td>
</tr>
<tr>
<td></td>
<td>Females (n=61)</td>
<td>Males (n=28)</td>
<td>Females (n=61)</td>
</tr>
<tr>
<td>Driver’s License (%)</td>
<td>99 (98)</td>
<td>66 (100)</td>
<td>30 (75)</td>
</tr>
<tr>
<td>Years of Exp.(M) (Range)</td>
<td>4.7 (1-13)</td>
<td>7.0 (1-22)</td>
<td>3.3 (1-17)</td>
</tr>
</tbody>
</table>

6.3.2 Warnings
Overall, the warnings were perceived as important but the warning type Mechanical Failure was rated somewhat more important than Reminder and
Operational Failure. However, the Chinese respondents perceived the warning type Operational Failure as somewhat more important than the warning type Reminder. Regarding the specific warnings the Chinese respondents perceived the Mechanical Failure *high motor temperature* as the most important specific warning while the Swedish and US perceived the Reminder *low fuel level* as the most important specific warning. The US and Chinese respondents perceived the Reminder *low washer fluid* as the least important specific warning and the Swedish the Operation Failure *motor stall* as the least important specific warning (Table 4).

Table 4. Perceived importance of warnings distributed over markets (from 1 not important to 7 very important).

<table>
<thead>
<tr>
<th>Type of warning</th>
<th>Specific warnings</th>
<th>China (n=167)</th>
<th>Sweden (n=141)</th>
<th>US (n=89)</th>
<th>All (n=393)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Failure</td>
<td>high motor temperature</td>
<td>6.1</td>
<td>6.1</td>
<td>6.0</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>ABS failure</td>
<td>5.5</td>
<td>5.9</td>
<td>5.5</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>electrical failure**</td>
<td>5.8A</td>
<td>5.2B</td>
<td>5.3B</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>charging system failure</td>
<td>5.4</td>
<td>5.2</td>
<td>5.4</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>airbag not in function</td>
<td>5.1</td>
<td>5.0</td>
<td>4.9</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>5.6</strong></td>
<td><strong>5.5</strong></td>
<td><strong>5.4</strong></td>
<td><strong>5.5</strong></td>
</tr>
<tr>
<td>Reminder</td>
<td>low fuel level**</td>
<td>6.0A</td>
<td>6.3A, B</td>
<td>6.7B</td>
<td>6.3</td>
</tr>
<tr>
<td></td>
<td>low oil pressure**</td>
<td>5.5A</td>
<td>6.0B</td>
<td>5.5A</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>low tire pressure**</td>
<td>5.4A</td>
<td>4.3B</td>
<td>5.4B</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>service engine**</td>
<td>5.0A</td>
<td>4.5B</td>
<td>5.4B</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>door ajar**</td>
<td>5.3A</td>
<td>4.3B</td>
<td>4.4B</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>Poor driving conditions</td>
<td>4.4</td>
<td>4.5</td>
<td>4.3</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>low washer fluid**</td>
<td>3.6A</td>
<td>4.0B</td>
<td>3.3B</td>
<td>3.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>5.0</strong></td>
<td><strong>4.8</strong></td>
<td><strong>5.0</strong></td>
<td><strong>4.9</strong></td>
</tr>
<tr>
<td>Operational Failure</td>
<td>parking brake engaged</td>
<td>5.1</td>
<td>5.3</td>
<td>5.0</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>motor stall**</td>
<td>6.0A</td>
<td>2.9B</td>
<td>4.7C</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>malfunctioning light**</td>
<td>4.9A</td>
<td>4.3B</td>
<td>3.6C</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>5.3</strong></td>
<td><strong>4.2</strong></td>
<td><strong>4.4</strong></td>
<td><strong>4.6</strong></td>
</tr>
</tbody>
</table>

Means that have a letter in common are not significantly different from another ** p < .01

MANOVA’s showed significant differences between the Chinese and the Swedish respondents significant differences were found for the specific warnings *low oil pressure, low tire pressure, service engine, door ajar, and low washer fluid* within Reminder as well as the specific warning *electrical failure* within Mechanical.
Failure ($F(2,395) = 4.85, p=.018$, $F(2,395) = 27.19, p=.000$, $F(2,395) = 8.79; p=.027$, $F(2,395) = 15.34, p=.000$, and $F(2,395) = 6.01, p=.034$, respectively).

Between the Swedish and the US respondents for the specific warnings low tire pressure, service engine, and low washer fluid within Reminder ($F(2,392) = 27.19, p=.000$, $F(2,392) = 8.79, p=.000$, and $F(2,392) = 6.01, p=.006$, respectively).

The Swedish respondents perceived the specific warnings low washer fluid and low oil pressure as more important than both the Chinese and the US but the importance of the specific warning low tire pressure as less important than the other respondents did. Moreover, the Swedish respondents perceived the specific warnings low fuel level and service engine as of less importance than the US and the specific warnings service engine, door ajar, and electrical failure as of less importance than the Chinese.

Between the Chinese and the US respondents significant differences were found for the specific warnings low fuel level and door ajar within Reminder as well as for electrical failure within Operational failure ($F(2,395) = 8.66, p=.000$, $F(2,395) = 15.34, p=.000$, and $F(2,395) = 9.25, p=.011$, respectively). The Chinese respondents perceived the specific warning low fuel level as of less importance than the US while the opposite was true for the specific warnings door ajar and electrical failure. Finally, significant differences were found between all three markets for the specific warnings malfunctioning light and motor stall within Mechanical failure ($F(2,395) = 20.47, p=.000$, and $F(2,395) = 121.91, p=.000$, respectively). The Chinese respondents perceived the specific warnings malfunctioning light and motor stall as of more importance than the Swedish and the US did. The US respondents, on the other hand, perceived the specific warning motor stall as of more importance than the Swedish while the opposite was true for the specific warning malfunctioning light.
In Table 5 are the placements of warnings distributed over markets presented. Under each market is the most popular placement given for each specific warning followed by the actual percentage of the total of the respondents who chose that placement. Overall, the most chosen placement for the specific warnings was the HDD and the least chosen was the HUD. Both the Chinese and the Swedish respondents chose the HDD for all specific warnings within Mechanical and Operational failure and the latter also chose the HDD for all the specific warnings within Reminder. The Chinese respondents chose the HUD for the specific warning low washer fluid and the IF for the specific warnings service engine and poor driving condition, all within Reminder, while the US chose the HDD for the specific warning poor driving condition, within Reminder, and for both airbag not in function (Mechanical Failure) and malfunctioning light (Operational Failure) the choice was split between the HDD and the IF.

Table 5. Placement of warnings and percentages of respondents that chose the position(s).

<table>
<thead>
<tr>
<th>Type of warnings</th>
<th>Specific warnings</th>
<th>China (n=167)</th>
<th>Sweden (n=142)</th>
<th>US (n=89)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Failure</td>
<td>high motor temperature</td>
<td>HDD (60)</td>
<td>HDD (58)</td>
<td>HDD (66)</td>
</tr>
<tr>
<td></td>
<td>ABS failure</td>
<td>HDD (43)</td>
<td>HDD (58)</td>
<td>HDD (53)</td>
</tr>
<tr>
<td></td>
<td>electrical failure</td>
<td>HDD (45)</td>
<td>HDD (48)</td>
<td>HDD (40)</td>
</tr>
<tr>
<td></td>
<td>charging system failure</td>
<td>HDD (43)</td>
<td>HDD (60)</td>
<td>HDD (59)</td>
</tr>
<tr>
<td></td>
<td>airbag not in function</td>
<td>HDD (33)</td>
<td>HDD (43)</td>
<td>HDD/IF (39)</td>
</tr>
<tr>
<td>Reminder</td>
<td>low fuel level</td>
<td>HDD (68)</td>
<td>HDD (71)</td>
<td>HDD (70)</td>
</tr>
<tr>
<td></td>
<td>low oil pressure</td>
<td>HDD (64)</td>
<td>HDD (64)</td>
<td>HDD (67)</td>
</tr>
<tr>
<td></td>
<td>low tire pressure</td>
<td>HDD (38)</td>
<td>HDD (52)</td>
<td>HDD (42)</td>
</tr>
<tr>
<td></td>
<td>service engine</td>
<td>IF (39)</td>
<td>HDD (48)</td>
<td>HDD (68)</td>
</tr>
<tr>
<td></td>
<td>door ajar</td>
<td>HDD (40)</td>
<td>IF (37)</td>
<td>HDD (52)</td>
</tr>
<tr>
<td></td>
<td>poor driving conditions</td>
<td>IF (37)</td>
<td>HDD (40)</td>
<td>IF (41)</td>
</tr>
<tr>
<td></td>
<td>low washer fluid</td>
<td>HUD (32)</td>
<td>HDD (68)</td>
<td>HDD (50)</td>
</tr>
<tr>
<td>Operational Failure</td>
<td>parking brake engaged</td>
<td>HDD (44)</td>
<td>HDD (56)</td>
<td>HDD (56)</td>
</tr>
<tr>
<td></td>
<td>motor stall</td>
<td>HDD (62)</td>
<td>HDD (52)</td>
<td>HDD (60)</td>
</tr>
<tr>
<td></td>
<td>malfunctioning light</td>
<td>HDD (42)</td>
<td>HDD (48)</td>
<td>HDD/IF (29)</td>
</tr>
</tbody>
</table>
In Table 4 are the 15 items concerning warnings presented and Table 6 shows the results of the factor analysis. Overall, all factors were significant with a high KMO and most of the components had strong internal correlations. The first components for each market were rated as very important.

Table 6. Factor Analysis of warnings (N = 398).

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Sweden</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$ (df)</td>
<td>528.66 (91)</td>
<td>551.98 (91)</td>
<td>545.28 (105)</td>
</tr>
<tr>
<td>$p$</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>KMO</td>
<td>.822</td>
<td>.804</td>
<td>.834</td>
</tr>
<tr>
<td>% explained</td>
<td>57</td>
<td>61</td>
<td>58</td>
</tr>
<tr>
<td>Factor 1 $a$ (M)</td>
<td>.718 (5.3)</td>
<td>.800 (5.6)</td>
<td>.856 (5.4)</td>
</tr>
<tr>
<td>Factor 2 $a$ (M)</td>
<td>.651 (5.0)</td>
<td>.533 (4.3)</td>
<td>.774 (4.5)</td>
</tr>
<tr>
<td>Factor 3 $a$ (M)</td>
<td>.621 (5.7)</td>
<td>.540 (3.9)</td>
<td>.487 (5.0)</td>
</tr>
<tr>
<td>Factor 4 $a$ (M)</td>
<td>.450 (4.8)</td>
<td>.492 (4.8)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

* low fuel removed due to low variation  
* low fuel removed due to low communality

The Chinese rated the first three components as very important, with strong internal correlations and the fourth as moderately important with a moderate internal correlation. Factor 1 consisted of the specific warnings motor stall, malfunctioning light, and parking break engaged within Operational Failure and the specific warnings service engine and door ajar within Reminder. Factor 2 consisted of the specific warnings ABS failure and airbag not in function within Mechanical Failure and the specific warning poor driving conditions within Reminder. Factor 3 consisted of the specific warnings high motor temp, electrical failure, and charging system failure within Mechanical Failure and the specific warning low oil pressure within Reminder. Factor 4 consisted of the specific warnings low washer fluid and low tire pressure within Reminder.

The Swedish respondents rated the first factor as very important, with a strong internal correlation, the second and fourth factors as moderately important, while the third factor was rated as not important and the last three had a moderate internal correlation. Factor 1 consisted of the specific warnings high motor...
temperature, charging system failure, ABS failure, airbag not in function, and electrical failure within Mechanical Failures and the specific warning low oil pressure within Reminder. Factor 2 consisted of the specific warnings poor driving conditions, low tire pressure, and low washer fluid within Reminder of which all dealt with items concerning the drivers’ operation of the vehicle. Factor 3 consisted of the specific warnings motor stall and malfunctioning light within Operational Failures and the specific warning service engine within Reminder. Factor 4 consisted of the specific warning parking brake engaged within Operational Failure and the specific warning door ajar within Reminder.

The US respondents’ ratings resulted in the first and third factors being rated as very important and the second factor as moderately important, the internal correlation of the first two were strong while the third was moderate. Factor 1 consisted of the specific warnings high motor temperature, charging system failure, ABS failure, electrical failure, and airbag not in function within Mechanical Failure and the specific warnings low oil pressure and low tire pressure within Reminder. Factor 2 consisted of the specific warnings door ajar, service engine, and poor driving conditions within Reminder and the specific warnings motor stall and malfunctioning light within Operational Failures. Factor 3 consisted of the specific warnings low fuel level and low washer fluid within Reminder and the specific warning parking brake engaged within Operational Failure.

6.3.3 Driver Information
Overall, DI was perceived as relatively important but the information type Support Information was somewhat more important than Safety and Comfort. Regarding specific information all three groups of respondents perceived the speedometer as the most important. The Chinese respondents perceived the outside temperature within Comfort as the least important specific warning while the
Swedish and US perceived the phone status within Comfort as the least important (Table 7).

Table 7. Perceived importance of warnings distributed over markets (from 1 not important to 7 very important).

