U.S. Department
of Transportation
National Highway
Traffic Safety
Administration

www.nhtsa.gov

DOT HS 812 173 August 2015

Enhanced Seat Belt Reminder System Features for Teenagers

DISCLAIMER

Lerner, N., Singer, J., Robinson, E., Huey, R., Walrath, J., & Freedman, M. (2015, August). *Enhanced seat belt reminder system features for teenagers.* (Report No. DOT HS 812 173). Washington, DC: National Highway Traffic Safety Administration.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT HS 812 173		

4. Title and Subtitle Enhanced Seat Belt Reminder System Features for Teenagers	5. Report Date August 2015
	6. Performing Organization Code
7. Author(s) Lerner, N., Singer, J., Robinson, E., Huey, R., Walrath, J., and Freedman, M.	8. Performing Organization Report No.
9. Performing Organization Name and Address Westat, Inc. 1600 Research Boulevard Rockville, MD 20850	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DTNH22-5-D-01002
12. Sponsoring Agency Name and Address National Highway Traffic Safety Administration Office of Program Development and Delivery 1200 New Jersey Avenue SE. Washington, DC 20590	13. Type of Report and Period Covered Draft Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

Michael Perel and Stephanie Binder were the Contracting Officer's Technical Representatives (COTR) for this project.

16. Abstract

This report describes a research study that evaluated the reactions of teenagers and their parents to enhanced seat belt reminders (ESBRs). ESBRs remind vehicle occupants to buckle up using alerts that are more assertive and persistent than the minimum seat belt reminder system prescribed in FMVSS No. 208. Teenagers 16 to 18 years old provided feedback regarding a set of ESBRs designed specifically for this study. Teens participated either individually or in groups of three or four friends. Participants experienced prototype ESBR systems and features in a real vehicle, with and without engaging in simulated drives. The primary dependent measures were participants' ratings of their likelihood of buckling up, the annoyance of the system, the appropriateness of the strength of alerts, and the desirability of the system or feature. There were strong and consistent effects of the ESBR system on ratings. Effectiveness and annoyance were highly correlated. No system or feature emerged as dramatically more effective than would be expected based on its annoyance. Visual displays in general were less effective and less annoying than other modalities. Additional sessions were conducted with parents of teens, who experienced the prototype ESBRs, provided ratings, and participated in group discussions about their teens' seat belt use and their preferences for teen ESBRs. Parents were generally in favor of ESBRs for their teens, and favored assertive system features to ensure seat belt use. Based on the findings, a set of recommendations for the design of seat belt reminder systems specifically oriented to teenage drivers and their passengers was developed.

17. Key Words	18. Distribution Statement
Occupant protection, seat belt, enhanced reminder, consumer acceptance, in-vehicle displays	Document is available to the public from the National Technical Information Service at www.ntis.gov

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22
Unclassified		111	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Acknowledgements

The authors thank Jennifer Warren, Stephanie Binder, Michael Perel, and Lisandra Garay-Vega of NHTSA for their support throughout this work. The authors also thank Stephane Ridore for his contributions to the study.

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Executive Summary

In 2011, there were 1,987 drivers 15 to 20 years old who died in motor vehicle crashes, and an additional 180,000 were injured (NCSA, 2013b). While young-driver involvement in crashes has decreased nearly 50 percent since 2002, young drivers are still overrepresented in fatal crashes: Young drivers represent only 6 percent of the driving population, but were involved in 10 percent of all fatal crashes and 13 percent of all police-reported crashes (NCSA, 2013b). Teens are most likely to engage in speeding and tailgating behaviors, and are at the greatest risk for crashes when driving with a group of peers (Simons-Morton, Lerner, & Singer, 2005; Williams, 2003). Despite the risks, 60 percent of vehicle occupants 15 to 20 years old who died in motor vehicle crashes were unrestrained at the time of the crashes (NCSA, 2013a).

One countermeasure that may help to achieve greater seat belt use among the high risk population of teen drivers and passengers is an enhanced seat belt reminder (ESBR). ESBRs present reminders that are more assertive and persistent than the minimum seat belt reminder system prescribed in Federal Motor Vehicle Safety Standard (FMVSS) No. 208. Many automotive manufacturers currently market vehicles with ESBRs. Current ESBRs vary widely in terms of alert type and timing. Evidence shows that at least some ESBRs can improve seat belt use rates for the general driving population (Ferguson, Wells, & Kirley, 2006; Young, Regan, Triggs, Stephan, Mitsopoulos-Rubens, & Tomasevic, 2008; Williams, Wells, & Farmer, 2002; Freedman, Levi, Zador, Lopdell, & Bergeron, 2007), but until recently, no research existed to indicate what aspects of ESBRs are effective in increasing seat belt use. Data was also limited regarding motorists' acceptance or preferences for various ESBR configurations.

NHTSA initiated a research project to address these issues and provide evidence regarding the effectiveness and acceptance of ESBRs for front occupants. The project consisted initially of three complementary tasks. The first was an observational study of over 50,000 vehicles (Freedman, Levi, Zador, Lopdell, & Bergeron, 2007), which found that most ESBRs increased the rate of belt use by about 3 to 4 percentage points over the non-ESBR rate of belt use. The second task was an experimental investigation of adults' reactions to a set of prototypical ESBRs during on-road driving and while stationary (Lerner, Singer, Huey, & Jenness, 2007). The study found that ESBRs were substantially more effective than the minimum reminder required by FMVSS No. 208, and that auditory alerts were substantially more effective in increasing the perceived likelihood of wearing a seat belt than visual alerts. The study also found a strong correlation between perceived effectiveness and annoyance of ESBR systems and components. Following the first two tasks, an additional task was undertaken (task four) (Freedman, Lerner, Zador, Singer, & Levi, 2008). This task included further analysis of the observational study data to evaluate the effectiveness and importance of various features of ESBRs (e.g., alert mode, timing); an analytical synthesis of the findings of the first two studies; and recommendations for the design of ESBR systems.

For the third task, which is the subject of the present report, teenagers 16 to 18 were recruited to provide feedback regarding a set of ESBRs designed specifically for this study. Research on ESBRs has given little attention to the teen population despite this group's high crash rates and relatively low seat belt use rates. Teens are cognitively and emotionally different from adults, and the factors that motivate teen belt use may not be the same as those that motivate adult belt use. Furthermore, the trade-off of effectiveness in promoting belt use versus consumer acceptance and preference factors may be different for teens than for adults, given the issues of poor hazard perception and risk-related judgment of teens. The study was conducted in an actual vehicle in which numerous ESBR elements and timing algorithms could be presented. The vehicle was stationary and driving was simulated. The primary dependent measures were participants' ratings of their likelihood of buckling up, the annoyance of the system, the appropriateness of the strength of the alerts, and the desirability of the system or feature. Thus the measure of effectiveness of alternative systems and features is based on participant ratings, and not on actual overt behaviors. The study involved two parallel methodologies. Thirty-one sessions were conducted with teens participating individually in solo sessions and 20 sessions were conducted with teens in "affinity groups" of three or four friends. Participants in these group sessions recruited their friends to participate with them to provide a more realistic teen group experience. All participants reported at least occasional seat belt nonuse. Participants in solo and group sessions first experienced a set of ESBR systems while engaged in simulated drives. Participants provided ratings for the systems during the simulated drives and answered additional questions at the completion of each drive. Following these simulated drives, solo participants made additional ratings about an additional set of brief ESBRs, which only displayed the first 30 seconds of each system, and then rated 27 individual alerts, which included an assortment of auditory, visual, and haptic elements. Group participants did not experience the brief ESBRs or individual alerts; instead, they participated in brief discussions with the experimenter regarding their thoughts about seat belt use and ESBRs.

In an additional subtask, 25 parents of novice teen drivers were recruited to experience the same ESBRs experienced by teens. Parents provided ratings about perceived system effectiveness and annoyance. Parents then participated in a discussion with the experimenter about their thoughts about teen seat belt use and preferences for ESBR systems for their teens.

Key results of the study include the following:

- There were strong and consistent effects of the ESBR system on ratings of effectiveness in prompting seat belt use, annoyance of the displays, strength appropriateness, and system desirability.
- Effectiveness and annoyance were highly correlated. This correlation was seen for all three procedures: simulated drives with complete ESBR systems, brief ESBRs (first 30 to 40 seconds of a system), and individual alerts. No system or feature emerged as dramatically more effective than would be expected based on its annoyance, although some were better than others in this regard.
- The minimal belt reminder system, meeting FMVSS No. 208 requirements but with no enhanced feature, was rated much lower in effectiveness than any other system. It was also the least desirable of all the systems and its display was rated the least appropriate in terms of signal strength.
- Factors other than the ESBR system were typically not statistically significant and rarely interacted with the ESBR system for measures of belt use effectiveness, annoyance, signal strength appropriateness, or desirability. These additional factors included participant gender, driver alone versus with passengers, seat position, group composition, and seat belt condition (unbuckled or buckled).
- Overall acceptability of the concept of an ESBR system was good for both teens and their parents. There was little strong negativity seen among the group of teen participants

towards ESBR systems; acceptability among persistent non-users of seat belts was not tested.

- Visual displays in general were less effective and less annoying than other modalities. Findings regarding alert features were generally consistent with the findings of the adult-oriented systems investigated in Lerner, Singer, Huey, and Jenness (2007) and with the ESBR system characteristics analysis of observational data reported by Freedman, Lerner, Zador, Singer, & Levi (2009).
- Voice messages were positively received, and may warrant consideration for the belt reminder application.
- The visual display showing a schematic of vehicle occupants and their belt use status was well received by teens. Although it was not rated as effective as various displays using tones or voice, it was quite effective relative to its low annoyance. Teens and parents also felt it would help promote positive interactions to encourage others to buckle up.
- Haptic alerts (seat pan vibration) were seen as most effective. While also rated relatively high in annoyance, it was rated no more annoying than other displays rated as less effective.
- The ESBR system incorporating driver seat vibration was rated as the most desirable system by drivers in the experiment. Parents and teens did express some concerns about this mode, including whether it might engender startle effects or whether it might not provide sufficient motivation to buckle.