<table>
<thead>
<tr>
<th>Type of information</th>
<th>Specific items</th>
<th>China (n=167)</th>
<th>Sweden (n=142)</th>
<th>US (n=89)</th>
<th>All (n=398)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Information</td>
<td>Speedometer**</td>
<td>5.7A</td>
<td>6.6B</td>
<td>6.4B</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>Fuel level**</td>
<td>5.4A</td>
<td>6.2B</td>
<td>6.4B</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td>Oil pressure level</td>
<td>5.1</td>
<td>5.0</td>
<td>5.2</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>Tachometer*</td>
<td>5.0A</td>
<td>5.2A</td>
<td>4.6B</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Trip computer</td>
<td>4.6</td>
<td>5.0</td>
<td>4.6</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>5.2</strong></td>
<td><strong>5.6</strong></td>
<td><strong>5.4</strong></td>
<td><strong>5.4</strong></td>
</tr>
<tr>
<td>Safety</td>
<td>Door ajar**</td>
<td>4.7A</td>
<td>4.0B</td>
<td>4.5C</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Malfunctioning light**</td>
<td>4.7A</td>
<td>4.3A,B</td>
<td>3.9B</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Seatbelt reminder*</td>
<td>4.2A</td>
<td>3.8B</td>
<td>3.9A,B</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>4.5</strong></td>
<td><strong>4.0</strong></td>
<td><strong>4.1</strong></td>
<td><strong>4.2</strong></td>
</tr>
<tr>
<td>Comfort</td>
<td>Clock**</td>
<td>3.6A</td>
<td>4.7B</td>
<td>5.6C</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Scrollable menu</td>
<td>4.1</td>
<td>4.4</td>
<td>4.5</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Cruise control**</td>
<td>3.9A</td>
<td>4.3B</td>
<td>4.5B</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>Climate control status**</td>
<td>3.6A</td>
<td>4.7B</td>
<td>4.4B</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>Entertainment system</td>
<td>4.1</td>
<td>4.3</td>
<td>4.3</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>Outside temperature**</td>
<td>2.9A</td>
<td>4.4B</td>
<td>4.0B</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Phone status**</td>
<td>3.8A</td>
<td>2.7B</td>
<td>3.5C</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>3.7</strong></td>
<td><strong>4.2</strong></td>
<td><strong>4.4</strong></td>
<td><strong>4.1</strong></td>
</tr>
</tbody>
</table>

Means that have a letter in common are not significantly different from another *p<.05 **p<.01

MANOVA’s showed significant differences between the Chinese and the Swedish respondents for the Support Information types speedometer and fuel level, for Safety which door is ajar and seatbelt reminder, and for Comfort outside temperature, cruise control, climate control, and phone status $(F(2,383) = 20.90, p=.000$, $F(2,383) = 21.94, p=.000$, $F(2,383) = 8.25, p=.000$, $F(2,383) = 3.57, p=.031$, $F(2,383) = 36.07, p=.000$, $F(2,383) = 6.96, p=.048$, $F(2,383) = 17.06, p=.000$, and $F(2,383) = 14.05, p=.000$, respectively). Between the Chinese and the US respondents significant differences were found for the specific information types speedometer and fuel level within Support Information, for the specific warnings
which door is ajar and which light is malfunctioning within Safety and for the specific warnings outside temperature, cruise control, and climate control within Comfort ($F(2,383) = 20.90$, $p=.000$, $F(2,383) = 21.94$, $p=.000$, $F(2,383) = 8.25$, $p=.000$, $F(2,383) = 6.46$, $p=.003$, $F(2,383) = 36.07$, $p=.000$, $F(2,383) = 6.96$, $p=.002$, and $F(2,383) = 17.06$, $p=.001$, respectively). The Chinese respondents perceived the specific information speedometer, fuel level, outside temperature, cruise control, and climate control as of lesser importance than the Swedish and US, however, which door is ajar was perceived as of more importance by the Chinese than the others. The Chinese respondents perceived phone status and seatbelt reminder as being less important than the Swedish, and they perceived the specific information which light is malfunctioning as less important than the US.

Between the Swedish and the US respondents significant differences were found for the specific item tachometer within Support Information as well as the specific item which door is ajar within Safety and the specific item phone status within Comfort ($F(2,383) = 3.14$, $p=.045$, $F(2,383) = 8.25$, $p=.043$, and $F(2,383) = 14.05$, $p=.003$, respectively). The US respondents perceived the specific item tachometer as less important than the Swedish while the opposite was true for the specific information phone status and which door is ajar. Finally, significant differences were found between all three markets for the specific item clock within the information type Comfort, $F(2,383) = 41.28$, $p=.000$. The US respondents perceived the clock as of more importance than the Swedish and Chinese did while the Swedish perceived it as more important than the Chinese did.

In Table 8 the chosen placements of driving information distributed over markets are presented. Under each market is the most popular placement given for each specific information followed by the actual percentage of the total of the respondents who chose that placement. Overall, the most chosen placements
were the HDD and the IF, the CS was chosen the least, and the HUD was not chosen at all. Overall, the Chinese, Swedish, and US respondents chose the HDD for the information within Support Information. The Chinese respondents chose the IF for Safety and the CS for Comfort while the Swedish chose the IF for both Safety and Comfort and the US chose the HDD for Safety, and the IF and the CS for Comfort.

Table 8. Placement of DI and percentages of respondents that chose the position(s).

<table>
<thead>
<tr>
<th>Type of information</th>
<th>Specific items</th>
<th>China (n=167)</th>
<th>Sweden (n=142)</th>
<th>US (n=89)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Information</td>
<td>Speedometer HDD</td>
<td>(78)</td>
<td>HDD (59)</td>
<td>HDD (78)</td>
</tr>
<tr>
<td></td>
<td>Fuel level HDD</td>
<td>(64)</td>
<td>HDD (80)</td>
<td>HDD (71)</td>
</tr>
<tr>
<td></td>
<td>Oil pressure level HDD</td>
<td>(49)</td>
<td>HDD (76)</td>
<td>HDD (68)</td>
</tr>
<tr>
<td></td>
<td>Tachometer HDD</td>
<td>(65)</td>
<td>HDD (73)</td>
<td>HDD (70)</td>
</tr>
<tr>
<td></td>
<td>Trip computer HDD</td>
<td>(33)</td>
<td>IF (57)</td>
<td>IF (47)</td>
</tr>
<tr>
<td></td>
<td>Speedometer IF</td>
<td>IF (40)</td>
<td>IF (48)</td>
<td>IF (41)</td>
</tr>
<tr>
<td></td>
<td>Malfunctioning light IF</td>
<td>IF (31)</td>
<td>IF (38)</td>
<td>HDD (38)</td>
</tr>
<tr>
<td></td>
<td>Clock CS</td>
<td>(33)</td>
<td>IF (64)</td>
<td>IF (58)</td>
</tr>
<tr>
<td></td>
<td>Outside temperature CS</td>
<td>(43)</td>
<td>IF (51)</td>
<td>IF (57)</td>
</tr>
<tr>
<td></td>
<td>Scrollable menu IF</td>
<td>IF (41)</td>
<td>IF (54)</td>
<td>IF (55)</td>
</tr>
<tr>
<td></td>
<td>Cruise control IF</td>
<td>(37)</td>
<td>HDD (63)</td>
<td>HDD (68)</td>
</tr>
<tr>
<td></td>
<td>Climate control status CS</td>
<td>(46)</td>
<td>IF (50)</td>
<td>CS (47)</td>
</tr>
<tr>
<td></td>
<td>Entertainment system CS</td>
<td>(49)</td>
<td>CS (50)</td>
<td>IF/CS (48)</td>
</tr>
<tr>
<td></td>
<td>Phone status CS</td>
<td>(46)</td>
<td>CS (52)</td>
<td>CS (50)</td>
</tr>
</tbody>
</table>

In Table 7 are the 15 items concerning types of driving information presented and Table 9 shows the results of the factor analysis. Overall, all factors were significant with a high KMO and most of the components had a strong internal correlation. Each country had components that varied from not very important to very important.
Table 9. Driving information Factor Analysis (N = 398).

<table>
<thead>
<tr>
<th></th>
<th>Chinaa</th>
<th>Swedenb</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x^2$(df)</td>
<td>850.74 (105)</td>
<td>530.26 (105)</td>
<td>573.26 (105)</td>
</tr>
<tr>
<td>$P$</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>KMO</td>
<td>.840</td>
<td>.751</td>
<td>.817</td>
</tr>
<tr>
<td>% explained</td>
<td>54</td>
<td>58</td>
<td>68</td>
</tr>
<tr>
<td>Factor 1 a (M)</td>
<td>.804 (3.8)</td>
<td>.762 (4.2)</td>
<td>.824 (4.2)</td>
</tr>
<tr>
<td>Factor 2 a (M)</td>
<td>.769 (5.2)</td>
<td>.674 (4.0)</td>
<td>.728 (4.5)</td>
</tr>
<tr>
<td>Factor 3 a (M)</td>
<td>.599 (4.4)</td>
<td>.775 (4.7)</td>
<td>.859 (6.4)</td>
</tr>
<tr>
<td>Factor 4 a (M)</td>
<td>n/a</td>
<td>.588 (5.7)</td>
<td>.804 (4.5)</td>
</tr>
</tbody>
</table>

*forced 3 factors since scrollable menu ended up alone otherwise b forced 4 factors instead of 3

The Chinese rated the first component as not important, the second as moderately important and the third as very important and all with a strong internal correlation. Factor 1 consisted of the specific items outside temp, clock, entertainment status, climate control status, phone status, and cruise control within Comfort and the specific item trip computer within Support Information. Factor 2 consisted of the specific items fuel level, tachometer, speedometer, and oil pressure level within Support Information and the specific item which light is malfunctioning within Safety. Factor 3 consisted of the specific items seatbelt reminder and which door is ajar within Safety and the specific item scrollable menu within Comfort.

The Swedish rated the first three components as moderately important and the fourth as very important and all with a strong internal correlation. Factor 1 consisted of the specific items climate control status, entertainment system status, clock, outside temperature, cruise control, and phone status within Comfort. Factor 2 consisted of the specific items which door is ajar, seatbelt reminder, and which light is malfunctioning within Safety. Factor 3 consisted of the specific item scrollable menu within Comfort and the specific item trip computer within Support Information. Factor 4 consisted of the specific items oil pressure level, tachometer, speedometer, and fuel level within Support Information.
The US respondents rated the third component as very important and the remaining three as moderately important and all of them with a very strong internal correlation. Factor 1 consisted of the specific items climate control status, outside temperature, phone status, entertainment status, cruise control, and clock within Comfort. Factor 2 consisted of the specific items which light is malfunctioning, which door is ajar, and seatbelt reminder within Safety and the specific items oil pressure level and tachometer within Support Information. Factor 3 consisted of the specific items speedometer and fuel level within Support Information. Factor 4 consisted of the specific item trip computer within Support Information and the specific item scrollable menu within Comfort.

### 6.3.4 In-Vehicle Technologies

Overall, the IVT’s were perceived as moderately important but the IVT type Driver Efficiency as somewhat more important than the IVT types Driver Assistance and Advanced Help. However, the Chinese respondents perceived the IVT type Driver Assistance as somewhat more important than the IVT type Driver Efficiency. Regarding specific IVT’s the Chinese respondents perceived lane change helps within Driver Assistance as the most important specific IVT, the Swedish the specific IVT navigator within Driver Efficiency and the specific IVT parking helps within Driver Assistance while the US respondents perceived the specific IVT lane change helps within Driver Assistance as the most important. The Chinese respondents perceived the specific IVT advanced menu within Advanced Help as the least important specific IVT, the Swedish the specific IVT video of passengers within Driver Assistance, and the US respondents perceived the specific IVT external speed control within Driver Assistance as the least important (Table 10).

MANOVA’s showed significant differences between the Chinese and the Swedish respondents for the specific IVT’s image of road in poor weather, excessive
speed indicator, and shift light for sport driving within Driver Efficiency as well as the specific IVT’s lane change helps, parking helps, external speed control, and video of passengers within Driver Assistance and the specific IVT’s adjustable display and econo-meter within Advanced Help (F(2,383) = 19.93, p=.000, F(2,383) = 53.67, p=.000, F(2,383) = 8.03, p=.000, F(2,383) = 20.92, p=.000, F(2,383) = 5.13, p=.017, F(2,383) = 68.90, p=.000, F(2,383) = 21.60; p=.000, F(2,383) = 3.91, p=.023, and F(2,383) = 9.55, p=.000, respectively).

Table 10. Perceived importance of warnings distributed over markets (from 1 not important to 7 very important).

<table>
<thead>
<tr>
<th>Type of IVT</th>
<th>Specific items</th>
<th>China (n=167)</th>
<th>Sweden (n=142)</th>
<th>US (n=89)</th>
<th>All (n=398)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Efficiency</td>
<td>Image of road**</td>
<td>5.3A</td>
<td>4.1B</td>
<td>4.6B</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>Navigator</td>
<td>4.6</td>
<td>4.2</td>
<td>4.7</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Excessive speed indicator**</td>
<td>5.2A</td>
<td>3.3B</td>
<td>3.5B</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Shift light economy</td>
<td>4.1</td>
<td>4.1</td>
<td>3.9</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Shift light sport**</td>
<td>4.2A</td>
<td>3.4B</td>
<td>3.7A,B</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>4.7</strong></td>
<td><strong>3.8</strong></td>
<td><strong>4.1</strong></td>
<td><strong>4.2</strong></td>
</tr>
<tr>
<td>Driver Assistance</td>
<td>Lane change helps**</td>
<td>5.4A</td>
<td>4.1B</td>
<td>5.0A</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>Parking helps**</td>
<td>4.8A</td>
<td>4.2B</td>
<td>4.2A,B</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>ACC**</td>
<td>4.4</td>
<td>3.9A</td>
<td>4.6B</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Image of road hinders**</td>
<td>4.7A</td>
<td>3.0B</td>
<td>3.8C</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>External speed control**</td>
<td>5.2A</td>
<td>3.3B</td>
<td>2.9B</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>Video of passengers**</td>
<td>4.0A</td>
<td>2.6B</td>
<td>3.7A</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>4.8</strong></td>
<td><strong>3.5</strong></td>
<td><strong>4.0</strong></td>
<td><strong>4.1</strong></td>
</tr>
<tr>
<td>Advanced Help</td>
<td>Adjustable display*</td>
<td>4.3A</td>
<td>3.8B</td>
<td>4.0A,B</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Advanced options</td>
<td>3.7</td>
<td>3.7</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>Econo-meter**</td>
<td>4.0A</td>
<td>3.2B</td>
<td>3.3B</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>Advanced menu</td>
<td>3.4</td>
<td>3.1</td>
<td>3.2</td>
<td>3.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>3.9</strong></td>
<td><strong>3.5</strong></td>
<td><strong>3.6</strong></td>
<td><strong>3.7</strong></td>
</tr>
</tbody>
</table>

Means that have a letter in common are not significantly different from another *p<.05 **p<.01

Between the Chinese and US respondents significant differences were found for the specific IVT’s image of road in poor weather and excessive speed indicator within Driver Efficiency as well as for the specific IVT external speed control within Driver Efficiency.
Assistance and for the specific IVT *econo-meter* within Advanced Help ($F(2,383) = 19.93, p=.009$, $F(2,383) = 53.67, p=.000$, $F(2,383) = 68.90, p=.000,$ and $F(2,383) = 9.55, p=.011$, respectively). The Chinese respondents perceived the specific IVT’s *external speed control*, *image of road in poor weather*, *excessive speed indicator*, and *econo-meter* as more important than both the Swedish and the US did. Moreover, the Chinese respondents perceived the specific IVT’s *lane change helps*, *parking helps*, *video of passengers*, *shift light for sport driving*, and *adjustable display* as more important than the Swedish did. Between the Swedish and US respondents significant differences were found for the specific IVT’s *lane change helps*, *ACC*, and *video of passengers* within Driver Assistance ($F(2,383) = 20.92, p=.000$, $F(2,383) = 4.76, p=.017,$ and $F(2,383) = 21.60, p=.000$ respectively).

The US respondents perceived all the specific IVT’s within Driver Assistance as more important than the Swedish did. Finally, significant differences were found between all three markets for the specific IVT *image of road hinders* within Driver Assistance ($F(2,383) = 20.47, p=.000$). The Chinese respondents perceived this specific IVT as more important than the Swedish and the US did, while the US perceived it to be more important than the Swedish did.

In Table 11 the chosen placements of the specific IVT’s distributed over markets are presented. Under each country is the most popular placement given for each specific IVT followed by the actual percentage of the total of the respondents who chose that placement. Overall, the most chosen placement for the specific IVT’s was the IF and the least chosen was the CS. The Chinese respondents chose the IF for all Driver Assistance items while the Swedish and US chose the IF for all Advanced Help items. The Chinese respondents chose the CS for all but one Advanced Help item. Both the Swedish and the US respondents chose the HUD for the specific IVT *lane change helps* within Driver Assistance and the specific IVT *image of road in poor weather* within Driver Efficiency.
Table 11. Placement of In-Vehicle Technology types and percentages of respondents that chose the position(s).

<table>
<thead>
<tr>
<th>Type of IVT</th>
<th>Specific items</th>
<th>China (n=167)</th>
<th>Sweden (n=142)</th>
<th>US (n=89)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Efficiency</td>
<td>Image of road IF</td>
<td>IF (34)</td>
<td>HUD (44)</td>
<td>HUD (50)</td>
</tr>
<tr>
<td></td>
<td>Navigator IF</td>
<td>IF (49)</td>
<td>IF (69)</td>
<td>IF (73)</td>
</tr>
<tr>
<td></td>
<td>Excessive speed indicator</td>
<td>HDD (46)</td>
<td>HDD (38)</td>
<td>HDD (45)</td>
</tr>
<tr>
<td></td>
<td>Shift light economy IF</td>
<td>IF (39)</td>
<td>HDD (49)</td>
<td>HDD (38)</td>
</tr>
<tr>
<td></td>
<td>Shift light sport IF</td>
<td>IF (46)</td>
<td>HDD (41)</td>
<td>HUD (48)</td>
</tr>
<tr>
<td>Driver Assistance</td>
<td>Lane change helps IF</td>
<td>IF (44)</td>
<td>HUD (41)</td>
<td>HUD (41)</td>
</tr>
<tr>
<td></td>
<td>Parking helps IF</td>
<td>IF (41)</td>
<td>HDD (43)</td>
<td>IF (40)</td>
</tr>
<tr>
<td></td>
<td>ACC IF</td>
<td>IF (42)</td>
<td>HDD (41)</td>
<td>HDD (37)</td>
</tr>
<tr>
<td></td>
<td>Image of road hinders IF</td>
<td>IF (35)</td>
<td>HDD (39)</td>
<td>IF (39)</td>
</tr>
<tr>
<td></td>
<td>External speed control IF</td>
<td>IF (41)</td>
<td>HDD (41)</td>
<td>HDD (36)</td>
</tr>
<tr>
<td></td>
<td>Video of passengers IF</td>
<td>IF (53)</td>
<td>IF (43)</td>
<td>IF (60)</td>
</tr>
<tr>
<td>Advanced Help</td>
<td>Adjustable display IF</td>
<td>IF (42)</td>
<td>IF (42)</td>
<td>IF (45)</td>
</tr>
<tr>
<td></td>
<td>Advanced options CS</td>
<td>(34)</td>
<td>IF (47)</td>
<td>IF (55)</td>
</tr>
<tr>
<td></td>
<td>Econo-meter CS</td>
<td>(37)</td>
<td>IF (38)</td>
<td>IF (57)</td>
</tr>
<tr>
<td></td>
<td>Advanced menu CS</td>
<td>(41)</td>
<td>IF (53)</td>
<td>IF (51)</td>
</tr>
</tbody>
</table>

In Table 10 are the 15 items concerning IVT’s presented and in Table 12 the results of the factor analysis. Overall, all factors were significant with a high KMO and strong internal correlations.

Table 12. Warnings Factor Analysis (N = 398).

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Sweden*</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \chi^2(df) )</td>
<td>1095.24 (105)</td>
<td>830.12 (91)</td>
<td>685.65 (105)</td>
</tr>
<tr>
<td>( P )</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>KMO</td>
<td>.880</td>
<td>.857</td>
<td>.787</td>
</tr>
<tr>
<td>% explained</td>
<td>59</td>
<td>63</td>
<td>69</td>
</tr>
<tr>
<td>Factor 1 ( \alpha ) (M)</td>
<td>.823 (3.9)</td>
<td>.842 (3.8)</td>
<td>.799 (4.1)</td>
</tr>
<tr>
<td>Factor 2 ( \alpha ) (M)</td>
<td>.832 (4.8)</td>
<td>.844 (3.4)</td>
<td>.836 (3.7)</td>
</tr>
<tr>
<td>Factor 3 ( \alpha ) (M)</td>
<td>.630 (5.2)</td>
<td>.849 (3.3)</td>
<td>.780 (4.4)</td>
</tr>
<tr>
<td>Factor 4 ( \alpha ) (M)</td>
<td>n/a</td>
<td>n/a</td>
<td>.737 (3.2)</td>
</tr>
</tbody>
</table>

*removed video of passengers, shift light for economy driving due to low communalities

The Chinese respondents rated the first component as less important, the second as moderately important, and the third as very important, all with a strong
internal correlation. Factor 1 consisted of the specific IVT’s advanced menu, advanced options, econo-meter, shift light for economy driving, and adjustable display within Advanced Helps and the specific IVT shift light for sport driving within Driver Efficiency and the specific IVT video of passengers within Driver Assistance. Factor 2 consisted of the specific IVT’s parking helps, ACC, image of road in poor weather, and lane change help within Driver Assistance and the specific IVT’s navigator and image of hinders in road within Driver Efficiency. Factor 3 consisted of the specific IVT excessive speed indicator within Driver Efficiency and the specific IVT external speed control within Driver Assistance.

The Swedish respondents rated all the components as less important and all with a very strong internal correlation. Factor 1 consisted of the specific IVT’s image of hinders in road, parking helps, lane change help, and ACC within Driver Assistance and the specific IVT’s image of road in poor weather, shift light for sport driving, and navigator within Driver Efficiency. Factor 2 consisted of the specific IVT’s advanced menu, advanced options, adjustable display, and econo-meter within Advanced Helps. Factor 3 consisted of the specific IVT excessive speed indicator within Driver Efficiency and the specific IVT external speed control within Driver Assistance.

The US respondents rated the first and third components as moderately important and the remaining two as less important and all with a strong internal correlation. Factor 1 consisted of the specific IVT’s image of road in poor weather and navigator within Driver Efficiency, the specific IVT image of road hinders within Driver Assistance, and the specific IVT econo-meter within Advanced Helps. Factor 2 consisted of the specific IVT’s advanced menu, advanced options in menu, and adjustable display within Advanced Helps and the specific IVT’s shift light for sport driving and shift light for economy driving within Driver Efficiency. Factor 3 consisted of the specific IVT’s lane change help, ACC, parking helps, and video of passengers within Driver Assistance. Factor 4 consisted of the specific IVT
external speed control within Driver Assistance and the specific IVT excessive speed indicator within Driver Efficiency.

6.4 Discussion
Even though, all three markets are unique in themselves as mentioned earlier i.e. China is a developing country where the automobile revolution is relatively new, Sweden is an industrial country in which the public transportation is highly developed, and US is also an industrial country but without a highly developed public transportation system and the automobile as the primary mode of transportation. It would be reasonable to assume that both the Swedish and the US respondents had more similarities to each other than China since both markets and their infrastructures are suited for the automobile as a common form of transportation and, since, people have used automobiles in many generations and its ownership is widespread. Therefore, it is acceptable to think that those markets' understanding of the automobile would be quite unique to China's where the automobile ownership is relatively uncommon and its infrastructure has not yet had a chance to be built up to meet the present demands.

6.4.1 Warnings
The Mechanical Failure component was rated as most important by all markets, which could be explained as reasonable considering the severity of the mechanical damage that would occur if the driver did not take immediate preventive action. Reminders were rated as very important by the Chinese and US respondents while the Swedish rated it as moderately important. Operational Failure which was only rated as very important by the Chinese respondents, reminds the driver of specific needs that should be checked. It is likely that the Chinese respondents rated electrical failure, motor stall, door ajar, and malfunctioning light more important than the others since all of these items were perceived to be more relevant in Chinese traffic thus warranting their concern. The traffic situation in China makes it difficult for drivers to stop on the side of the road if
problems or the need to make adjustments arise (Lindgren, Chen, Jordan, & Ljungstrand, 2008).

It is possible that the concern for individual safety may be greater for the individual Chinese than for the Western individual. Since safety is stressed more in the Western world it would be logical to think that the Westerners feel safer in traffic and are not as worried about safety in traffic. Swedish respondents rated low oil pressure and low washer fluid as more important than the others. Low oil pressure probably related to the importance of a well maintained motor and to a vehicles’ wellbeing and this warned for possible motor problems. The low washer fluid does relate to the type of weather Swedes face in late fall, winter, and early spring where salt and sand are regularly used to prevent slippery roads, of which, ends up on the windshields. Keeping the windows clean is necessary, therefore this warning is important because it helps alert the driver that the fluid is getting low so they can prepare to refill it, thus, prevent it from running empty. The Swedish rated low tire pressure and service engine as less important which might be explained by the fact that Swedes often have two sets of tires, one for the winter season and one for the summer and when they change the tires twice a year they are recommended to check the air pressure also and, therefore, they might not feel any great need of these specific warnings. On the other hand accidents caused by tire problems has gotten a lot of media attention in the US, i.e. Ford vehicles had serious problems with Firestone tires that exploded on the highways due to under inflation and some statistics say that up to 44% of all accidents on Chinese roads are caused by tires exploding (Huang et al., 2006; Valdes-Dapena, 2007). Service engine is probably not a great concern to the Swedes since they have been shown to buy quality automobiles and maintain them well (Vehicle Inspections, 2008). The warning low fuel level was rated by the US respondents as most important possibly due to the urban nature in South Florida where gas stations are very near to each other not requiring drivers to plan their trips
according to the fuel level, they just need to wait for the warning to show letting them know when they need to fuel up.

Overall, the warnings were rated as very important and were chosen to be placed in the HDD. For both the Mechanical Failure and Operational Failure warnings all groups did prefer the HDD placement. For Reminder warnings the Chinese respondents choose service engine and poor driving conditions, rated as very important, to be placed in the IF possibly because they were not directly linked to physically operating the vehicle. The Chinese were the only ones to place a warning, low washer fluid, in the HUD directly below the line of sight, even though it was not rated as important. This could be due to an interest of having the warnings placed in an area where one can directly relate it to its use, there the mental model comes naturally, and in this case the windshield washer fluid relates to the windshield. The Swedish respondents were satisfied with the traditional placements of warnings, with one exception, door ajar. This warning was placed in the IF and probably perceived as not being a necessary information during the drive. The US respondents choose the warnings airbag not in function, poor driving conditions, and malfunctioning light, rated as moderately important and not important, to be placed in the IF probably because they related these items to happenings beyond the driver’s own control and therefore were chosen to be placed further away from the driver’s line of sight.

The factor groupings gave relatively strong components with relatively high internal correlations. The Chinese responses emphasized responsibility of the individual, followed by vehicle safety functions, then mechanical stability, and, finally, items needing regular checks. The first component, specific for the Chinese, was rated as very important, it was also the greatest component, and it related to the driver’s responsibility to provide a safe driving environment for oneself and the passengers. The second factor, the third most important
component, dealt with items that help protect the vehicles passengers, the third factor rated as most important probably because it dealt with safe mechanical operation which is necessary if the vehicle is going to be used in traffic, while the fourth factor, rated as moderately important, was the least important of the four and dealt with items that are of routine maintenance which could impair safe driving if not taken care of but are easily fixed by most drivers.

The Swedish components followed a pattern where the most basic mechanical needs are grouped first, followed by conditions that could impair driving, then maintenance, and, finally, items that need to be checked before driving. The first component dealt with the vehicle’s mechanical operation and the mechanical functionality of which the driver would be warned for. The second item dealt with items that warn for things that can impair safe driving. Thirdly, maintenance items dealt with that the driver has to do to keep the vehicle running safely, and, finally, reminders of items that could go unnoticed, i.e. door ajar and parking brake engaged. The most basic needs for vehicle operation came first and were rated as most important so it seemed that the emphasis was upon the vehicles traffic worthiness.