Based on the findings, a set of recommendations for the design of seat belt reminders specifically oriented to teenage drivers and their passengers was developed. The recommendations included specific suggestions related to graded alerts, alert modality, seat belt status display, vehicle adaptation, and customization. Comments on the recommendations were solicited from a number of automotive companies and were synthesized to complement the information. The comments were diverse across companies, and there was no clear consensus on the various topics addressed. Since there is no common industry practice for general (“adult”) enhanced reminder systems, the recommended teen reminder system cannot be directly compared with an “adult” system. However, it does differ in emphasizing certain aspects that may be less desirable or less critical for a more general vehicle system. These aspects include: a two-phase (reminder and motivator) display system; assertive (motivating) sounds within 15 to 20 seconds of ignition or when a speed threshold is reached (whichever comes first); continuous cycling of the motivator phase; visual feedback for unbelted passengers in all seat positions; and a visual indication of passenger belt status for the driver. Details of these and other recommendations are provided in the report as explicit guidance statements with accompanying rationale.

While the methods of the study appear to have been successful in eliciting meaningful responses from participants, it should be kept in mind that the measures are subjective and not behavioral. The method and findings have not been validated in a field study with operational ESBR systems. Furthermore, the very concept of a teen-oriented ESBR system implies that such a system would be more effective for teens than a system designed for the general driving public, but this was not tested.

1. Introduction

1.1 Background

In 2011, there were 1,987 drivers 15 to 20 years old who died in motor vehicle crashes and an additional 180,000 who were injured (NCSA, 2013b). While young-driver involvement in crashes has decreased nearly 50 percent since 2002, young drivers are still overrepresented in fatal crashes: Young drivers represent only 6 percent of the driving population, but were involved in 10 percent of all fatal crashes and 13 percent of all police-reported crashes (NCSA, 2013b). Teens are most likely to engage in speeding and tailgating behaviors, and are at the greatest risk for crashes when driving with a group of peers (Simons-Morton, Lerner, & Singer, 2005; Williams, 2003). Despite the risks, 60 percent of vehicle occupants 15 to 20 years old who died in motor vehicle crashes were unrestrained at the time of the crashes (NCSA, 2013a).

Despite the fact that teens are at greater risk of traffic crashes, injuries, and fatalities than driver in other age groups, many teens fail to wear seat belts. A national survey found that only 79 percent of teens reported "often or always" wearing seat belts as drivers, and only 70 percent reported "often or always" wearing seat belts as passengers (Winston et al. Eds., 2007). Another survey in which 2,000 teens were interviewed three times during the first year of licensure found that about one-third of the teens at least once admitted to not always wearing seat belts within the past week (Ouimet et al., 2008). In 2011, only 40 percent of vehicle occupants 15 to 20 who were killed in crashes were wearing seat belts (NCSA, 2013a). The combination of high crash risk and low seat belt use rates, especially when in groups, is a significant teen health and safety problem.

One approach to encouraging vehicle occupants to buckle up is to give them in-vehicle reminders. However, the reminder system currently required by Federal law is limited in its effectiveness (Transportation Research Board, 2003). If the driver belt is not fastened and the ignition switch is turned on, FMVSS No. 208 S7.3 requires an audible signal for a period of 4 to 8 seconds and, and depending on which option the manufacturers chooses to comply with, a warning light for not less than 60 seconds or for 4 to 8 seconds.[1] Many automobile manufacturers are now voluntarily installing enhanced reminder systems in their current models. These systems differ considerably from one vehicle to another in terms of the visual and auditory displays they use, the rules that trigger a display, the manner in which the displays change with time, distance, or speed, the aggressiveness of the system (in terms of urgency and annoyance), and the use of sensing and displays for occupants other than the driver. In addition to currently implemented systems, there have also been a variety of prototypes, experimental concepts, and design recommendations. These enhanced systems range from very simple displays (e.g., flashing icon) to complex, multistage systems triggered by driving status (e.g., speed, travel distance) and featuring multiple types of visual, auditory, voice, and possibly even haptic (tactile) alerts, as well as interlocks, delays, or limitations on some aspect of vehicle performance (e.g., gear shifting, speed, entertainment system).

[1] The option chosen affects what the system must do when the belt is latched. If the 60 second warning light is chosen when the belt is not latched, then no warning light needs to activate when the belt is latched. If the 4 to 8 second warning light is chosen when the belt is not latched, then a 4 to 8 second warning light must activate when the belt is latched.

Evidence shows that at least some ESBR systems can improve seat belt use rates (Ferguson, Wells, & Kirley, 2006; Young, Regan, Triggs, Stephan, Mitsopoulos-Rubens, & Tomasevic, 2008; Williams, Wells, & Farmer, 2002). Fleet management products that include intelligent technologies for sensing seat belt use and providing driver feedback also appear to increase seat belt use rates for commercial vehicle fleets and ambulance fleets (e.g., Levick & Swanson, 2005). Field observations indicate that some reminder systems are more effective than others (e.g., Krafft, Kullgren, Lie, & Tingvall, 2006). In an observational study of over 50,000 vehicles conducted as a separate task within the current project (Freedman, Levi, Zador, Lopdell, & Bergeron, 2007), ESBR systems were associated with increases of about 3 or 4 percentage points in front seat occupant seat belt use rate compared to vehicles without such systems, even when controlling for potential confounding factors.

In another task conducted within this project, investigators experimentally evaluated adults' reactions to a set of prototypical ESBRs during on-road driving and while stationary (Lerner, Singer, Huey, & Jenness, 2007). All participants had reported occasional or frequent seat belt nonuse. The study found that all of the prototypical ESBRs were rated as more effective in eliciting seat belt use (self-reported likelihood of use) than the minimum system required by FMVSS No. 208. Furthermore, auditory alerts were perceived to be significantly more effective than visual alerts. With few exceptions, the alerts that drivers considered effective were also considered to be annoying. Taken together, the findings of the field observational study and the adult ESBR experimental evaluation yielded a number of recommendations for ESBR features that may contribute to effectiveness and acceptance for the general driving population (Freedman, Lerner, Zador, Singer, & Levi, 2009).

ESBRs show promise for improving seat belt use rates among the general population, but little attention has been paid to the high-risk teen population in particular. To date, there has been no comparative evaluation of the features of ESBRs that best promote seat belt use as well as acceptance by teens and their parents. The factors that motivate teens to use or not use seat belts are not necessarily the same as those that motivate older drivers and passengers. Teens are different from older drivers in terms of driving experience, cognitive and emotional maturity, motivations, and social settings. For example, teens are often more prone to risk taking than older drivers (Lee, 2007), especially male drivers in the presence of male passengers (Simons-Morton, Lerner, & Singer, 2005). Furthermore, the trade-off of effectiveness in promoting belt use versus consumer acceptance and preference factors may be different for teens than for adults, given the issues of poor hazard perception and risk-related judgments of teens. In the literature on warnings and alerts, there is a commonly observed correlation between how effective a display is in promoting a desired response versus how annoying it is (and associated issues of consumer acceptance). A reasonable consumer product represents some trade-off of these two factors. As long as a teen ESBR system is capable of discriminating when the teen is driving the car, as opposed to an adult, the trade-off can be made appropriately to the teen driver context, as opposed to the general driving public.

It is important to understand how the characteristics of teens influence their seat belt use, and to identify countermeasures that can increase teen belt use. To be truly effective, however, ESBRs must be acceptable to teens and their parents; and each group is likely to have its own preferences and motivations.

1.2 Task Objectives

The research described here was conducted as a task (Task 3) under a broader project to investigate the effectiveness and acceptability of ESBR systems. This experiment was complementary to the other two tasks conducted under this project. Task 1 was an observational study of drivers' seat belt use (Freedman, Levi, Zador, Lopdell, & Bergeron, 2007). Seat belt use of drivers and passengers was observed at selected locations and, through linking of license plate numbers to vehicle identification numbers (VIN), the presence and type of seat belt reminder system in each vehicle was determined. While Task 1 could quantify differences in occupant seat belt use among vehicles and their associated reminder systems, there were limitations to its ability to determine *why* the systems differed in effectiveness. In contrast to the field observational method of Task 1, Task 2 was an experiment that collected systematic subjective data from participants (Lerner, Singer, Huey, & Jenness, 2007). Adult participants experienced seat belt reminder systems while driving a test vehicle along a prescribed route on public roads, and experienced additional features while parked. Since the various displays were experimentally manipulated, the study reduced the chance of potential confounds of reminder system characteristics with other characteristics of the vehicles and their drivers.

Task 4, which was completed prior to Task 3, was a synthesis of the findings of Tasks 1 and 2 (Freedman, Lerner, Zador, Singer, & Levi, 2009). The report combines the observational findings of Task 1 and the experimental findings of Task 2 to identify the relationships between ESBR components and effectiveness.

The objective of the present task (Task 3) was to evaluate the effectiveness and acceptance of ESBRs among teens in an experimental setting. An additional subtask investigated parents' reactions to ESBRs for their teen children. Though the basic objectives were the same as in Task 2, the unique characteristics and concerns regarding teens influenced the research objectives and methods. Teen passengers were also included in this study because peer passenger presence is known to influence teen driving behavior, crash risk, and seat belt use. The primary research questions were:

1. What ESBR systems and features are rated as most effective in getting teens to buckle?
2. What ESBR systems and features are most acceptable to teens?
3. Do teen drivers' and passengers' have different subjective responses to ESBRs?
4. Do teen drivers' subjective responses to ESBRs differ depending on whether they are alone or among a group of friends?
5. What are parents' general opinions about ESBRs, and what features do they want in ESBRs for their teens?

The ultimate goal of this task was to develop a set of recommendations for ESBRs specifically intended for teen drivers, considering both the reactions of teens and parents.