The US factor components followed a similar pattern to the Swedish in that the core functions necessary to vehicle operation came first followed by hinders and important reminders. First were items dealing with warnings for problems relating to both mechanical operation and the functions of the safety systems, followed by items that dealt with the actual operation of the vehicle, and, finally, by reminders that dealt with that which is necessary for vehicle operation, i.e. fuel level, washer fluid, and parking brake. The US respondents differed from the other groups in that they focused more on the physical operation of the vehicle and to some extent on the human factors involved but mostly on the vehicles operation.
The differences between the Swedish and US groups might somewhat be explained by the cultural differences in that good maintenance has been shown to be important in Sweden, that’s also probably why they rated maintenance warnings as not important, on the other hand, it is more common in the US to allow professional mechanics to take care of the vehicle. This would explain a greater interest in warnings for safe vehicle operation so they can be told when to service the vehicle. The US respondents probably perceived vehicles to be more of a functional object used for transportation, something easily replaced, whereas the Swedish probably perceived automobiles as of more personal value, and, therefore, something to bother about. These differences can be reflected in the cost of owning and maintaining an automobile. In Sweden driver’s licenses are expensive, vehicles are taxed more than in the US, and, therefore, more expensive, fuel is 3 times as expensive because of taxes, Sweden is a small market with less competition than the US, and the cost of parts and repairs are much more expensive than in the US.

6.4.2 Driving Information
Overall, Support Information was rated as the most important within the driving information. Both the Swedish and US respondents rated Comfort as moderately important followed by Safety. The Chinese respondents also rated them as moderately important but Safety was rated higher than Comfort. The Comfort items seem to be relatively important for the mature automobile market but not so for the developing automobile market. Items of less importance for the Swedish and US respondents were those items that probably were perceived as obvious like the seatbelt reminder. It may be because seatbelt usage is very high in Sweden at 95% (NTF Nättidning, 2007) and relatively high in Florida, US at 89% (NHTSA, 2007). The Chinese statistics show a seatbelt usage as low as 6% (George Institute, 2007) and the Chinese respondents did rate the seatbelt reminder as more important than the other groups. Since the traffic is much more
regulated and enforced in both Sweden and US, in relation to China, it is reasonable to think that the speedometer would be more important for drivers in the Western markets, which also was true for the respondents in this study. Concerning fuel level, the Chinese rated this as of lesser importance than the Swedish and the US, thus, it is reasonable to think that they may have taken fuel level and fuel consumption more seriously in their preparation and planning of a trip, thus, status of the fuel would be of less importance under the drive than it would be before the drive. There might also be differences in how time is understood, e.g. dependence upon keeping time, and the respondents rating of how important the clock is also showed this. US respondents rated the clock as very important, followed by the Swedish with moderate importance, and then the Chinese who rated it as not important. An explanation could be the countries relation to work, as shown in the International Labour Organization report “Key Indicators of the Labour Market” (2007). The US citizens work the most productive hours, Sweden falls in similar to European levels, and then China at one fifth of the Western levels. The respondents’ focus on work and productivity is most likely reflected in their focus on working, thus needing to keep track of time.

Overall, the HDD and IF were the most preferred placements and the CS was only used for some Comfort items. The Chinese respondents chose information relating to the vehicles travel to be placed in HDD probably because this is where it traditionally is located. Information relating to personal safety along with extra functions like scrollable menu and cruise control were placed in the IF a little further away from the line of sight but still within the peripheral vision so that they can be read while driving. Information relating to personal comfort was placed in the CS, furthest away from the line of sight, and in a position there the driver is required to look away from the traffic to read the status of those items.
This placement was probably chosen because those items of comfort, i.e. climate control and entertainment system, are normally found there.

The Swedish respondents placed information that dealt directly with the forward travel of the vehicle in the HDD, this is where the information is commonly found today. The safety information and support functions for the drive were placed in the IF, these are typically found in the HDD, while entertainment system and phone status were chosen to be placed furthest away from the line of sight in the CS, where they are also traditionally found. This shows that the respondents wanted a separation of items but it is possible that they tried to imitate the vehicle they are most familiar with in these separations since entertainment system which is adjusted more often than climate control was chosen to be placed further away from the forward line of sight. The IF and CS selections are further away from the line of sight than the HDD and cannot be read unless the head is turned towards them it is, therefore, probable to assume that the respondents took into consideration what information was utmost necessary for driving and what was more of a support function, and separated them accordingly.

The US respondents placed information relating to driving, vehicle travel, and safety in the HDD, where they traditionally are found. Items that generally use digital displays; trip computer, which malfunctioning light, clock, outside temperature, scrollable menu, and entertainment system, were placed in the IF position, while climate control and phone status were placed in the CS. The respondents separated the information up into three groupings there that which was necessary for driving and safety and that which only required quick looks, were placed closest to the line of sight in the IF while items that needed a display and/or needed to be read more carefully were placed further away as to reduce clutter in the HDD. Climate control status is not changed often under travel nor is phone status used much since the majority of drivers use hand held mobile phones (Cellphones,
and, therefore, most of the interaction occurs with the hand-held unit and not the vehicle's own functions.

The three groups' categorization of information placement was based upon how they perceived the necessity of information in relation to the drive, and separated them thereafter. Information relating to vehicle travel was placed in the HDD, while support functions to the drive were placed in the IF, and information not seen as important to the drive was placed furthest away, in the CS. The Chinese have much simpler vehicles with fewer accessories than the Swedish and US, thus, they placed more items in the CS since they are not used to having them available while driving. The Swedish differed from the US in that they chose safety reminders to be placed further away in the IF, and they wanted the entertainment system information to be placed even further away in the CS even though it is likely that it is used often while driving. Overall the drivers showed three groupings based upon their cultural differences; that which was most important for the drive was placed in the HDD, information to be used while driving in the IF, and extra information in the CS.

The factor analysis components resulted in three similar groups. For purposes of explanation they are called Comfort, Vehicle Status, and Safety Reminders for the Chinese, Comfort, Safety, Vehicle Information, and Vehicle Status for the Swedish, and Comfort, Safety, Vehicle Status, and Vehicle Information for the US. All groups rated Vehicle Status as most important and most likely so because it pertained to the information necessary for vehicle operation in traffic. Personal Comfort was also a common component for all three groups and it was rated of moderate importance by the Swedish and US respondents unlike the Chinese who rated it of less importance. Safety was the third component that the groups had in common and it only presented items of safety status, not warnings, and, therefore, it was only rated as moderately important.
The Chinese respondents differed from their Western counterparts on Comfort probably due to the differences in comfort standards in automobiles in that both the Swedish and US automobiles contain many standard items for driver comfort, i.e. air conditioning, while the Chinese automobiles do not. Safety information was perceived as more important by the Chinese respondents, which in part could reflect their greater concerns for traffic safety, since traffic in China is relatively unsafe in relation to their more developed counterparts. Items chosen to be placed nearest the driver’s line of sight (HDD) were most important to vehicle operation, while those chosen to be placed further away related to driving safely (IF), of which time and distance items were included. Finally, items concerning the phone and entertainment system were chosen to be placed in the CS, far from the line of sight, probably because they are already found there in typical automobiles.

The Swedish placed Vehicle Status in the HDD where it is traditionally found and closest to the line of sight, probably because this information is observed often while driving. Safety and some Personal Comfort items, including climate control, which is not often adjusted during travel, were placed in the IF perhaps to reduce clutter in the HDD but the entertainment system which is adjusted often under a drive was placed furthest away in the CS. This would be reasonable if modern vehicles had this layout but that is not necessarily true. It is possible that the respondents felt that if moving the entertainment system further from the line of sight the chance that it would distract them would be less.

The US respondents differed from the Swedish and Chinese in that they included both mechanical and personal safety information in the Safety component and they also chose these items to be placed closest to the line of sight in the HDD. This can be explained in that the US respondents possibly wanted to see
automobiles as more functional items there only the important information is presented directly to the driver while all the other items were placed aside. Comfort items and Vehicle Information were placed in the IF thus in a place only seen by the peripheral vision but still easily noticed. The respondents wanted information separated but in an area they could easily notice it.

6.4.3 In-Vehicle Technologies
Both the Chinese and the US respondents rated Driver Efficiency and Driver Assistance as moderately important and Advanced Help as of lesser importance while the Swedish rated all groups of IVT’s as of lesser importance. The groups differed concerning image of road hinders, there the Swedish and US respondents considered this information of less importance while the Chinese considered it as moderately important. Since this is a new function available only in exclusive automobiles it is probable that the respondents did not understand how it could work or its advantages while driving but most likely it was rated low because it is not commonly used today and therefore probably perceived as unnecessary.

The Chinese respondents rated the items image of road in poor weather, excessive speed indicator, and external speed control as more important than both the Swedish and US which probably relates to the very different traffic situation found in China there roads are not clearly marked, road signs are difficult to read, and road maintenance is poor especially during times of poor weather and speeding is often not enforced (Huang et al., 2006). The Chinese respondents also rated the IVT’s shift light for sport driving, parking helps, and adjustable display as more important than the Swedish. These items are extra finesses found in some vehicles, thus, not likely seen as important for the Swedish respondents but since the Chinese rated all the IVT’s as more important than the other groups they also perceived these as being overall more important, perceiving that all IVT items are as necessary regardless.
The Chinese respondents placed almost all items in the IF position while the Swedish and US followed a similar pattern where the ratings of importance correlated with the placement of items that could prevent crashes as they were placed as close to their line of sight as possible, e.g. the HUD, while items concerning functions and information of improving the task of driving were placed in the HDD. The remaining items, which related to information that could make the drive more efficient, e.g. video of passengers, navigator, and adjustable display, were placed in the IF. The Chinese placed one item in the HDD, excessive speed indicator, probably to alert them when they look at the speedometer if they are driving too fast. Three IVT’s were placed in the CS, advanced options, econo-meter, and advanced menu, probably since they were perceived as too complex to use while driving, just like the driving information items. All other items that had to do with Driver Efficiency and Driver Assistance were placed in the IF, e.g. further away from the line of sight but within the peripheral vision so they can be looked at with only some difficulty while driving. Both are used to help make the drive easier and prevent accidents.

The Swedish respondents chose HUD for image of road in poor weather, lane change helps, and parking helps for safety reasons. They wanted these accident prevention items high up within the line of sight, there they would not be missed while driving and the driver would not need to take their eyes from the traffic scene to see them. Items that seemed to require a digital display, i.e. navigator, video of passengers, advanced menu, etc., were chosen to be placed in the IF position and this was the same as for driving information.

The US respondents chose the HUD location for four IVT’s concerning safety, image of road in poor weather, excessive speed indicator, lane change helps, and shift light for sport driving. This was similar to the Swedish responses in that they wanted safety items where they could use them without taking their eyes from the traffic
scene. An extra item of fun, *shift light for sport driving*, was also chosen to be placed in the HUD maybe so they could drive without letting the function distract them. Three items were chosen to be placed in the HDD, *shift light for economy*, ACC, and *external speed control*, and these are status indicators which show what the vehicle is doing, thus, not very important for vehicle operation but placed close to the line of sight so that the driver could read them when looking at the speedometer. The remaining IVT’s were placed in the IF and all these were items that would use a digital display to present information in a larger format, i.e. *navigator, image of road hinders, video of passengers, adjustable display*, etc.

Overall, the factor analysis components resulted in groupings that were called Advanced Help, Visual Driving Helps, Advanced Options, and Speed Control. These were not common for all groups but overall the results showed that the Advanced Help component was rated as not very important. The Swedish respondents differed from the others in that they rated all the factors as of less importance. Visual Driving Helps were common for all the groups and it was rated as moderately important by the Chinese and US respondents and as less important by the Swedish. Advanced Options were rated as less important by all three groups while speed control was rated as very important by the Chinese respondents and as less important by the Swedish and US. The Speed Control component was rated as very important by the Chinese respondents probably due to the lack of traffic enforcement in China and they probably thought that with this type of IVT speeding would be reduced. Visual Driving Helps were rated as moderately important and placed in the IF, these items concern functions that could be used to reduce accidents through better planning and assistance. Advanced Options were rated as of less importance and concern items that give the driver a better overview of the vehicle.
The Swedish respondents rated all the factors as of less importance but components concerning Visual Driving Helps, were chosen to be placed close to the line of sight, in the HUD and HDD, those concerning advanced options, in the IF position, and those concerning speed control in the HDD position. The Swedish respondents low ratings for these IVT’s, which are to help reduce accidents, probably relates to the fact that Sweden has one of the safest traffic environments (International Road Safety, 2007), therefore, they are satisfied with today’s safety standards.

The US respondents chose advanced driving information as the most important component and it concerned information which helps the driver survey the situation when planning for maneuvers, the second, concerned items that can be used to reduce accidents through better planning and assistance, and the third, concerned information that could help give a better understanding and usage of the vehicle. Speed control items were rated as less important and last, probably due to certain cultural norms in which Americans do not like to have their freedoms taken away from them, even in the case of safety. While the US automotive culture, probably the most mature of the three, still needs improvements considering that the US traffic fatalities are 200% higher than the Swedish levels. Hence, the US respondents expressed a need for more and better safety functions in the vehicle, just as the Chinese did. The US automobile manufactures have been quick to introduce new technologies in affordable vehicles, e.g., in 1988 was the first vehicle with HUD sold on the US market (Iversen, 1988). This can, in part, help explain why the US respondents showed a freedom to choose the HUD both for applications of safety and shift light for sport driving.
7 Usability

7.1 Introduction
The trend today is to produce automobiles which enhance the users’ driving experiences and the IVT’s are used to improve traffic but also to give vehicle occupants greater enjoyment of the vehicle. Since the driving process is highly visual (Peacock & Karwowski, 1993; Schieber, 1994) and both the ADAS and IVIS functions also are highly visual. Too much, or improper, information at the wrong time can lead to a distraction by taxing the drivers’ mental processing capabilities (Wikman, Nieminen, & Summala, 1998). The driving process demands that a driver tracks changes in the traffic environment but, if the drivers’ attention is captured by a non-driving secondary task or if the driver is cognitively loaded in another way (Horrey & Wickens, 2006) the driver will not be able to react quickly and appropriately to unexpected hazards. Numerous crash records have reported that the visual attention of the crash involved a driver that was focused on items inside the car at the time of the crash (Wierwille & Tijerina, 1996). One of the main safety considerations when using visually demanding in-car equipment, like IVT’s, is the driver’s ability to detect objects approaching in front of the vehicle (Lamble, Laakso, & Summala, 1999). In such situations, feedback from IVT’s can also be of great help to the drivers in assisting them to adhere to environmental changes more appropriately. It is important to note that feedback should not increase the cognitive load of drivers because the feedback itself can interfere with the driving performance.

When attention is focused on onboard displays, road control can still be maintained when the distance of the display to the line of sight outside is not too great (Wittmann et al., 2006). International recommendations for DI placements are vague allowing many generalizations but the Japanese Automobile Manufacturers Association (JAMA) (2004) recommendations state that display systems should be located at a position that can provide a sufficient visibility of
the forward field when the driver is looking at the display. This is similar to the Alliance of Automobile Manufacturers (AAM) (2002) recommendations in that the display should be high up on the instrument panel towards the driver’s side of the CS. The closer the display is positioned to the windscreen (e.g., above the CS or above the dashboard) the less the detrimental effect demands on the eye movements and onboard visuo-motor control of a secondary task have on the actual driving performance (Lamble et al., 1999; Wittmann et al., 2006).

As stated by Wickens (1996) cognitive load and stress reduction need to be the focus of IVT design so that it takes into consideration the user and their capabilities in the driving environment. When designing information displays Wickens and Hollands (2000) state that if “perceptual narrowing among information sources or unsystematic scanning does occur, then reducing the amount of unnecessary information [visual clutter] and increasing its organization … will buffer the degrading effect of stress” (p. 491). It must be noted that high display compatibility is needed which conforms to a mental model of the task or of the responses (Wickens & Hollands, 2000). Different drivers have different capabilities and experiences which effect their driving performance therefore the “good screen design” (Szabo & Kanuka, 1998) work has influenced layout, consistency, color, spatial display, and organizational display of displays which all have lead to improved task completion.

The purpose of this chapter is to, from a user perspective, test and compare four different placements of DI in relation to what information is presented and how it is experienced. Firstly, will drivers compare placements A, B, C, and D (see Figure 7) for usability and safety while driving by completing two different types of tasks, secondly, they will state preferred placement of different warning types, and, thirdly, they will state their perceptions of the full experiment with the
Driving Activity Load Index (DALI) (Pauzié, Manzano, & Dapzol, 2007; Pauzié & Pachiaudi, 1997; Pauzié, Sarpedon, & Saulneir, 1995).

7.2 Method

7.2.1 Respondents
Forty respondents with more than five years driving experience completed the experiment, 20 males and 20 females whose ages varied from 27 to 65. On average they drove 200 km/week. Eleven respondents asked to quit due to simulator sickness and one because he/she did not feel comfortable operating the simulator.

Figure 7. Four different display positions for onboard information presentation.

7.2.2 Driving environment
The experiment was conducted in a high-fidelity fixed base simulator with four programmable digital displays (Figure 7), of which one (D) was a touch-screen. The mock-up is a Volvo XC90, with an automatic transmission, which has been instrumented to collect all relevant data from the driver and provide visual and aural feedback to the driver. The display system for the external environment presents a horizontal field of view of approximately 70°. Digital liquid crystal display (LCD) screens were used to present graphical information to the driver to test different information formats and placements in four areas. The HUD
placement consisted of a 8” LCD screen placed from 10’ to 12’ below the line of sight in front of the driver, the HDD consisted of a 12” LCD screen placed behind the steering wheel from 18’ to 22’ below the forward line of sight, the IF consisted of a 8” LCD screen 30’ to the right of the driver and 15’ below the line of sight, and the CS consisted of a 12” touch-screen placed on edge placed 30’ to the right of the driver and 30’ below the line of sight, and consisting of a graphical interface there touch controls for the media center and climate controls were found. All vehicle controls; speed, braking, steering, blinkers, gear placement, etc., were connected via the vehicles own computer network to the simulator environment. Sound for road noise, motor noise, wind, and stereo system was given through a speaker system.

7.2.3 Road environment
The road environment contained three driving parts, namely the practice session, the baseline, and the experiment. The practice session consisted of a 10 km stretch of road beginning in a rural area with light traffic continuing through an urban area to a town with moderate traffic and finishing in a rural area with minimal traffic. There were neither incidents nor traffic distractions for the respondents to be concerned about, but there were three rotaries and three turns required in the route. The baseline drive consisted of a 15 km route that began in a rural area with light traffic continuing through several small communities to a town, where the driver met moderate traffic and was required to stop at a traffic light. The route had two rotaries and finished up with light traffic in a rural area. The experiment route was the same as the baseline but in the reverse direction. This stretch required driving through two small communities, where there were several traffic incidents which were designed to increase the drivers’ cognitive load. It began with a detour, then a rotary, followed by an intersection were crossing vehicles required the driver to stop, then a slow traveling car which required the respondent to pass on the left side. After that two speeding cars that
required the driver to brake and wait for them to pass before completing the 
maneuver and then a car that stopped directly in front without noticeable brake 
lights. At the first intersection a cyclist crossed the intersection from behind a 
large truck requiring a hard braking maneuver to not hit the cyclist, and, finally, 
the respondent drove through the final rotary.

7.2.4 Procedure
All respondents, after having participated in the training drive, drove the 15 km 
roadway in both directions. The forward direction was the baseline run where 
traffic was arranged so that no unexpected occurrences would appear. The 
experimental run was driven in reverse direction, so that the respondents would 
not meet the same events as in the baseline run, e.g. the same situations were met 
in reverse direction, along with several unexpected occurrences. Half of the 
respondents randomly divided up amongst the groups drove the experiment first 
and the other half drove the baseline first.

The respondents were split up into four groups where two groups, Reset 2 and 
Reset 4, responded to a warning message for which they were to press a “reset” 
button easily accessible on the turn signal handle to confirm that they had noticed 
the message and to erase it from the screen. The warnings were shown 10 times 
during the drive and often when the outside environment also demanded the 
respondents’ attention. The Reset 4 group was shown the warning in one of the 
four screens, while the Reset group 2 was shown the warning and speed 
information in both the HUD and HDD screens simultaneously. The remaining 
two groups, Task 2 and Task 4, were given a task to perform inside the vehicle 
in accordance with a given message. The Task group 4 was given 10 messages in 
one of the four screens in which they were to use the vehicles own systems to 
adjust temperature, change volume, activate CD, activate MP3, change MP3 
artist, call two different telephone numbers and change the fan speed. The Task 2
The specific variables were tested for significant differences between sex, age, and driving experience. Age was separated into 4 groups; 30 and under, 31 to 40, 41 to 50, and 51 and over. The Driving Experience group was split up into 4 groups; 75 km/week and under, 76 to 150 km, 151 to 250 km, and 251 km and up. Both Age and Driving Experience were split up so that an even separation of respondents would be found in each of the groups. After each driving test the respondents filled out the DALI questionnaire and an interview was conducted after the full experiment was completed. The data from the questionnaires was analyzed in SPSS 15.0.

### 7.3 Results

#### 7.3.1 Respondents

In this study 40 drivers participated (50% were females), 10 in each of the tests: Reset 2 screens, Task 2 screens, Reset 4 screens, and Task 4 screens (Table 13). The respondent’s average age was 38 years and the females were somewhat younger, 36 years as opposed to 40 years. The average age for the groups were; 39 in Reset 2, 41 in Task 2, 35 in Reset 4, and 36 in Task 4. The respondents had owned a drivers’ license for an average of 19 years and the females did own their license for a shorter period than the males, 16 years and 22 years respectively. The average period of owning a license was 19 for the Reset 2 group, 21 for the Task 2, 17 for the Reset 4, and 18 for the Task 4. The average distance traveled was 150 km a week and the females, overall, drove less than their male counterparts, 109 km a week as opposed to 185 km a week. The average distance driven for each group was 138 km for Reset 2, 151 km for Task 2, 152 km for Reset 4, and 157 km for Task 4.
Table 13. Sociodemographics distributed over tests and gender.

<table>
<thead>
<tr>
<th></th>
<th>Reset 2</th>
<th>Task 2</th>
<th>Reset 4</th>
<th>Task 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td></td>
<td>(n=10)</td>
<td>(n=10)</td>
<td>(n=10)</td>
<td>(n=10)</td>
</tr>
<tr>
<td>Age (M)</td>
<td>34.4</td>
<td>43.2</td>
<td>36.6</td>
<td>46.0</td>
</tr>
<tr>
<td>(Range)</td>
<td>(20-43)</td>
<td>(24-58)</td>
<td>(24-57)</td>
<td>(24-60)</td>
</tr>
<tr>
<td>License (M)</td>
<td>13.2</td>
<td>25.0</td>
<td>14.8</td>
<td>27.6</td>
</tr>
<tr>
<td>(Range)</td>
<td>(2-25)</td>
<td>(6-41)</td>
<td>(3-30)</td>
<td>(7-42)</td>
</tr>
<tr>
<td>Km/week (M)</td>
<td>86</td>
<td>190</td>
<td>114</td>
<td>188</td>
</tr>
<tr>
<td>(Range)</td>
<td>(10-200)</td>
<td>(8-300)</td>
<td>(80-200)</td>
<td>(50-450)</td>
</tr>
</tbody>
</table>

7.3.2 Placement of Information

Overall, the HUD was rated as the best placement for both reading and completing the task and the CS placement as the poorest (Table 14). The HDD and IF ratings differed only marginally from each other in both how the placements were experienced by the respondents and the difficulty of completing a task from those placements. Overall, operating the driving simulator and completing the task was rated by the respondents as being slightly more difficult than operating a normal car.

Table 14. The respondents ratings of HUD, HDD, IF, and CS (1 very good – 5 very poor) and ratings of simulator and task (1 very easy – 10 very difficult).

<table>
<thead>
<tr>
<th></th>
<th>HUD &amp; HDD</th>
<th>Single screen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reset 2</td>
<td>Task 2</td>
</tr>
<tr>
<td>Experience HUD</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Experience HDD</td>
<td>2.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Experience IF</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Experience CS</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Complete HUD</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Complete HDD</td>
<td>2.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Complete IF</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Complete CS</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Rating of sim**</td>
<td>5.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Rating of task**</td>
<td>2.7</td>
<td>8.2</td>
</tr>
</tbody>
</table>

*p<.05 **p<.01  n/a – no warning/message presented to the driver
In Table 14 are the respondents’ own subjective experience and subjective opinion of how well they completed the task presented from each respective display position. The HUD was rated by all groups as being very good, the HDD and the IF as being good, and the CS was rated as poor. The Reset 2 and Task 2 groups were presented information via both the HUD and HDD simultaneously and all the respondents did choose to use the HUD only for information gathering. Eight of the respondents did not notice any warning or message in the HDD and those who did say that they were uncertain of the HUD placement at the beginning of the drive but after comparing both placements a couple of times, to see if they coincided, finally they chose to totally rely on the HUD because it was easier to use.

The Reset 4 and Task 4 groups needed to be alert for warnings and messages that could show up in one of the four displays and these groups preferred the HUD before the HDD, and the IF before the CS since they said that the CS was too far away from the road scene to use effectively. The Reset 4 group rated the CS as a very poor placement for them to read and acknowledge warnings as one respondent summed it up, “Even though the warnings were clearly noticeable, the task of driving while looking for a warning in a position that’s so far away from the road just seemed wrong”. No significant differences were found concerning Experience and group or Complete and group. However, significant differences were found in the Experience CS between ages where the 51 and over group rated the test as significantly more difficult than the 30 and under group $F(3,16)= 3.934, p= .028$, also a significant difference was found in the Complete CS group between ages where the 30 and under group rated the test as significantly more difficult than the 51 and over group $F(3,16)= 5.456, p=.009$.

When average distance driven each week was compared a significant difference was found in the Complete HDD group $F(3,36)= 6.632, p=.001$, where the 251 km and up group felt that it was easier to complete a task given in the HDD than
the 75 km and under and 76 to 150 km groups did. Overall, the simulator was rated slightly more difficult to drive than a normal automobile and the Task 2 group rated it as more difficult than all the other groups and significantly more than the Task 4 group $F(3,36) = 3.49, p = .025$. The ratings of the tasks varied from easy Reset 2, moderate Reset 4, to difficult Task 4, and slightly more difficult Task 2. The differences between the two Task groups and the Reset groups was significant $F(3,35)= 22.609, p=.000$. No significant differences were found between the female and male respondents for the respective tests.

### 7.3.3 Placements of Warnings

Overall, the HUD was the preferred position for both Reset groups and the Task 2 group. For warnings concerning serious failures and vehicle operation was the HUD most preferred and for service items and miscellaneous reminders was the HDD most preferred by both Reset groups and the Task 2 group. The Task 4 group differed in choosing HDD as the preferred display and the HUD for service items (Table 15).

#### Table 15. Preferred presentation for warnings.

<table>
<thead>
<tr>
<th>Placement</th>
<th>Reset 2</th>
<th>Task 2</th>
<th>Reset 4</th>
<th>Task 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferred Display</td>
<td>HUD (80)</td>
<td>HUD (80)</td>
<td>HUD (70)</td>
<td>HDD (50)</td>
</tr>
<tr>
<td>Serious Failures</td>
<td>HUD (90)</td>
<td>HUD (80)</td>
<td>HUD (80)</td>
<td>HUD (60)</td>
</tr>
<tr>
<td>Vehicle Operation</td>
<td>HUD (80)</td>
<td>HUD (80)</td>
<td>HUD (70)</td>
<td>HUD (90)</td>
</tr>
<tr>
<td>Service Items</td>
<td>HDD (40)</td>
<td>HDD (50)</td>
<td>HDD (40)</td>
<td>HUD (40)</td>
</tr>
<tr>
<td>Misc. Reminders</td>
<td>HDD (60)</td>
<td>HDD (50)</td>
<td>HDD (40)</td>
<td>HDD (60)</td>
</tr>
</tbody>
</table>

### 7.3.4 Driving Distractions

Overall, the respondents listened to the stereo and adjusted the controls in the CS while driving. Roughly half called, and talked, on the mobile phone while driving and less than one third read and sent text messages and a third used a GPS while driving (Table 16).
Table 16. Activities completed in own vehicle.