The concept of a teen-oriented ESBR is based on the premise that an optimal teen-oriented system will differ in some respects from a system appropriate for the general driving public. Therefore, an inherent assumption in this study is that a functional vehicle-based system is capable of determining when the vehicle is operated by a teen driver. Many driver identification methods are feasible, though the particular method used is not critical for the purposes of this study. Possibilities include smart keys, biometric recognition, or selectable programming of vehicle options by a parent.

2 Teen ESBR Evaluation

2.1 Overview and Experimental Design

The purpose of the teen occupant experiment was to investigate the acceptability and potential effectiveness of ESBRs as a function of the particular seat belt reminder system or specific system features and parameters. Teens 16 to 18 who were not consistent seat belt users were exposed to a variety of systems and features. They provided ratings or other feedback related to their subjective opinions of acceptability/annoyance and their perceptions of how effective the system would be in inducing them to buckle up. This was not a behavioral study that measured actual seat belt use but rather a user feedback assessment that directly compared alternatives. The study permitted direct comparison of prototypical systems as well as other possible system features. These data are intended to help in devising systems that optimally balance effectiveness and acceptance among teens and their parents.

Teens participated in the study either individually in solo sessions or as an affinity group of three or four friends. Different procedures were used for solo and group sessions. In both procedures, participants first experienced seat belt reminder systems in an automobile that was modified to be capable of presenting a variety of seat belt reminder displays (visual, auditory, and haptic), and provided feedback about them. Participants experienced the systems while engaging in video driving simulations. Periodically during each simulated drive, participants rated the likelihood that they would buckle up (or encourage fellow occupants to buckle up), how annoyed they were by the seat belt reminder, and the appropriateness of the strength of the alerts. At the completion of each drive, they answered further questions about the system.

Following the simulated driving portion of the study, participants in solo sessions experienced brief seat belt reminder systems, displayed without concurrent video simulations, which permitted a more efficient evaluation of a wide range of reminder system features and parameters. Next, participants in solo sessions experienced brief, individual alerts outside the context of reminder systems. Finally, solo participants provided written answers to questions about the ideal design of seat belt reminder systems for teens.

Participants in group sessions did not experience the brief reminder systems or individual alerts. Instead, they participated in a greater number of simulated drives and also in group discussion moderated by an experimenter about seat belt reminders and seat belt use in general.

Table 1 summarizes the various independent variables used in this study and their levels. Details regarding the various factors are provided in the methodological details that follow.

Table 1. Independent variables and their levels

Independent Variable	Levels of the Variable
Seat Position	Driver, front seat passenger, rear seat passenger
Vehicle Occupancy	Driver only (solo); driver with passengers
Group Composition	Single gender (male); single gender (female); mixed gender
Seat Belt Status (per occupant)	Buckled; not buckled
Driver Accompaniment	Alone (solo); with passengers
Driver Gender	Male; female
Full ESBR System	Six systems, including non-enhanced control
Time of Rating	30, 90, and 150 sec into drive (for full ESBR evaluations)
Brief ESBR System	12 systems
Individual Alerts	27 alerts

2.2 Participants

Study participants were teens 16 to 18 years old who reported occasional or frequent seat belt nonuse, as determined through a telephone screening process in which callers were asked how frequently they do not wear their seat belts as a driver, front seat passenger, and rear seat passenger. Recruiting materials stated that the study required individuals with various belt use rates, in order to minimize potential false reporting. Participants were primarily recruited through flyer distribution to students in high schools in Montgomery County, Maryland, which is in the suburban Washington, DC, metropolitan area. Additional recruitment was conducted through a local newspaper. Participants were paid for their participation. Although teens were recruited directly, written parental consent was required for participants under 18 years old.

Because the influence of peers may be an important consideration in teen behavior in vehicles, this study included various combinations of vehicle occupants. For “solo” sessions, only a single participant was present, seated in the driver seat position. For affinity group sessions, there were three or four occupants in the vehicle. Some groups were composed of all participants of the same gender (all males or all females). Other groups were of mixed gender. The analysis of the data included consideration of the group composition: no passengers, single gender group, or mixed gender group.

To participate in a solo session, teens were required to have a valid driver’s license (full or provisional license) and must have reported occasional or frequent seat belt nonuse as a driver. To participate as a group, teens were required to refer their own friends to the study. All interested teens were screened and project staff then determined whether the affinity group qualified as a whole. To qualify, each group was required to have at least one participant who qualified to sit in the driver’s seat (valid license and self-reported seat belt nonuse as driver), at least one participant who qualified to sit in the front passenger seat (self-reported seat belt nonuse as front seat passenger), and at least one participant who qualified to sit in the rear passenger seat (self-reported seat belt nonuse as a rear seat passenger). Participants in the passenger seats were not required to have driver’s licenses, but were required to report that they occasionally or frequently ride as passengers of teen drivers.

Because of the challenges of finding seat belt nonusers in an area with particularly high belt use rates, and especially assembling affinity groups of seat belt nonusers, a major recruitment effort was initiated. More than 40,000 recruitment flyers were distributed to Montgomery County public high school students, faculty, and staff, and nearly 1,700 teens were screened. As a result, 31 teens participated in solo sessions, and 20 affinity groups were assembled with a total of 72 group participants. There were slightly more male participants than females, which reflected males' higher self-reported seat belt nonuse rates among screened teens. Among solo participants, there were 17 males and 14 females. Because affinity groups were naturally occurring groups of friends, no attempt was made to influence the gender makeup of groups. There were 10 all-male groups, 6 all-female groups, and 4 groups with mixed gender.

2.3 Instrumentation and Displays

2.3.1 Experimental Setting and Video Simulation

Experimental sessions took place in an enclosed garage bay. The experimental platform was a four-door 2001 Saturn L200 sedan that was fitted with custom displays for the presentation of visual, auditory, and haptic alerts. The vehicle's existing visual and auditory alerts were concealed or disabled. Alert presentation was controlled by an experimenter seated behind the vehicle with a laptop computer. The experimenter could communicate with vehicle occupants and monitor in-vehicle activity using a two-way auditory monitor. Occupant detection sensors were installed in the two front seats and in the two outboard rear seats. The vehicle remained stationary for the duration of experimental sessions, though a portion of experimental sessions involved a simple driving simulation. To ensure the safety of the novice driver participants, no actual driving was involved in the study.

During the first portion of experimental sessions, participants experienced ESBRs while viewing driver's-eye-view video of a roadway scene. On a 4-foot tall by 6-foot wide projector screen placed directly in front of the experimental vehicle's bumper, participants were shown video recorded from a hood-mounted video camera on a car as it drove along two-lane, rural roads in Montgomery County (see Figure 1). The road sections were chosen because they did not include any traffic control devices (allowing the vehicle to travel at a constant speed), because they had minimal traffic, and because they had uniform characteristics that were unlikely to differentially influence participants' reactions to the ESBRs. Speed limits on the road segments ranged from 30 mph to 50 mph. All of the videos began with the vehicle stopped on the roadside or at a red traffic signal for a few seconds before beginning to move. The videos included the ambient sound recorded inside the car's cabin (e.g., engine, road noise, wind), which was reproduced during experimental sessions using speakers placed under the driver's seat. Videos were controlled via the experimenter's laptop and were projected onto the screen using a digital projector mounted on the roof of the car. All lights were turned off in the garage bay, so the ambient light of the video provided the only illumination.

The roadway videos were the basis for a simple tracking task performed by participants in the driver's seat during the simulated drives. A blue rectangular icon was overlaid upon the video image using a software program. Participants in the driver's seat could control the lateral position of the icon on the screen by turning the vehicle's steering wheel. The simulator's front wheels rested on turntables to allow them to turn freely and the steering column was attached to a string potentiometer that registered the steering wheel's position and adjusted the blue rectangle's position on the video image accordingly in real time. (Participants in the passenger positions were not required to perform any secondary tasks.) "Drivers" were instructed to keep the icon in the center of the roadway in the video by turning the steering wheel in the direction of upcoming turns in the video. The purposes of this video tracking task were to (a) direct driver visual attention to the roadway, and motor resources to a driving task rather than allow them to focus on the in-vehicle alerts, (b) to encourage participants to sit in a normal driving posture, (c) to prevent the driver from focusing attention on the ESBR displays. Driver performance on the tracking task was not evaluated because its function was simply to promote a more meaningful simulation. Figure 1 shows participants engaging in the tracking task.

Figure 1. Experimental setting and video tracking task

2.3.2 Visual Displays

Experimenters temporarily installed visual displays on the vehicle's dashboard, in the center console, in front of the front seat passenger, above the rear view mirror, in the small console in front of the center rear seat, and on the B-pillar behind the driver's head. The front seat visual displays are shown in Figure 2, the B-pillar display is shown in Figure 3, and the rear seat visual display is shown in Figure 4. All visual displays are described in Table 2.

The driver, passenger, rear view mirror, and rear console displays were set in rectangular black plastic boxes 3.8 cm tall, 7 cm wide, and 1.9 cm deep. Each display included a fixed message or icon that was illuminated from behind by color light emitting diodes (LEDs) and surrounded by a black background. The center console display was an LCD screen capable of displaying any image in full color, which is similar to existing center console displays in some vehicles that can be used to control and view infotainment features. The images shown on the center console during study sessions included (a) a "main menu" screen, simulating touch screen displays found in some vehicles, which appeared as the default display when no ESBR displays were presented on the screen; (b) a large "buckle seatbelt" icon and text, (c) a "stereo disabled" message that appears when the vehicle's stereo system was locked out, (d) a schematic of the vehicle interior showing the seating positions of unbuckled occupants (the seat belt icons flash), and (e) text warning to buckle the seat belt. Figure 5 shows each of these images.