<table>
<thead>
<tr>
<th>Task (%)</th>
<th>Reset 2</th>
<th>Task 2</th>
<th>Reset 4</th>
<th>Task 4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text messaging</td>
<td>30</td>
<td>10</td>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Call from phone</td>
<td>40</td>
<td>60</td>
<td>40</td>
<td>40</td>
<td>45</td>
</tr>
<tr>
<td>Talk on phone</td>
<td>50</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>65</td>
</tr>
<tr>
<td>Listen to stereo</td>
<td>80</td>
<td>100</td>
<td>90</td>
<td>100</td>
<td>93</td>
</tr>
<tr>
<td>Adjust controls</td>
<td>90</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>93</td>
</tr>
<tr>
<td>Use GPS</td>
<td>30</td>
<td>40</td>
<td>10</td>
<td>10</td>
<td>23</td>
</tr>
</tbody>
</table>

Only 30% of the respondents practiced text messaging while driving, though, almost all practiced it regularly while not driving. Only 45% of the respondents made telephone calls regularly while driving while 65% talked on the phone. Almost every respondent, 93%, listened to the stereo while driving and 93% also adjusted the controls in the CS. Directional guidance helps like the Global positioning system (GPS) was used regularly by only 23% of the respondents. Significant differences were found for Use of GPS between the sexes $F(38)=7.813, p=.008$, in which, males used the GPS more.

7.3.5 Driving Activity Load Index

Overall, the Global Attention Demand (GAD) and Visual Demand were rated as higher than in a normal car and the Auditory Demand and Tactile Demand as lesser than in a normal car (Table 17).

Overall significant differences were found between the baseline run there the experimental run was rated higher in Visual Demand $t(39)=-2.379, p=.022$, Stress $t(39)=-3.846, p=.000$, Temporal Demand $t(39)=-2.171, p=.036$, and Interference $t(39)=-2.333, p=.025$. Within the Task 2 group was the experiment run significantly higher than the baseline run for Visual demand, $t(9)=-4.583, p=.001$, and Temporal Demand, $t(9)=-2.623, p=.028$, and the same was true for
the Task 4 group for Tactile Demand, \( t(9) = -3.280, p = .010 \) and Stress, \( t(9) = 3.857, p = .004 \). When taking sex into account the experimental run showed that the males perceived their level of Stress to be significantly higher than the females \( F(38) = .4.519, p = .040 \) and when distance traveled per week was taken into account significant differences were found in GAD there the 251 km and up group rated the task as more demanding than the 76 to 150 km group \( F(3,36) = 3.134, p = .037 \).

Table 17. DALI results (from 0 low to 5 high).

<table>
<thead>
<tr>
<th></th>
<th>Reset 2 Base</th>
<th>Exp</th>
<th>Task 2 Base</th>
<th>Exp</th>
<th>Reset 4 Base</th>
<th>Exp</th>
<th>Task 4 Base</th>
<th>Exp</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAD</td>
<td>3.8</td>
<td>4.1</td>
<td>3.6</td>
<td>4.0</td>
<td>3.8</td>
<td>3.6</td>
<td>3.8</td>
<td>4.2</td>
</tr>
<tr>
<td>Visual Demand</td>
<td>3.6</td>
<td>3.7</td>
<td>3.5</td>
<td>4.2*</td>
<td>3.4</td>
<td>3.9</td>
<td>3.0</td>
<td>3.4</td>
</tr>
<tr>
<td>Auditory Demand</td>
<td>1.9</td>
<td>2.1</td>
<td>1.3</td>
<td>1.6</td>
<td>2.3</td>
<td>2.5</td>
<td>1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Tactile Demand</td>
<td>2.9</td>
<td>2.5</td>
<td>1.9</td>
<td>2.3</td>
<td>2.8</td>
<td>2.8</td>
<td>2.4</td>
<td>3.8*</td>
</tr>
<tr>
<td>Stress</td>
<td>3.5</td>
<td>3.7</td>
<td>3.5</td>
<td>4.0</td>
<td>3.1</td>
<td>3.7</td>
<td>2.8</td>
<td>3.7**</td>
</tr>
<tr>
<td>Temporal Demand</td>
<td>3.3</td>
<td>3.3</td>
<td>2.8</td>
<td>4.1*</td>
<td>2.9</td>
<td>2.6</td>
<td>2.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Interference</td>
<td>2.7</td>
<td>3.3</td>
<td>3.3</td>
<td>3.6</td>
<td>3.4</td>
<td>3.3</td>
<td>2.4</td>
<td>3.0</td>
</tr>
</tbody>
</table>

* significant difference was found between baseline and experiment runs \( *p < .05 \) \( **p < .01 \)

**7.4 Discussion**

**7.4.1 Placements of Information**

The groups, Reset 2 and Task 2, got to use the HUD as a constant source of information and therefore were able to get used to it and compare its level of usability as opposed to the HDD. Three of the four groups preferred the HUD as a primary source of information and probably because it was much easier to read while driving and looking at the traffic scene. The reason the Task 2 group rated the HDD position as poorer than the three other groups was probably because they were so few that initially saw and used the HDD information while driving. The Task 4 group gave the poorest rating for the HUD of all the groups.
probably because their task demanded so much of them that they were never
given a chance to become comfortable with a new location, this can also explain
why they liked the HDD better than the other groups did. Many felt that the
driving simulator was more difficult to operate than their normal automobile due
to lack of vehicle motion, minimized field of sight in the driving environment,
same feeling of steering at all speeds, the brakes were either too sensitive or not
sensitive enough, and not used to an automatic transmission. It could be possible
that the respondents in Task 2 felt that it was more difficult to drive due to
factors not studied here since those studied; e.g. sex, age, and driving experience
did not show significant differences.

The tasks were rated according to their level of difficulty for logical reasons,
those given simpler tasks, Reset 2 and 4, as opposed to tasks that, for instance,
included making a telephone call, Task 2 and 4. The Task 2 group rated the task
as marginally more difficult than the Task 4 group which could relate to the fact
that the respondents used the HUD location for instructions while the task was
completed in the CS, which was furthest away in the compartment. While the
Task 4 groups received messages from varied locations, most of them were much
closer to the CS than the HUD. As one respondent explained, “it’s easier to
complete a difficult task like making a phone call when the number I’m going to
call is close to the keypad”. When age was added as a factor the youngest group
and those who drove the least had more difficulty with the CS, which could
relate to driving experience, in that those who were older drove more and the
more one is familiar with the vehicle compartment the easier it is for them to
complete a more demanding task in it. This would support studies that say that
age can be a negative determinant in drivers’ abilities, where young lesser
experienced drivers find themselves more often in accidents (Reason, Manstead,
Stardling, Baxter, & Campbell, 1990; Williams, 1999).
7.4.2 Placement of Warnings

The Reset 2 and Task 2 groups had a speedometer in both the HUD and HDD while the Reset 4 and Task 4 only had it in the HDD. A possible explanation why the Task 4 group did not choose HUD as the preferred placement could be that they did not get to experience a constant stream of information from that placement, like the Reset 2 and Task 2 did. They instead were given instructions from four different placements, of which the HUD was one, as one respondent stated “It seemed like the messages in the HUD were too far away from the CS to perform a task there”. Even though, the Task 2 group used the HUD in their tasks and did not mention that the HUD was too far away from the task but preferred the messages to be in the HUD instead of another position. It is probable that the Task 4 group did not get a chance to practice using the HUD location enough to get used to its advantages over the other placements like the other groups did. The HUD position was chosen by all groups as the preferred placement for Serious Failures and Vehicle Operation. Information in Service Items and Miscellaneous Reminders were of lesser importance to the physical act of driving and probably therefore they were chosen to be placed further away from the line of sight. The Task 4 group also chose HUD for Service Items, this differed from the other groups and could relate to the Task 4 groups’ test experience in that they needed to scan all four screens for instructions. That may have helped them to understand the difficulties of noticing important information presented from several different areas in the vehicle, while the other groups never did get such an opportunity for such an in-depth hands on experience.

7.4.3 Driving Distractions

Overall the respondents showed concern over the distractions that can be caused by their own actions. Therefore more than two-thirds chose not to read nor send text messages while driving, more than half did not make telephone calls, and one-third refused to talk on the phone while driving. It was stated by the
respondents that talking on the phone was not a problem but that the task of calling is because they needed to look away from the traffic scene in order to dial. Almost all used the stereo and adjusted the CS controls to change adjustments on the stereo, climate control, etc. while driving and they did not see it as a distraction problem. Three respondents did not use the stereo, one of them felt that he/she did not want to be distracted by anything while driving and the other said that their vehicle did not have a stereo installed. Some of the respondents said that they make all the necessary adjustments in the CS when stopped and do not intentionally make any adjustments while driving. Only 30% used a GPS for directional help while driving and those who did not have one did not see a need for having one in their daily travels. Overall the drivers realized that there were safety risks involved in secondary tasks and they did chose to drive safe.

7.4.4 Driving Activity Load Index

In comparing all groups baseline run vs. the experimental run were four factors rated as significantly higher; Visual Demand, Stress, Temporal Demand, and Interference. The respondents most likely rated Visual Demand as higher since they needed to scan for warnings and messages as to not miss them while doing the experiment. Although, they did not need to scan for any warnings or messages in the baseline run, it was more like driving in traffic. In a traditional vehicle the presentation of a warning is often coupled to an auditory indicator which is to alert the driver that a change of status has occurred concerning a symbol or message, which, knowing this, do drivers then look for new information, hence, scanning for information without auditory signals is uncommon.

Stress was naturally higher in both Task 2 and Task 4 since they were more demanding in the experimental run and some of the messages showed up in situations where the driver needed to be more focused on the traffic scene. The
respondents tried to complete all the tasks while driving, although, almost all waited until after they had passed the incident area before completing them. In testing for Temporal Demand, the respondents were never given any time restraints to complete the tests but they still felt that they had to perform under time pressure. It seemed that the respondents felt that because they were in a test situation they had to perform the given tasks as quickly as possible. The respondents in Task 4 rated Interference as lower than any other group, even though, they were given the most cognitively demanding task of all, probably so because they were able to focus on driving and completing the task and not think about the simulator as a test. Some of the respondents said the task was very difficult but they realized that they only could do their best and accept the results whereas the other groups may have placed an increased demand on themselves to perform better which may have affected their rating of Interference as being higher.

In general, the driving simulator was rated as demanding a higher Visual Demand, Stress, Temporal Demand, and Interference than the respondents personal vehicles did probably due to the fact that the respondents were new to a driving simulator, experienced anxiety to the situation, the driving environment was not exactly the same as in real life, and also the fact that it was a test situation added extra pressure to respondents. An additional factor that needs to be mentioned is that the driving simulator does not handle like an automobile, it lacks motion, vibrations, a full 360° picture of the outside world, and its mechanical functions like steering and brakes are not speed sensitive like a “real” automobile is. Both the Auditory Demand and the Tactile Demand were rated as having a lesser demand than the average automobile since those items were not tested, thus, the demand was reduced to a minimum.
The Reset 2 group had similar ratings for both the baseline and the experimental runs due to the low cognitive load required in the experiment. For the Task 2 group a similar level of attention was required from the respondents to notice the messages, but an additional level of comprehension and concentration was also needed to complete the task. They needed to read and understand the message, therefore, both Visual Demand and Temporal Demand were rated as higher. Another factor that could have affected the Temporal Demand was that several of the respondents said that they felt that they needed to complete the task as quickly as possible. However, the instructions never stated that and that was not part of the test.

The Task 4 group was given a message on one of the four display locations instructing them to complete a task in the CS area of the simulator. This experiment was the most demanding of all the four since it required visual scanning, increased attention, and an ability to follow instructions and completing them correctly. Tactile Demand was rated higher and according to the respondents having a touch screen further away from the line of sight made things difficult since they could not feel when their finger was in the correct position when pressing the “buttons” on the flat touch screen. A few of the respondents stated that some of the given tasks were too difficult to complete while driving in traffic. The level of Stress was also rated higher in the experimental run probably because the experiment was designed to test how quickly drivers noticed and reacted to messages while in situations where the traffic demanded higher attention levels. An increased level of Stress would be the natural reaction, even though only a few drivers chose not to complete some of the more demanding tasks while driving in the most difficult situations. But Task 4 group rated Inference lowest out of all the experimental runs, even though, their stress level was somewhat higher they did not feel disturbed by the concurrent secondary tasks when driving. This could be because the most
difficult tasks came from messages that were located closer to the CS, thus, the time spent looking at the display and the task were minimal in relation to the HUD messages that Task 2 had, who rated Interference as greatest.
8 General Discussion

8.1 Preferences

Safety and practicality are important issues in vehicle design, as cited earlier in Hoffman (2002), “safety sells cars”. In a global online survey A. C. Nielsen (2005) found that price is the overall determining factor for automobile sales, followed by performance, fuel consumption, and safety. It is possible that the present studies began to categorize factors where the A. C. Nielsen survey finished off, i.e. at safety. The overall responses in this study showed that safety was followed by quality, practicality, and attractiveness. It seems to be that those who are not satisfied with the level of traffic safety in their country, the Chinese and the US and Swedish females, chose safety as most important and those who are satisfied with the present level of safety chose quality (CARE, 2005) and practicality. Quality was also important according to the Western respondents while the Chinese placed it as least most important. Other concerns did weigh so high that Quality was not even considered. Practicality was important for all the male respondents especially the US, even though, the reason for its functionality differed in the various markets. Attractiveness was ranked as last by the males and next to last by the female respondents. This shows that most people are satisfied with the automobile styling of today’s vehicles, thus, the concerns about safety, quality, and practicality are more important. These results show that safe and practical cars with quality could attract consumers without any special aesthetic changes. The Chinese respondents’ responses show that the desire for traffic safety is high while the social norms of driving safe are low although in the US are the social norms changing and new laws are being implemented (Williams, 1999). The Swedish and US males seemed to be more satisfied with the safety mechanisms that are in place, while the females still saw safety as a concern. Even though, Sweden has some of the lowest crash and fatality statistics in the world (CARE, 2005) and the US is at par with other developed countries (Kopits & Cropper, 2004). These results seem to coincide with Robert Green (2006) in
that governments need to work seriously on improving the traffic behavior and the cultural limitations in order to increase traffic safety.

8.2 Warnings
The questionnaire study resulted in that all groups basically preferred the HDD placement for warnings. The Chinese respondents placed emphasis on the warnings that reminded the driver for something they may have missed, while both the Swedish and US respondents placed more importance on warnings for mechanical operation of the vehicle. An additional question can be asked “Why don’t they want important warnings and driver helps to be placed closer to the line of sight?” In China automobiles are often driven by professionals with time pressures, contain more passengers, safety belts are not commonly used, driving under the influence of alcohol is common, and many Chinese drivers do not understand the importance of some typical driving functions (Huang et. al., 2006). Simply stated, there are typically more distractions found inside the Chinese vehicles. Therefore it is probable that the Chinese respondents would not want more items that could increase the possibility for distraction and especially not items that could possibly block the line of sight. It is possible that if Chinese drivers were shown that the information displayed was capable in helping prevent dangerous situations then it would be more accepted. The Swedish respondents’ responses showed a greater concern for the mechanical function, therefore, they are more careful about vehicle maintenance and, thus, would items that are regularly checked be of lesser safety concern. The US responses hinted towards an importance of, or focus on, convenience, which can be seen in the items that were rated as most important and the factor groupings.

8.3 Driver Information
Overall the groups wanted information necessary for vehicle operation to be placed in the HDD, driver support information in the IF, and extra information to be placed in the CS. The most important information for driving was placed
closest to the forward line of sight, while information that was perceived as least important was placed furthest away. This type of groupings seem logical but little is found concerning this in the literature. All three groups of respondents showed strong similarities, even though, the results do show that there were some differences. The Chinese respondents did not see Comfort items as a priority because many of these items are not common in their vehicles and the US respondents wanted a more simple presentation of driving information there all important information for driving and safety was to be placed together in the HDD. The Chinese placed more importance in safety information but placed them in the IF position. This grouping of information showed that the respondents, possibly unintentionally, chose placements that reduce clutter and distraction.

8.4 In-Vehicle Technologies
The HUD was chosen by the Swedish and US respondents as a viable option for safety options. The Chinese are experiencing an automobile revolution and they possibly expressed their driving needs, in part, through their ratings of the IVT’s, by rating items concerning speed control as very important and visual driving helps as moderately important. Even though Swedish respondents did not rate the IVT’s as important they prioritized certain items to be placed in the HUD, image of road in poor weather, lane change helps, and parking helps. This shows that the IVT’s are not so important for them when purchasing a new vehicle but if they are present they are considered so important that they would like them to be placed within the line of sight. The Swedish respondents also wanted the more complex information presentation, like navigator, to be placed in the IF position probably to reduce clutter in the HDD and to keep more complex presentation of information further from the line of sight as to reduced distraction (Horrey, Wickens, & Consalus, 2006; Tijerina, 2000). The US preferred IVT’s that could directly prevent accidents to be placed in the HUD which is in accordance with
Tsimhoni, Green, & Watanabe (2001). IVT’s that helped reduce accidents and planning the drive were rated as important. While items restricting their individual freedoms, like their ability to choose how fast they can drive, were rated as not important which is unfortunate and is a difficult problem to deal with (Williams, 1999).

8.5 Usability
When given the option to use either the HUD or HDD to read the speedometer all respondents except one chose the HUD. For preferences of warnings the HUD was chosen as the most preferable display position. When comparing the different display positions, the HUD was preferred overall because the respondents said that they could see and read the information without needing to remove their vision from the traffic scene, which agrees with earlier research (Wittmann et al., 2006). Since the price of manufacturing HUD’s has become more affordable it could be appropriate to add these in future vehicles (Head up price, 2006). The respondents were divided over the second most important placement. Some liked the IF because it was high up close to the line of sight where they could still see if something appeared and quickly look there to find out what it was. They said that they did not need to look down or directly away from the road to read the information and if they focused on the IF position they could still quickly look back to the scene without any hinder. Previous research has shown that the higher up on the instrument panel is placed the lower the distraction risk due to looking too far away from the traffic scene (Liu & Wen, 2004). The layout just must be designed as to keep the cognitive workload down because many drivers do not realize that they are becoming distracted (Lesch & Hancock, 2004; Wogalter & Mayhorn, 2005a). Those who drove most rated the GAD higher than the other groups possibly because they are more used to performing tasks in their own specific vehicle and when they entered a new driving situation it was more demanding for them.
A couple of respondents expressed the concern that too much information or too small text can be detrimental to them in that they must focus too much on reading and less on driving. Information has to be easy to read (Szabo & Kanuka, 1998). Overall the respondents preferred the HUD for more serious warnings and the speedometer and the HDD for other warnings and basic information for vehicle operation. This is something that could be used in future instrument panel design, since good layout and a good screen design is necessary. A continuation of that would be to use information groupings that fit the user’s mental models. Although the drivers said that they tried not to conduct distractive tasks in their vehicle, some do anyways; while others do not realize that they have a reduced cognitive capacity while doing things in the vehicle. It could also be possible that the temptation to get something done quickly overrules the desire to be safe and safe drivers take chances while driving (Lesch & Hancock, 2004; Wogalter & Mayhorn, 2005a).
9 Conclusions
As stated by Zhang et al. (2006) the American drivers placed more emphasis on the “characteristics of the driver relating to how to deal with signal systems, the vehicle, the environment, and other vehicles” (p.25), which relates to the driver’s understanding of the situation. In contrast to the Chinese who placed emphasis on the “characteristics relating to the driver skills, experiences, and physical capabilities” (p.25) which focuses more on the driver’s unique skills to navigate in traffic. These differences reflect a “survival of the fittest” attitude where Chinese drivers are to respond to a lesser developed traffic environment. A likely explanation why the Chinese respondents rated the safety items as more important is that they did see a need for external helps while navigating in traffic while the US respondents place more focus on the vehicle being practical to use so that it does not restrict their use of it while driving.

Results from both the questionnaires and the simulator study supported a desire for logical grouping of DI there information that is most urgent is placed closest to the traffic scene. The Chinese responses stressed safety while the Swedish did not show a great need for high tech safety options but they did also show a need for logical groupings of information based upon their specific needs to keep the vehicle highly maintained. The US respondents also stressed safety and practicality which shows that they focused more on the physical operation of the vehicle and on the human factors involved to make the drive safer and easier. This is probably why the US respondents showed a need for more advanced technology like IVT’s and the HUD for more practical usage which includes important safety information presentation. They also showed a need for safety measures but they did not want the safety systems in the vehicles to limit their freedom to choose how to drive (Williams, 1999).
An important question is how to implement these changes for the different markets. There are substantial differences which need to be considered in finding the underlying factors to what motivates consumers to like and buy automobiles. It is known that Western made products hold a certain level of admiration in China therefore advertisements many times mimic Western ones when selling Chinese products (Chang, 2008). Even though safety was rated as the most important factor by the respondents it was still ranked as fourth behind price, performance, and fuel consumption by car owners in Asia (A.C.Nilsen, 2005). It may be true that “safety sells” (Hoffman, 2002) but the question for another study is what role does safety play in marketing.

The results of the simulator experiment showed that peoples’ preferences can differ from their actual behavior. Even though the driver’s responses did not agree with the questionnaire results, they do support each other, in that they both showed relevant groupings of DI. However, what the questionnaire did not take into account the fact that the HUD would be wanted to be used by the drivers for many types of warnings, of which, were originally chosen to be placed in the HDD. After the placements were tested in the simulator the drivers preferred warnings along with other IVT’s to be moved up to the HUD for better safety.
10 References


Campbell, J. L., Hoffmeister, D. H., Kiefer, R. J., Selke, D. J., Green, P., & Richman, J. B. (2004). Comprehension Testing of Active Safety Symbols. *Journal of Passenger Car, SAE International 2004-01-0450*. Retrieved March 15, 2007, from http://www.elecpubs.sae.org/NXT/gateway.dll/meta.collections/GM/gm001/151486?f=templates$fn=document-fraomeset.htm$q=%Brank%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A%5Bsum%3A$X=server$3.0#LPHit1


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Appendix A

Questionnaire concerning information in automobiles

The Division of Industrial Design at Luleå University of Technology is participating in an OPTIVe project (Optimized System Integration for Safe Interaction in Vehicles) which purpose is to investigate, evaluate, and demonstrate methods and technical solutions for safe, efficient, and cost effective integration of HMI (Human Machine Interaction) systems in cars. This is in cooperation with the Swedish Department of Transportation, Volvo Car Corporation and Volvo Technology. The specific goal of this survey is to gain knowledge about how to improve the type of information being presented to the driver.

You can help us by answering this questionnaire. The results will presented in such a way that no individual can be identified. Please help us in gaining knowledge about how future vehicles should be designed for the drivers.

Thank you for your participation.

Sincerely,

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Phone: (+46) 920 492855
E-mail: phillip.tretten@ltu.se
Part I. Warning symbols

Information displayed in automobiles is found in the windshield (area 1) and in three areas of the dashboard (areas 2–4). Remember that information placed in the windshield (area 1) is transparent and will not impair your vision.

Now, imagine yourself in the act of buying a new private vehicle. Please answer the following questions to the best of your knowledge. Remember there is no right, or wrong, answer, it is your opinion that is of interest. Please mark the number that you feel best fits your opinion. Choose also where you feel the information found in each question should be placed in the dashboard, an example is given below.

Example:

![Warning symbol for steering failure is important to me.](image)

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not true</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>True</td>
</tr>
</tbody>
</table>

| Warning symbol for low window washer fluid is important to me. |
| 1 2 3 4 5 6 7 |
| Not true | | | | | | True |

| Warning symbol for low tire pressure is important to me. |
| 1 2 3 4 5 6 7 |
| Not true | | | | | | True |

| Warning symbol for improper oil pressure is important to me. |
| 1 2 3 4 5 6 7 |
| Not true | | | | | | True |

| Warning symbol for low fuel level is important to me. |
| 1 2 3 4 5 6 7 |
| Not true | | | | | | True |
### Warning Symbol for Parking Brake Engaged

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Improper Engine Temperature

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Electrical Charging System Failure

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Airbag Not in Function

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Anti-lock Braking System (ABS) Failure

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Door Ajar

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Engine Stall

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Poor Road Conditions

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|

### Warning Symbol for Electrical Malfunction

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|
|   | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|   |   |   |   |   |   |   | True|
Warning symbol meaning *engine in need of service* is important to me.

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<td>Not true</td>
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<td>True</td>
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</table>

[Image]
**Part II. Driver information**

An example of driver information displayed in automobiles is placed below. This information can be found in the windshield (area 1) and in three areas of the dashboard (areas 2-4). **Remember** that information presented on the windshield (area 1) is transparent and will not impair your vision.

Now, imagine yourself in the act of **buying a new private vehicle**. Please answer the following questions to the best of your knowledge. Remember there is no right, or wrong, answer, it is your opinion that is of interest. Mark the number that best fits your opinion, an example is found below.

Example:

*Radiator fluid level information is important to me.*

![Radiator Fluid Level Image]

<table>
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<tr>
<th>1</th>
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<tr>
<td>Not true</td>
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<td>True</td>
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</tbody>
</table>

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*Speedometer information (vehicle speed) is important to me.*

![Speedometer Image]

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<tbody>
<tr>
<td>Not true</td>
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</tbody>
</table>

*Fuel level information is important to me.*

![Fuel Level Image]

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<th>1</th>
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<th>4</th>
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<tr>
<td>Not true</td>
<td></td>
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<td>True</td>
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</tbody>
</table>

*Tachometer information (motor speed) is important to me.*

![Tachometer Image]

<table>
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<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>Not true</td>
<td></td>
<td></td>
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<td>True</td>
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</tr>
</tbody>
</table>

*Oil pressure information is important to me.*

![Oil Pressure Image]

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Not true</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>Feature</td>
<td>Rating</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------</td>
<td>---</td>
<td>---</td>
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</tr>
<tr>
<td>A clock is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Actual outside temperature indicator is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Seatbelt reminder indicator is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Indicator showing which door/hatch is ajar is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Indicator showing which light bulb is malfunctioning is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Cruise control indicator is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Climate control information is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Entertainment information is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Mobile telephone information is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Trip computer presenting; average economy, fuel consumption, instant economy, miles remaining before empty, etc. is important to me.</td>
<td>True</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Scrollable menu of options showing vehicle status (like service interval, mileage, temperature, vehicle malfunctions, fluid levels, etc) is important to me.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not true</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>True</td>
</tr>
</tbody>
</table>

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**Part III. Advanced driver helps**

An example of an advanced driver help is shown below. This information can be found in the windshield (area 1) and/or in three areas of the dashboard (areas 2-4). **Remember** that information presented on the windshield (area 1) is transparent and will not impair your vision.

Now, imagine yourself in the act of **buying a new private vehicle**. Please answer the following questions to the best of your knowledge. Remember there is no right, or wrong, answer, it is your opinion that is of interest. Mark the number that best fits your opinion, an example is also found below.