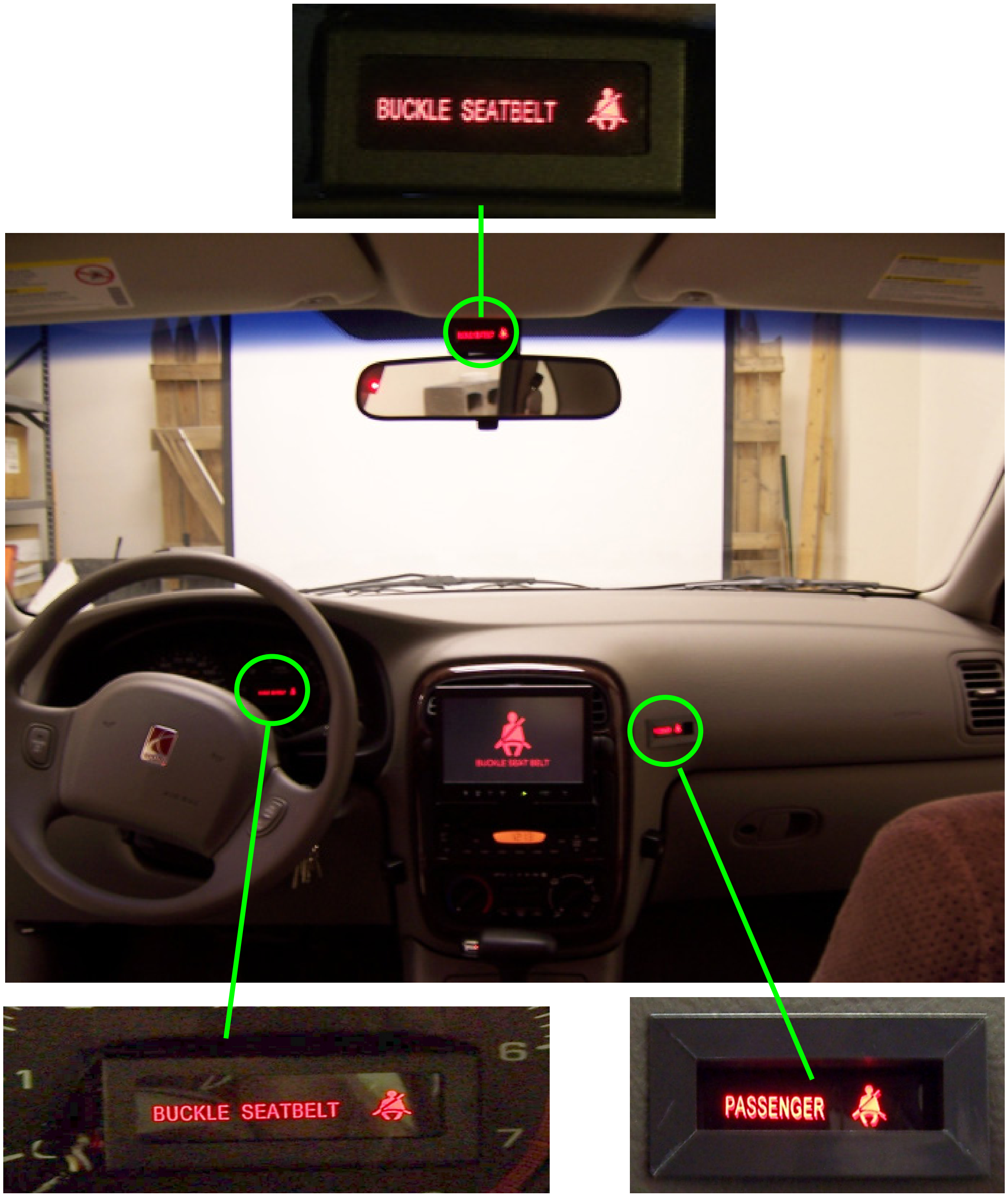


Figure 2. Front seat visual displays

Figure 3. B-pillar visual display

Figure 4. Rear seat display

Table 2. Characteristics of visual displays

Location	Display	Display size	Brightness	Housing
Dashboard	red text and seat belt icon, independently or simultaneously lit	text height: 0.4 cm; icon height: 0.8 cm	Norm: 70 cd/m^2 High: 700 cd/m^2	black plastic box 3.8 cm tall, 7 cm wide
Front passenger	red text and seat belt icon, simultaneously lit	text height: 0.4 cm; icon height: 0.8 cm	Norm: 70 cd/m^2 High: 700 cd/m^2	black plastic box 3.8 cm tall, 7 cm wide
Center console	fully customizable, computer-controlled LCD display		Variable	
Rear view mirror	red text and seat belt icon, simultaneously lit	text height: 0.4 cm; icon height: 0.8 cm	Norm: 70 cd/m^2 High: 700 cd/m^2	black plastic box 3.8 cm tall, 7 cm wide
Rear console	green text and seat belt icon	text height: 0.4 cm; icon height: 0.8 cm	700 cd/m^2	black plastic box 3.8 cm tall, 7 cm wide
B pillar	single red LED	single small LED		within B pillar speaker housing

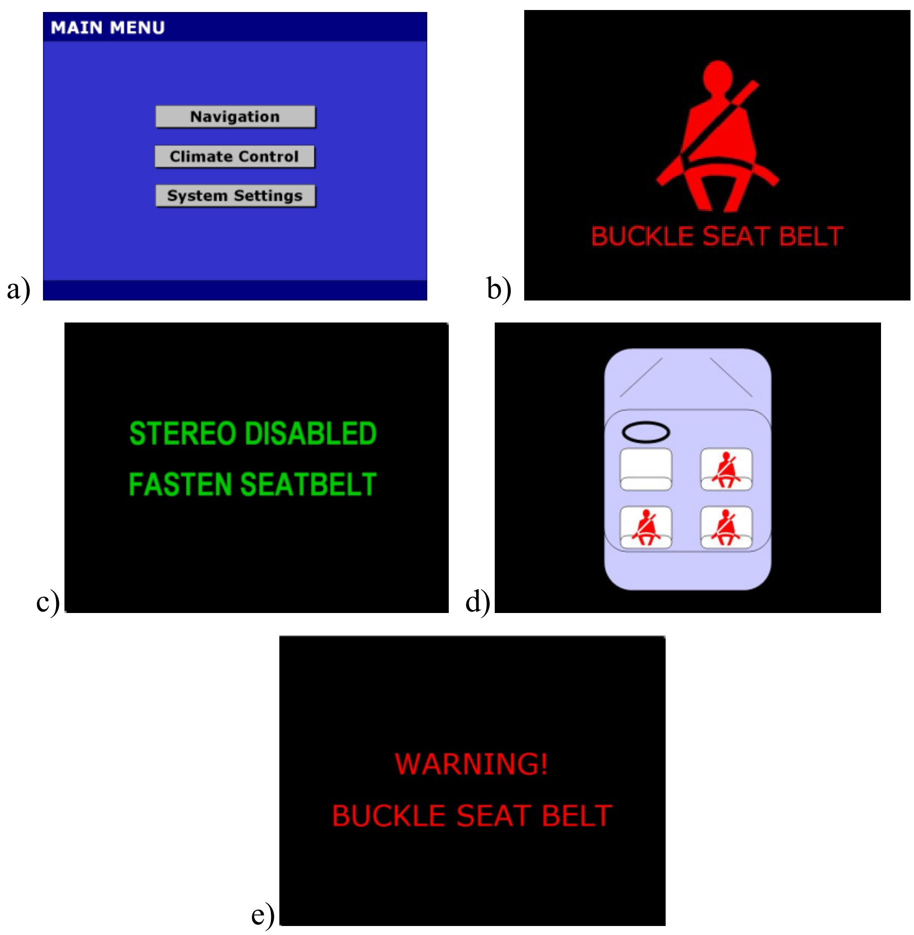


Figure 5. Images shown in center console display

2.3.3 Auditory Displays

Speakers were installed in five locations in the vehicle to present auditory ESBR alerts. The speakers were located in the driver's knee well, in the front passenger's knee well, on the left C pillar, on the right C pillar, and above the driver's belt retractor (collocated with the B-pillar visual display). Each speaker could be activated independently.

Speakers were used to present a variety of sounds including beeps, chimes, and male voice messages. The full list of sounds is presented in Table 3. All sounds were calibrated using a Quest Model 2800 sound level meter to achieve equivalent A-weighted peak sound pressure levels. A-weighting most closely matches human perception of loudness. Peak sound pressure level was the highest sound pressure level reached for each sound. For each speaker, the meter was placed on a tripod at the approximate head level of the nearest occupant, with the microphone facing the speaker. All sounds were adjusted to a achieve a peak volume of 78 decibels (dB(A)) for each speaker. Some sounds were also adjusted to achieve a loud peak volume of 90 dB(A).

Table 3. List of auditory alerts

Sound	**Description**
Slow chime	The chime plays at a rate of 0.83 Hz. The sound level of each chime decays over time until the next chime occurs. The chime is presented for a total of 6 seconds. The sound was sampled from a 2002 Chevrolet Cavalier.
Fast chime	The same sound as the slow chime, but played at a rate of 2.5 Hz. The chime is presented for a total of 6 seconds.
High urgency	A rapid, urgent beeping sound that consists of sequential bursts of four pulses, with slightly greater volume on the second and fourth pulses. Each four-pulse burst is 0.4 second in duration, with a 0.1 second pause before the following set of bursts, and the duration of the entire signal is a total of 6 seconds.
High urgency slow	Same as high urgency, but the gap between sets of bursts is approximately 2 seconds, so the alert contains mostly silence punctuated by quick bursts of sound.
Male polite	A male voice that says "buckle seat belt" in a pleasant tone.
Male warning	A male voice that says "warning, buckle seat belt" in an urgent tone.
Beep	A brief sound that transitions from a high tone to a lower tone, with slightly greater volume on the high tone. The sound plays with a high-tone duration of 0.5 second and a low-tone duration of 0.32 second for a total of 0.82 seconds.

2.3.4 Haptic Alerts (Seat Vibration)

Vibrating motors from an electric massaging seat pad were installed under the surface of the driver's seat in the test vehicle. The vibration was used as a haptic ESBR alert component. The vibration was set at a constant intensity level, which was the maximum intensity of the original consumer device.

2.3.5 Seat Belt Reminder Systems

Six ESBRs were created for presentation to study participants. Each system was activated upon turning the vehicle key to the ON position, which simulated engine ignition. Each system was presented for a total of three minutes during simulated driving. Each is briefly described below. Note that alerts are only displayed to an occupant in a given seat if the seat is occupied and the occupant is unbuckled. Detailed system specifications are provided in Appendix A.