**Example:**
*Steering assistant used for lane changing is important to me.*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>True</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not true</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Image of road obstacles and other vehicles is important to me (similar to the example above).*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>True</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not true</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Image of road to help the driver in conditions of poor visibility is important to me (similar to the example above).*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>True</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not true</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

124
<table>
<thead>
<tr>
<th>Feature</th>
<th>Rating</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigator (digital directional guidance help in the automobile) is important to me.</td>
<td>1</td>
<td>Not true</td>
</tr>
<tr>
<td>Excessive speed indicator (alerts driver when the speed limit is surpassed) is important to me.</td>
<td>7</td>
<td>True</td>
</tr>
<tr>
<td>Adaptive cruise control information (automatically keeps your vehicle from getting too close to the vehicle in front of you) is important to me.</td>
<td>1</td>
<td>Not true</td>
</tr>
<tr>
<td>External Vehicle Speed Control (assists drivers in keeping the government-defined speed limit) is important to me.</td>
<td>7</td>
<td>True</td>
</tr>
<tr>
<td>Parking aids indicating vehicle position in relation to other cars and obstacles is important to me.</td>
<td>1</td>
<td>Not true</td>
</tr>
<tr>
<td>Video image of backseat (so that you do not need to turn around to see what the passengers/children are doing) is important to me.</td>
<td>7</td>
<td>True</td>
</tr>
<tr>
<td>Electronic brake assist information (assists your vehicle in quickly braking for obstacles that you, the driver, did not respond to) is important to me.</td>
<td>1</td>
<td>Not true</td>
</tr>
<tr>
<td>Lane change aid information (alerts you if there is another vehicle in hard to see areas when you attempt to change lanes) is important to me.</td>
<td>7</td>
<td>True</td>
</tr>
<tr>
<td>Feature</td>
<td>Importance Rating</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Shift light for sport driving</strong> (shows you when to shift for optimal acceleration) is important to me.</td>
<td>1 2 3 4 5 6 7 True</td>
<td></td>
</tr>
<tr>
<td><strong>Shift light for economical driving</strong> (shows you when to shift for optimal economical driving) is important to me.</td>
<td>1 2 3 4 5 6 7 True</td>
<td></td>
</tr>
<tr>
<td><strong>Econo-meter</strong> (shows an accumulated value of economical driving, showing how much total energy is saved) is important to me.</td>
<td>1 2 3 4 5 6 7 True</td>
<td></td>
</tr>
<tr>
<td><strong>Advanced driver menu</strong> (choice of language, functions and what other options are available when driving) is important to me.</td>
<td>1 2 3 4 5 6 7 True</td>
<td></td>
</tr>
<tr>
<td><strong>Advanced driver options</strong> (choice of where information is to be shown) is important to me.</td>
<td>1 2 3 4 5 6 7 True</td>
<td></td>
</tr>
<tr>
<td><strong>Adaptable display</strong> (where only relevant information is presented in the correct situation. The information displayed adapts to the situation, like cold start, cruising or rush-hour traffic) is important to me.</td>
<td>1 2 3 4 5 6 7 True</td>
<td></td>
</tr>
</tbody>
</table>
Sociodemographical questions

Sex
☐ Female    ☐ Male

Age

Personal status
☐ Single    ☐ Single with children    ☐ Married/ Partner
☐ Married/Partner with children

Please choose your level of education
☐ Practical    ☐ High school    ☐ College    ☐ Other ___________________

Approximate yearly income in dollars
☐ - 10,000    ☐ 10,001 – 20,000    ☐ 20,001 – 30,000    ☐ 30,001 – 40,000
☐ 40,001- 60,000    ☐ 60,001 - 80,000    ☐ 80,001 -

What state and/or country do you originally come from? _______________________________________

Do you have a driver’s license? ☐ No    ☐ Yes, for how long? __________

The vehicle I am most familiar with, (own, drive or have ridden in) is…
Brand ___________________________ Model ___________________________ Year ______

a. The vehicle I would like to own is…
Brand ___________________________ Model ___________________________ Year ______

b. Why?
__________________________________________________________________________________________
__________________________________________________________________________________________

Why do you like that particular design?
__________________________________________________________________________________________
__________________________________________________________________________________________

Rank the order of importance you place on these items when you are deciding to buy a new private automobile.
1 is most important and 5 is least important
☐ exterior design
☐ interior design
☐ feel of quality
☐ practical
☐ feels safe

Do you have experience in these 7 areas?

Acting Yes ☐ Interest
☐ Hobby
☐ Educated
☐ Field of employment
No ☐
<table>
<thead>
<tr>
<th>Art</th>
<th>Yes</th>
<th>Interest</th>
<th>Hobby</th>
<th>Educated</th>
<th>Field of employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architecture</td>
<td>Yes</td>
<td>Interest</td>
<td>Hobby</td>
<td>Educated</td>
<td>Field of employment</td>
</tr>
<tr>
<td>Automobiles</td>
<td>Yes</td>
<td>Interest</td>
<td>Hobby</td>
<td>Educated</td>
<td>Field of employment</td>
</tr>
<tr>
<td>Fashion</td>
<td>Yes</td>
<td>Interest</td>
<td>Hobby</td>
<td>Educated</td>
<td>Field of employment</td>
</tr>
<tr>
<td>Music</td>
<td>Yes</td>
<td>Interest</td>
<td>Hobby</td>
<td>Educated</td>
<td>Field of employment</td>
</tr>
<tr>
<td>Product Design</td>
<td>Yes</td>
<td>Interest</td>
<td>Hobby</td>
<td>Educated</td>
<td>Field of employment</td>
</tr>
</tbody>
</table>

Thank you for your participation
Appendix B

Instruktion för testpersoner

Välkomna respondenten

2. Om Du behöver gå på toaletten kan Du passa på att göra det nu då hela experimentet kommer att ta cirka 1 ½ tim.
3. Du kommer att medverka i ett experiment som handlar om användargränssnitt i en förarmiljö.
   a. Experimentet är uppdelat i 3 moment; inlärning och två huvudmoment, med en paus mellan varje enskilt moment.
   b. I det första momentet ska Du lära Dig att köra bilen och känna dess egenskaper.
   c. I det andra momentet ska Du köra bilen som Du gör i vanlig trafiken, följa trafikregler, osv.
   d. I det tredje momentet kommer Du att lära det samtidigt som Du köra bilen.
   e. Efter varje huvudmoment kommer vi att be Dig fylla i ett frågeformulär.
   f. Under tiden Du köar kommer vi att mäta dina ögonrörelser, din körförmåga, samt hur din kropp reagerar rent fysiologiskt (puls, GSR, handtemperatur (stressindikatorer).
5. Det är viktigt att Du inte berättar för andra vad Du gjort i experimentet, det kan påverka kommande resultat, men efter den 6:e juni "nationaldagen" är det fritt.

Träning

1. Vi ska nu gå igenom de viktigaste funktionerna som Du behöver känna till för att köra bilen. Du kommer även att få köra ca 10 min för att bekanta dig med bilen.
2. Nu ska vi gå igenom bilens funktioner
   a. Lägg märke till att bilen har en automatisk växellåda, allt Du behöver göra är att sätta den i läge "D" för att kunna köra.
   b. Vi vill att Du ska lära känna bilen och dess egenskaper; gasa, bronsa, styra genom svängar och rondeller, osv.
   c. Försöka hålla hastigheten under körningen.
**Fysiologiska mätutrustningar**

1. Vi ska nu sätta på dig utrustning för att mäta din puls, handtemperatur och handens ledningsförmåga. Vi kommer även att mäta din puls via tre sensorer på dina nyckelben samt på ditt nedersta revben.


**Experiment**

1. Det här är huvudmoment två. Här ska du köra en 15 km sträcka där meddelanden kommer att dyka upp i någon av bilens displayar vid flera tillfällen.
   a. Alla varningar/tecken och all text är tydligt angett och du ska utföra uppgiften som du anser det passar dig bäst.

2. Din uppgift när meddelanden dyker upp är att:
   a. **Vid kvittera:**
      i. Kvittera bort meddelanden. Tryck på ”reset” knappen på vänster rattspak och meddelandet försvinner från displayen.
   b. **Vid handla:**
      i. Utför handlingen som displayen visar. När handlingen är avklarad försvinner meddelandet.

   a. Håll dig till hastighetsbegränsningarna.
   b. Om bilar framför dig är för långsamma kan du göra en omkörning.
   c. Sträckan börjar med 70 km/h.

4. Du kan kliva ut ur bilen,
   a. ta en kort paus
   b. och fylla i frågeformuläret om hur du upplevde detta moment.

**Baseline**

1. I det här är momentet ska Du köra en 15 km sträcka utan några andra uppgifter att sköta. Det gör vi för att vi ska kunna jämföra med huvudmoment två där du samtidigt utför vissa uppgifter.

2. Du ska köra bilen som om den är en riktig bil.
   i. Håll dig till hastighetsbegränsningarna.
   ii. Om bilar framför dig är för långsamma kan du göra en omkörning.
   iii. Sträckan börjar med 70 km/h.

3. Du kan kliva ut ur bilen,
   i. ta en kort paus
   ii. och fylla i frågeformuläret om hur du upplevde detta moment.
   iii. Under tiden förbereder vi nästa moment.

**Intervju**

- Nu ska vi avsluta med några frågor om hur du upplevde att köra bilen.

**Tack för din medverkan!**

- Du får en matkupong på Centrumresturang. Kvittera här för att visa att du fick kupongen
Appendix C

DALI - Driver Workload Test

During the experiment that you have just achieved, you may have felt some constraints and difficulties with regard to your usual driving task.

Also, we are proposing to evaluate these potential modifications through 7 factors; these factors are described on the board below. Don’t hesitate to ask any questions if you need it.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global attention demand</td>
<td>Mental (to think about, to decide…) visual and auditory demand required during the test to achieve the whole activity.</td>
</tr>
<tr>
<td>Visual demand</td>
<td>Visual demand required during the test to achieve the whole activity.</td>
</tr>
<tr>
<td>Auditory demand</td>
<td>Auditory demand required during the test to achieve the whole activity.</td>
</tr>
<tr>
<td>Tactile demand</td>
<td>Specific constraints induced by vibrations during the test.</td>
</tr>
<tr>
<td>Stress</td>
<td>Level of stress during the whole activity such as fatigue, insecure feeling, irritation, discouragement…</td>
</tr>
<tr>
<td>Temporal demand</td>
<td>Pressure and specific constraint felt due to timing demand when running the whole activity.</td>
</tr>
<tr>
<td>Interference</td>
<td>Disturbance of the driver’s state and consequences on the driving activity when conducting the driving activity simultaneously with any other supplementary task such as phoning, using systems or radio…</td>
</tr>
</tbody>
</table>

For each factor, you are going to rate the level of constraint felt during the session on a scale from 0 (low) to 5 (high) with regard to your usual driving task.
Global Attention Demand
How do you rate the global attention required during the test with regard to what you usually feel while driving?

Lower: 0  1  2  3  4  5
Higher:

Visual Demand
How do you rate the visual demand required during the test with regard to what you usually feel while driving?

Lower: 0  1  2  3  4  5
Higher:

Auditory Demand
How do you rate the auditory demand required during the test with regard to what you usually feel while driving?

Lower: 0  1  2  3  4  5
Higher:

Tactile Demand
How do you rate the tactile demand required during the test with regard to what you usually feel while driving?

Lower: 0  1  2  3  4  5
Higher:

Stress
How do you rate the stress required during the test with regard to what you usually feel while driving?

Lower: 0  1  2  3  4  5
Higher:

Temporal Demand
How do you rate the pressure related to the time available to run the whole activity during the test with regard to what you usually feel while driving?

Lower: 0  1  2  3  4  5
Higher:

Inference
How do you rate the modifications of your driving behaviour during the test with regard to what you usually feel while driving?

Lower: 0  1  2  3  4  5
Higher:
Appendix D

Intervjufrågor

testpersonnummer ______________

I. Kön? ______

2. Ålder? _____

3. Vad är ditt civilstånd? _____________________________

4. Vad har du för inkomst/månad?______________________

5. Har du nedsatt syn? Om ja, Använder du glasögon eller kontaktlinser?____________________________________

6. Vilken utbildning har du?_________________________

Allmänna frågor

7. Hur länge har du haft körkort?_____________________


11. Har du erfarenhet av bilspel eller körsimulator? Omfattning?

__________________________________________________________________

12. På en skala från 1 till 10, där 1 är mycket enkel att köra och 10 är väldigt svår att köra, Hur skulle du säga att simulatorn är att köra ______

13. På en skala från 1 till 10, där 1 är mycket enkelt och 10 är väldigt svårt, Hur skulle du säga att det var att läsa och utföra de efterfrågade kvitteringarna/handlingarna när Du körde, _____


__________________________________________________________________

__________________________________________________________________

Interaktion


__________________________________________________________________

__________________________________________________________________
16. Fanns det kvitteringar/handlingar som var särskilt svåra att utföra? Kan du förklara?

__________________________________________________________________________

__________________________________________________________________________

17. Utförde du kvitteringarna/handlingarna så snart du uppfattade meddelandena?
   Varför/varför inte? _______________________________________________________

__________________________________________________________________________

18. Hur upplevde du informationen/meddelanden som fanns i de olika placeringarna?
   a. HUD

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

b. HDD

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

c. Infotainment

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

d. Center-stack

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

19. Hur var det att utföra en handling från ett meddelande presenterad i;
   a. HUD

__________________________________________________________________________

b. HDD

__________________________________________________________________________
20. Skulle Du föredra att information (varningar/meddelanden) placeras enbart bakom ratten eller skulle Du föredra att det delas upp på de olika skärmar som finns i simulator? Dvs. att information med olika grad av viktighet befinner sig på olika positioner? Förklara?

21. Vilken placering i bilen tycker Du passar bäst för varje typ av varning?
   a. Varningar för fel/problem som gör att Du måste stanna bilen t ex motorn överhettas
   b. Varningar om osäkra körhävningar t ex halka
   c. Varningar som kan åtgärdas direkt t ex dörren på glänt
   d. Varningar som meddelar om att utföra service snart t ex byta olja

Reflektioner om körning

22. Skulle Du utföra samma typ av kvitteringar/handlingar medan Du kör en vanlig bil/ Dins egen bil? (t ex. läsa ett meddelande/varning och sen kvittera bort det) Kan Du förklara?

23. Gör Du något av följande regelbundet under tiden Du kör bil?
   a. Skickar SMS?
   b. Pratar i telefon?
   c. Ringer upp med telefon?
   d. Lyssnar på radio/musik?
   e. Använder navigeringssystem?
   f. Ändrar inställningar i navigationssystemet?
   g. Justerar ventilation/värme/klimatanläggning?
   h. Gör Du saker eller använder Du funktioner som tar Din uppmärksamhet från vägen mer än två sekunder? (t ex. byta CD-skiva, byta låter i MP3-spelare, äta, osv.) Vilka?
Reflektioner om testet

24. Är det något du vill tillägga? Några ytterligare kommentarer?

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

25. Plats för övriga information av intresse som förekom under intervjun.

_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________
_______________________________________________________________________

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