Practice ESBR**:** All participants first experienced the practice ESBR. The alerts are designed to be somewhat typical of belt reminder systems, yet unique from the other full systems that participants will experience.

Minimal reminder: This system approximates the minimum seat belt reminder requirement established by FMVSS No. 208. This system is included as a baseline against which to compare the ESBRs.

ESBR 1: This system is based on the results of the adult ESBR study (Lerner et al., 2007), and the naturalistic seat belt buckling behavior observed by Malenfant and Van Houten (2005). It begins with the 6-second slow chime and steady icon, followed by 10 seconds of silence, then a brief 2-second reminder. The center console icon and text illuminate continuously following this reminder. The system then alternates between 20 seconds of silence and 4 seconds of fast chime until seat belts are buckled. The driver and front seat passenger icons flash continuously.

ESBR 2: This ESBR is less assertive than most used in this experiment. It begins with the 6-second slow chime and steady icon, then 50 seconds of silence. The system then alternates between 6 seconds of fast chime and 25 seconds of silence for the duration of the drive. The driver and front seat passenger icons alternate between steady and flashing. The key aspect of the system is the relatively long delay following the initial chime.

ESBR 3: This system was designed to meet the requirements and additional recommendations of the Euro New Car Assessment Program (NCAP) seat belt reminder protocol (Euro NCAP, 2004). The Euro NCAP protocol describes three levels of reminder signal: initial, intermediate, and final. Of these, only "final" is a requirement. For front seat positions, the signal must have both audio and visual components. Recommended signals are the use of a "loud and clear" voice message or prominent text message on an LCD screen. Progressive or stepped audio is also recommended. Visual signals should stay on the entire time that a seat is occupied and a seat belt is not in use. To meet these recommendations, ESBR 3 begins with the 6 second slow chime and steady icon, followed by 14 seconds of silence. The system then alternates between a brief voice message "buckle seat belt" and 10 seconds of silence for a total of 62 seconds. The final stage of the system alternates between 2.5 seconds of beeping and 2.5 seconds of silence. The driver and front seat passenger icons alternate between steady and flashing for the whole drive.

ESBR 4: This system uses most of the vehicle's visual alert capabilities and provides repeating auditory reminders. It begins with 4 seconds of slow chime and steady icon followed immediately by 2 seconds of fast chime. The system then alternates between 20 seconds of silence and 6 seconds of fast chime for the duration of the system. The driver and front seat passenger icons alternate between steady and flashing for the duration of the system. Additional visual displays (center console, rear view mirror, B-pillar light) are activated and some occasionally flash.

ESBR 5: This system includes a seat pan vibration element for the driver to determine the effects of haptic alerting as a component of an ESBR. It begins with 6 seconds of slow chime and steady icon, followed by 14 seconds of silence. The system then alternates between a 4-second reminder (vibration→voice reminder→vibration) and 20 seconds of silence for the duration of the system. Driver and passenger icons alternate between steady and flashing, and the center console icon flashes during reminder phases.

ESBR 6: This system was particularly designed to promote peer interaction to encourage one another to buckle up. It begins with 6 seconds of slow chime. The system then alternates between 20 seconds of silence and 6 seconds of fast chime for the duration of the system. Also, following the initial chime, the seating chart icon (see Figure 5d) appears in the center console, showing an icon in each seating position with an unbuckled occupant. The unbuckled occupant icons flash during each 6-second reminder display. Driver and passenger icons, and the B-pillar light, alternate between steady and flashing.

2.4 Procedure

Both solo and group sessions lasted for approximately two hours. Before arrival, each participant was screened for eligibility and provided with a consent form, parental consent form, and a pre-session questionnaire addressing seat belt use patterns and reasons for nonuse. Upon arrival, the experimenter collected these completed materials from each participant. The context of the experiment was explained to participants in the introductory portion of the instructions, which included the following overview:

> "Now I'll tell you more about this study. All passenger vehicles in the [United States] come equipped with a seat belt reminder system to alert drivers if they do not have their seat belt buckled. The law requires that a sound play for about 6 seconds when the ignition is turned on and a reminder light appears on the dashboard for at least one minute if the seat belt is unbuckled. Many vehicles on the road today have little or nothing more than this minimum required system, but some car companies have started using seat belt reminder systems that do more than this because they think it might be possible to create more effective reminders that are still acceptable to drivers. Today you are going to experience some enhanced reminder systems. I want to get your reactions to each one. This car is specially equipped to present many different kinds of seat belt reminder systems. It also knows which seats are occupied at any given time and when occupants are wearing their seat belts or not."

In the first part of the study, all participants experienced and provided ratings about the ESBRs while engaging in simulated drives. For participants in group sessions, the second part of the study consisted of a group discussion led by the experimenter and including all of the participants for that session. For solo participants, the simulated driving portion of the procedure was followed by additional ratings of brief ESBR systems and individual alerts, and a written questionnaire addressing design preferences for ESBRs. Table 4 below outlines the phases of the procedures for solo and group sessions.

Table 4. Outline of procedures for solo and group sessions (with number of trials per phase in parentheses)

Phase	Solo	Group
1	Simulated drives (6)	Simulated drives (12)
2	Brief ESBRs (12)	Group discussion
3	Individual alerts (27)	
4	Final questionnaire	

2.4.1 Simulated drives

In the first phase of each session, participants experienced ESBR systems, each lasting approximately three minutes, while engaging in a simulated driving task. The orders of ESBR system and video drive route presentations were independently randomized for each session to control for order effects. The experimenter was seated immediately behind the rear bumper of the vehicle with the trunk open and used two laptops in the trunk to control video and ESBR presentations. While experiencing the video drives and making their judgments, participants were asked to "imagine that you are driving to visit a friend that lives about 15 minutes away." This was done to provide a more meaningful context for making ratings than the brief simulated drives. Group participants were asked to behave as they normally would when driving with friends in the vehicle. During the simulated drives, the experimenter was positioned out of participants' sight and used a two way intercom to communicate with participants. Participants' voice channel was always open so they could speak through the intercom without picking it up or pressing any buttons. The lack of direct sight or voice contact between the experimenter and participants was intentionally contrived to elicit more natural behavior from participants, and peer groups in particular. Procedures differed between solo-participant sessions and group-participant sessions; each procedure is described below.

Procedure for solo participants

Solo participants remained unbelted for the duration of the experimental session so that the vehicle's ESBR systems would always respond to the unbelted occupant. Before experiencing the ESBRs, participants first completed a brief simulated drive lasting about a minute, which allowed them to become familiar with the tracking task. Participants then experienced a full duration practice video drive with the practice ESBR system for practice responding to ratings questions and to allow the experimenter to ensure that participants were providing responses correctly. Following the practice trial, participants in solo sessions experienced six more video drives, consisting of five ESBRs (ESBRs 1 to 5) and one trial with the non-enhanced Minimal reminder system. Each trial began with the vehicle's key turned to the off position. The experimenter then selected the appropriate ESBR system and video, and the participant activated the ESBR and video simulation by turning the key to the on position, without actually starting the engine.

At three times during each simulated drive (30 seconds, 90 seconds, and 150 seconds after reminder system activation), the experimenter asked the participant to make three ratings about the current reminder system:

1. How likely are you to buckle up?
2. How annoying is the reminder system? and
3. How appropriate is the strength of the alerts?

The first two questions were answered on a 10-point scale in which 1 represented the *least* likely/annoying and 10 represented the *most* likely/annoying. The third question was answered on a 9-point scale in which 1 represented "not nearly strong enough to get me to buckle," 9 represented "much stronger than necessary to get me to buckle," and 5, as the center point, represented "just the right strength to get me to buckle." Participants circled their answers on numerical scales in answer booklets. At the completion of each simulated drive, the experimenter instructed participants to turn the key back to the off position, flip to the next page in their answer booklets, and answer a set of post-drive questions about each system. The post-drive questionnaire included two questions on a 10-point scale:

1. Thinking specifically about the situations in which <u>you are a driver alone or with teen passengers</u> and sometimes do not wear your seat belt when you drive, how effective would this system be in getting you to wear your seat belt on those trips? [1 = definitely would not wear; 10 = definitely would wear]
2. How desirable would it be to you to have a seat belt reminder system like this in your vehicle? (keeping in mind that the reminder system would turn off once you put on your seat belt) [1 = extremely undesirable; 10 = extremely desirable]

The post drive questions also included two open-ended questions:

1. If this reminder system were in your car, what aspects of this system would be especially effective in getting you to buckle up?
2. If this reminder system were in your car, what aspects of this system would be especially annoying or undesirable?

This procedure was repeated for each of the 6 reminder systems.

<u>Procedure for group participants</u>

In group sessions, one participant acted as the driver while there was one front seat passenger and either one or two rear passengers. In cases where only one rear passenger was present, the participant was seated behind the driver. Seating positions were assigned by the experimenter according to information provided by participants during screening: participants were required to have reported seat belt nonuse in their seating position and teens seated in the driver's seat were required to have a full or provisional driver's license and experience driving with teen passengers. All group session participants remained in the same seating positions throughout the session.

During group sessions, participants completed 12 simulated drives, which included the same six reminder systems that the solo participants experienced, plus one additional system (ESBR 6). Furthermore, all systems with the exception of the minimal system and ESBR 6 were experienced twice, each time with different occupants wearing or not wearing seat belts, though at least one occupant was unbuckled for each trial. In contrast to the solo sessions, where the driver was unbuckled for all trials, in the group procedure the driver, as well as passengers, was buckled on some trials and not buckled on others. This was done to explore the effects of group dynamics and because some ESBR alert presentations differed depending on the seating positions of unbuckled occupants. For each group session, each ESBR was associated with the same seating arrangement(s). In other words, the combinations of ESBR and seating positions were the same for each group session. For a given trial, both rear seat occupants were always assigned the same seat belt use condition. Participants were instructed to buckle or unbuckle their seat belts before each trial began, and did not change their seat belt use during a trial.

As in the solo sessions, *unbuckled* participants in group sessions provided ratings about the current reminder system at three points during each simulated drive (30 seconds, 90 seconds, and 150 seconds after reminder system activation).

The experimenter asked the participant to make three ratings about the current reminder system:

1. How likely are you to buckle up?
2. How annoying is the reminder system? and
3. How appropriate is the strength of the alerts?

Unlike in solo sessions, however, some participants in group sessions were occasionally buckled for a given trial. Buckled participants made the same ratings as unbuckled participants, except Rating 1 shown above was replaced with "How likely are you to say something to one of the unbuckled people in the car to encourage them to buckle up?"

After the participants provided all three sets of ratings and the ESBR presentation ended, the experimenter asked participants to write answers to the same post-drive questions about the ESBR that were answered by solo participants (see above). This procedure was repeated for all 12 simulated drives.

One reason for evaluating teen response to ESBRs in the context of an affinity group is because teen behavior can be substantially influenced by the presence of peers in the vehicle (e.g., Simons-Morton et al., 2005). Despite this, as well as the fact that passenger presence is typical of serious teen driver crashes, most laboratory and simulator research investigating teen driving has ignored this critical context (Lerner, 2001). It was hoped that by recruiting affinity groups, where the teens had pre-established relationships, we could generate an atmosphere in the vehicle that more normally approached typical teen occupant behavior and interaction. The instructions were also constructed so as to permit this freedom, as long as the experimental requirements for data collection were also met. After the initial practice trials, the experimenter was usually out of view behind the vehicle, monitoring in-vehicle behavior via a speaker and by occasional visual monitoring. Subjectively, it appeared that the procedures were successful in generating an informal social atmosphere. Substantial social interaction was typical in most groups, with extensive conversation, joking, and laughter. While behavior was typically within socially acceptable bounds for the experimental setting, behaviors observed by the experimenters included sharing and eating food (e.g., peanuts, gummy bears), conversation on highly personal issues, antagonistic exchanges, casual postures (slouching, lifting legs), horseplay (e.g., arm punching, kicking seats), text messaging (despite the specific prohibition of this in the instructions), and physical displays of affection. The all-male affinity groups tended to act up more than the all-female groups. Experimenter intervention was limited, as long as the procedures were being followed and handled seriously. It appears, therefore, that the affinity group procedure generated the social atmosphere that was desired. Comparisons between solo participants and those in groups reflect this context.

2.4.2 Brief ESBRs (Solo Sessions Only)

Participants in solo sessions experienced 12 additional brief ESBRs, in which ESBRs with durations of 30 to 40 seconds were presented. This was intended to represent the initial stages of more extended systems and permitted participants to provide ratings about more ESBRs in a short period of time. Although the brief format precludes the ability to present ESBRs in their entirety, the 30 to 40 second time range was chosen because (a) the majority of drivers either buckle up within the first 30 seconds after vehicle ignition or do not buckle at all and (b) 30 seconds is enough time to present multiple alert phases. Some of the 12 ESBRs were similar to ones used during the simulated drives. The set of brief ESBRs is described below, and outlined in greater detail in Appendix B.

- BR1 is identical to the first 30 seconds of the minimal system presented during the video drives. It is included primarily as a baseline measure.
- BR2 has only the minimal auditory signal, but the driver icon increases in conspicuity every 10 seconds.
- BR3 rapidly increases the intensity of visual and auditory displays.
- BR4 presents brief reminders in rapid succession.
- BR5 has reminders that increase in duration from the first to second display phase.
- BR6 is equivalent to the first 30 seconds of ESBR 1.
- BR7 focuses alerts at the belt retractor location.
- BR8 also focuses on the belt retractor location, but uses voice prompts and a different reminder pattern than BR7.
- BR9 primarily relies upon a frequently repeating, polite male voice.
- BR10 is similar to BR9, but each voice prompt is preceded by a 1-second seat vibration.
- BR11 presents reminders in reverse increments, where each reminder phase is less aggressive than the previous phase.
- BR12 presents no more auditory alerts after the initial chime; the icon, center console, and vibration comprise the reminders.

Participants experienced the brief systems in the same stationary vehicle that was used for the simulated drives, though participants did not perform any secondary tasks or view any videos. The image on the projection screen was a plain blue screen. As with the simulated drives, the ambient light from the projection screen provided the only light in the enclosed garage bay. The experimenter remained seated behind the vehicle and controlled brief ESBR presentation via the laptop computers in the vehicle's trunk. For each trial, the experimenter instructed the participant to turn the car key to the Run position to activate the ESBR. After the presentation ended, the participant turned the car key back to Off and provided the same set of three ratings in the answer booklet that were made during the simulated drives:

1. How likely are you to buckle up?
2. How annoying is the reminder system? and
3. How appropriate is the strength of the alerts?

Unlike with the simulated drives, however, the ratings were made only once per brief ESBR, after the system finished playing. This procedure was repeated for all 12 brief systems, which were presented in a randomized order for each participant.

2.4.3 Individual Alerts (Solo Sessions Only)

Participants in solo sessions provided ratings about 27 individual alerts, presented outside the context of a full or brief ESBR system. Whereas the previous phases of the study assessed reactions to ESBRs with various alert combination and timing schemes, this phase was conducted to investigate reactions to particular alerts that may serve as elements of complete systems. Some of the alerts were used as components of previously experienced ESBRs, while others were unique to the individual alerts phase. The full list of alerts is provided in Table 5. All alerts were presented for 6 seconds unless otherwise noted, with the exception of voice messages which were presented just once and the beep→voice→beep alert which had a total duration of about 3 seconds. Unless specified otherwise, visual and auditory alerts were presented at their "normal" intensities and auditory alerts were presented from the driver speaker.

Participants were presented with each alert once (alerts were activated by the experimenter; participants did not turn the car key) and then answered two questions on the same 1 to 10 scales they used for the video drives and start up systems: (1) How likely are you to buckle up? (2) How annoying is this alert? Participants experienced the 27 individual alerts in a randomized order, with the exception that the stereo lockout was always presented last. For this alert, the participant was instructed to turn the car key to "On" and turn on the radio. The experimenter then triggered the stereo lockout, which silenced the radio and triggered a text message to appear on the center console display (see Figure 5c).

Table 5. List of individual alerts

Visual Alerts	**Tonal Alerts**
V1: Dashboard icon*	**T1**: Slow chime
V2: Dashboard icon (flashing)*	**T2**: Slow chime (loud)
V3: Dashboard icon/text*	**T3**: Slow chime (2s)
V4: Dashboard icon/text (bright, flashing)*	**T4**: Fast chime
V5: B-pillar light**	**T5**: Fast chime (2s)
V6: B-pillar light (flashing)**	**T6**: Slow-chime (4s) □ fast chime (2s)
V7: Center console - buckle seat belt icon/text***	**T7**: High urgency
V8: Center console - Warning text (flashing)***	**T8**: High urgency slow
V9: Center console - Vehicle schematic (unbelted driver position flashing)***	**Speech Alerts**
Haptic Alerts	**S1**: Voice: “buckle seat belt”
H1: Seat vibration (1s duty cycle)	**S2**: Voice: “Warning: buckle seat belt”
H2: Seat vibration (1s duty cycle) & fast chime	**S3**: Voice: “buckle driver seat belt” (belt retractor location)
H3: Seat vibration (1s duty cycle) & center console buckle seat belt icon/text (flashing)***	**Multimodal Alerts**
Stereo Lockout	**M1:** Voice: “buckle driver seat belt” (belt retractor location) & B-pillar light
SL1: Stereo lockout (with center console message***)	**M2:** Beep □ voice: “buckle seat belt” □ beep
	M3: B-pillar light (flashing) + fast chime**

* see Figure 2 ** see Figure 3 *** see Figure 5

2.4.4 Opinions of System Alternatives (Solo Sessions Only)

After rating all individual alerts, participants in solo sessions completed a brief written questionnaire on seat belt reminder system preferences. Questions addressed preferences for seat belt reminders that are effective in getting drivers and passengers to buckle up, yet acceptable to drivers; patterns for alert presentation; and the possibility of allowing drivers to customize seat belt reminder sounds. The question form is shown in Appendix C.

2.4.5 Group discussion (Group Sessions Only)

In group sessions only, after all video drives were completed participants moved to a small conference room where the experimenter led a discussion with all of the participants for that session. Discussions lasted for approximately 15-20 minutes and were recorded for later analysis. Topics included:

- best designs for ESBRs that are effective in getting drivers and passengers to buckle up, yet acceptable to drivers;
- best patterns for reminder presentation;
- factors influencing decisions to wear or not wear seat belts and group dynamics;
- opinions about the idea of creating particularly assertive ESBRs designed specifically for novice teen drivers; and
- opinions on allowing drivers to customize seat belt reminder displays.

3 Parent ESBR Evaluation

Following the teen ESBR study, a separate study was conducted to assess parents' reactions to ESBRs for teens and their willingness to provide ESBRs for their own novice teen drivers. The participants were 25 parents of teens who had participated in the teen ESBR study or who expressed interest in the study, but were not selected for participation. Fourteen participants were female and 11 were male. Participants convened in groups of 3 or 4.

The study was conducted in two parts. First, parents experienced six demonstration ESBRs in a stationary vehicle. The ESBRs and the experimental apparatus were the same that were used for the preceding teen study (described in Section 2). Second, parents participated in a group discussion moderated by an experimenter. The discussion addressed teen seat belt use and ESBR options.

3.1 Demonstration ESBRs

For the first part of the study, parents sat in a stationary vehicle and viewed the six ESBRs and the minimal reminder that were used in the teen ESBR study (see Section 2.3.5). The experimental apparatus was the same that was used for the teen ESBR study (see Section 2). Some aspects of the study design, however, differed from the teen study. Whereas teens made three sets of ratings during the course of a three-minute simulated drive, parents only made one set of ratings at the completion of a two-minute simulated drive. The multiple-choice questions addressed:

1. How the ESBR would affect their teens' seat belt use;
2. How the ESBR would affect teens who *rarely wear seat belts*;
3. The appropriateness of the strength of the alerts; and
4. How desirable each system was.

3.2 Procedure

Upon arrival, each participant completed a questionnaire addressing their teen's driving history, concerns about their teen's driving safety, and awareness of teen driver safety issues. Participants were then randomly assigned to a seating position within the vehicle and instructed on procedures for the first part of the study. Participants first experienced the Minimal reminder system, followed by the 6 ESBRs in a random order. Each system was active for about 2 minutes. Parents viewed the simulated driving videos while experiencing ESBRs, but unlike teens, parents did not perform the manual tracking task. After each system had finished playing, parents answered the four questions described above. After the final ESBR, participants were shown the entertainment system interlock, though they did not write any ratings for it. The entertainment system interlock was shown to provide a basis for discussion of the concept in the subsequent moderated discussion.

For the second part of each session, participants moved to a different room for a group discussion moderated by the experimenter. The discussion addressed parents' opinions about teen seat belt use, ESBR preferences, teen preferences, ESBR customization, value and prioritization of ESBRs, and methods to educate parents and teens about ESBR options.

4 Results

The presentation of the study results are organized under five groupings: (1) ratings from participants in the driver seat position during simulated drives; (2) ratings from participants in all seat positions in group sessions during simulated drives; (3) brief ESBRs; (4) individual alerts; and (5) parent opinions of ESBRs. These five sets of analyses correspond to Sections 4.1 through 4.5. The analyses of driver ratings in Section 4.1 include driver participants from both the Driver Alone and Driver With Passengers conditions. The group participants ratings in Section 4.2 include participants in all seat positions, including the driver seat position.

The presentation of the various results of the study includes summaries of the outcomes of analyses of variance (ANOVAs). More detail on the ANOVAs may be found in Appendix D. For analyses of ratings made during the simulated drives, each participant's score was based on the mean of the three ratings made at different times during the drive.

The analyses conducted on ratings of the appropriateness of the strength of the alerts were based on the absolute degree of deviation from a perceived ideal strength, without consideration of the direction of the difference. Alerts can be inappropriately strong or inappropriately weak, but the magnitude of the deviation was the only consideration for the ANOVAs. On the 9-point scale used for these measures, the maximum possible deviation was four points above or below the "ideal" point (5).

4.1 Simulated Drives (Drivers Only)

Participants rated each ESBR during simulated drives for effectiveness, annoyance, and strength appropriateness. Also, immediately following the drives, participants rated effectiveness and desirability. Analyses of variance were performed on data from participants in the driver's seat position only for each of these measures and are summarized in Table 6. The independent variables were: (a) Group composition (no passengers, one gender group, mixed gender group), (b) Gender, (c) ESBR (systems 1 through 5 and the Minimal system). Detailed analyses are presented in Appendix D.

Table 6. Drive rating ANOVA results (driver data)

Factor	Annoyance	Effectiveness	Strength
Group composition			
Gender			
ESBR	+	+	+
Gender X group composition			
ESBR X group composition			
ESBR X gender			

+ = $p < 0.05$

For the annoyance ratings, there was a significant main effect of ESBR, $F(5, 225) = 50.84$, $p < 0.05$. Mean ratings for each system are shown in Figure 6. The Minimal system was not considered annoying at all (1.05) and ESBR 2 was considered the next least annoying system (4.10), while ESBR 4 was considered the most annoying (7.82). These ratings were on a scale from 1 to 10, with 1 being the least annoying and 10 being the most annoying.

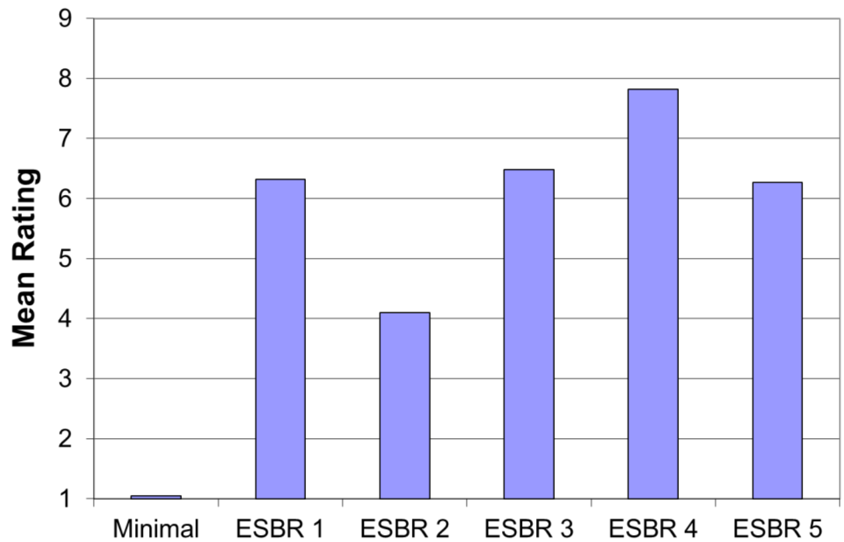


Figure 6. Mean annoyance ratings for each ESBR during simulated drives (driver data)

For the effectiveness ratings, there was a significant main effect of ESBR, $F(5, 225) = 77.10$, $p < 0.05$. Mean ratings for each system are shown in Figure 7. The Minimal system was considered the least effective (1.77), and ESBR 4 and ESBR 5 were considered the most effective (8.70 and 8.90, respectively). There were no significant interactions.

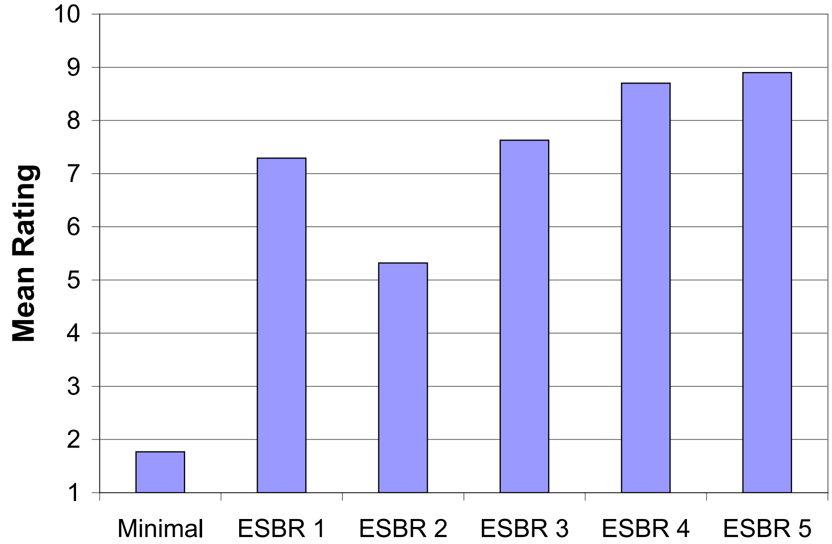


Figure 7. Mean effectiveness ratings for each ESBR during simulated drives (driver data)

For the mean absolute deviation of strength appropriateness ratings, there was a significant main effect of ESBR, $F(5, 225) = 16.91$, $p < 0.05$. Mean ratings for each system are shown in Figure 8. The Minimal system was considered the least appropriate in strength (3.84 mean absolute deviation), and ESBR 1 and ESBR 3 were considered the most appropriate in strength (1.33 and 1.51 mean absolute deviation, respectively). Note that the smaller the number, the closer the strength appropriate ratings were to the mid-point on a 9-point scale (with 5 being most appropriate strength, 1 being too weak and 9 being too strong). There were no significant interactions.

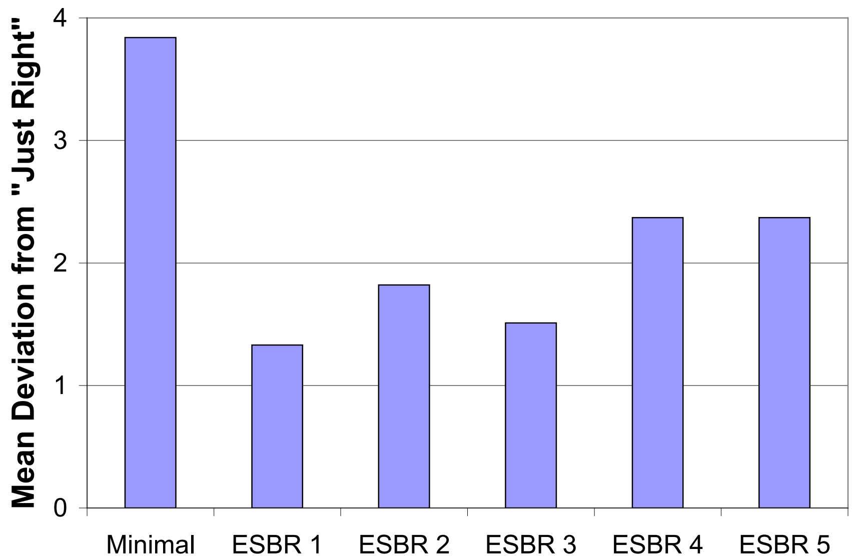


Figure 8. Mean absolute deviation of strength appropriateness ratings from "just right" (driver data)

Figures 9 through 11 show scatterplots of annoyance, effectiveness, and strength appropriateness ratings by ESBR type.

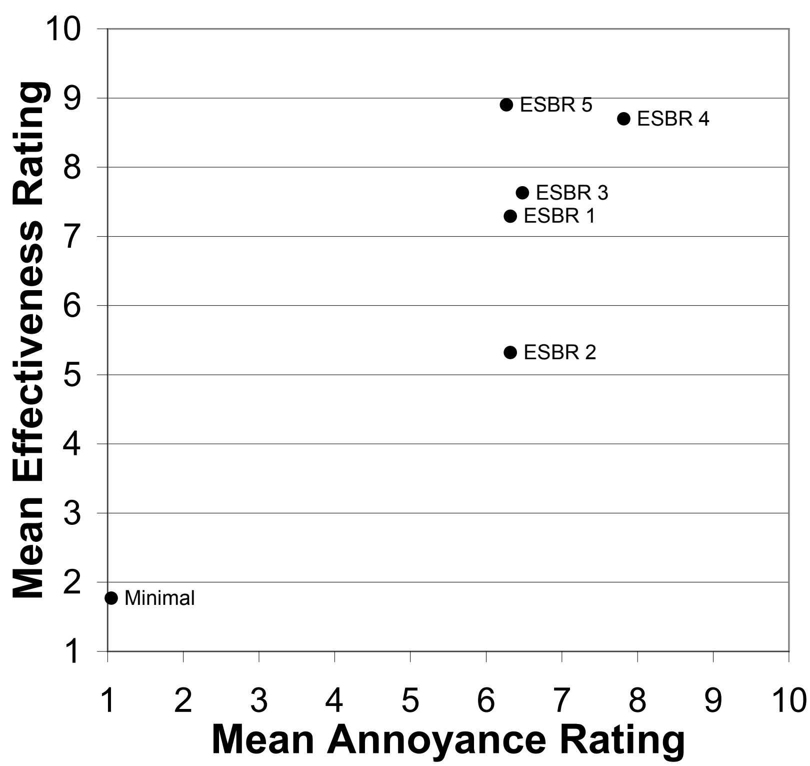


Figure 9. Scatterplot of annoyance ratings versus effectiveness ratings (driver data)

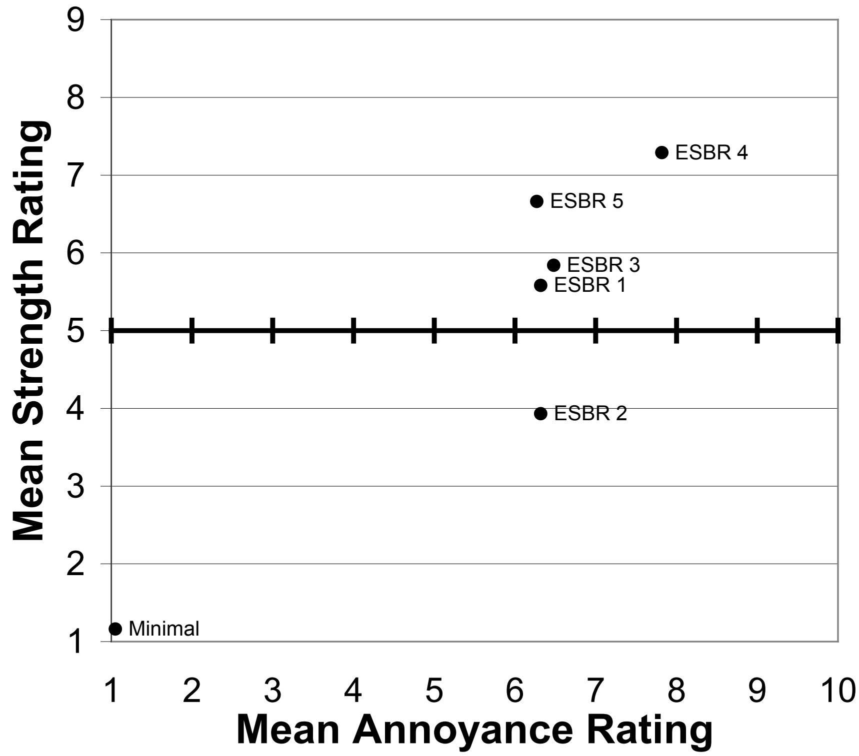


Figure 10. Scatterplot of annoyance ratings versus strength ratings (driver data)

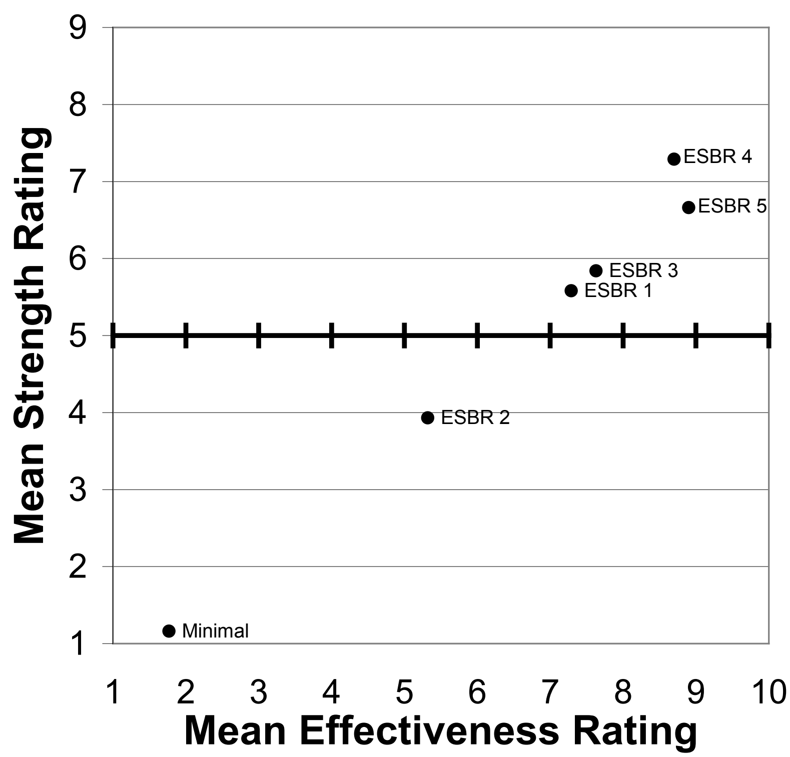


Figure 11. Scatterplot of effectiveness ratings versus strength ratings (driver data)

Table 7 summarizes the outcomes of the ANOVAs conducted on the post drive ratings. The table shows that of the factors considered, only ESBR system had a significant effect on ratings of system desirability or effectiveness.

Table 7. Post-drive ratings

Factor	Desirability	Effectiveness
Group composition		
Gender		
ESBR	+	+
Gender X group composition		
ESBR X group composition		
ESBR X gender		

+ = $p < 0.05$

For the post-drive desirability ratings there was a significant main effect of ESBR, $F(5, 303) = 6.24$, $p < 0.05$. Mean ratings for each system are shown in Figure 12. The minimal system had the lowest desirability ratings, and ESBR 5 was considered the most desirable (3.00 and 7.07, respectively). The other systems were clustered around the middle of the 10-point desirability scale. There were no significant interactions for this measure.

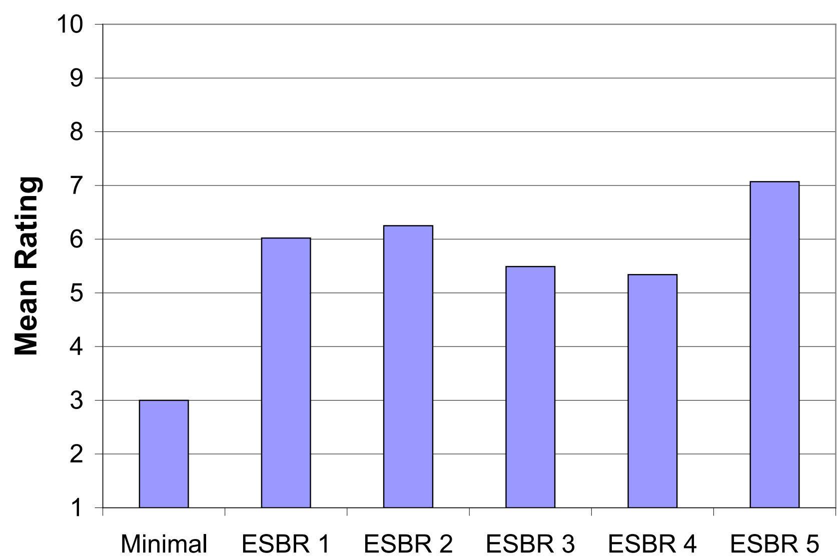


Figure 12. Mean post-drive desirability ratings for each ESBR (driver data)

For the post-drive effectiveness ratings there was a main effect of ESBR, $F(5, 303) = 81.07$, $p < 0.05$. Mean ratings for each system are shown in Figure 13. The minimal system was rated as least effective (1.67), and ESBR 5 and ESBR 4 were rated as very effective (9.15 and 8.84, respectively). There were no significant interactions for this measure.

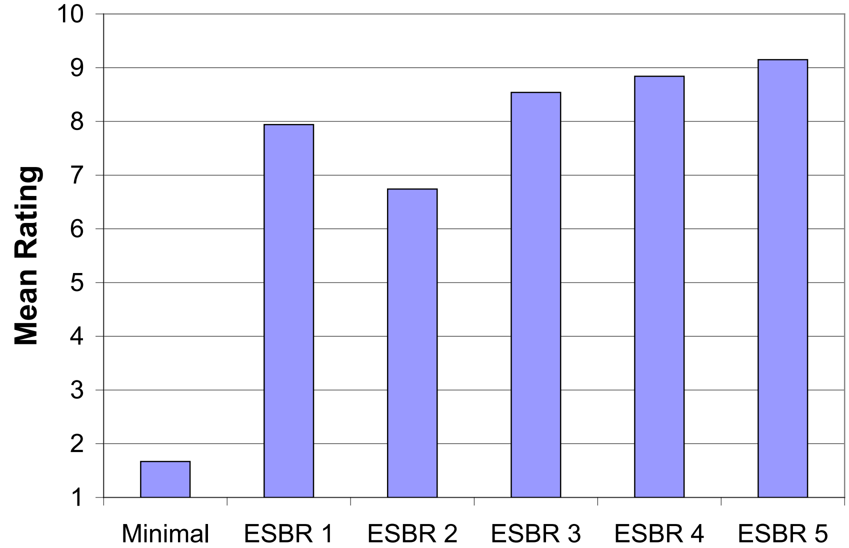


Figure 13. Mean post-drive effectiveness ratings for each ESBR (driver data)

Figure 14 shows a scatterplot of the desirability by effectiveness ratings by ESBR type.

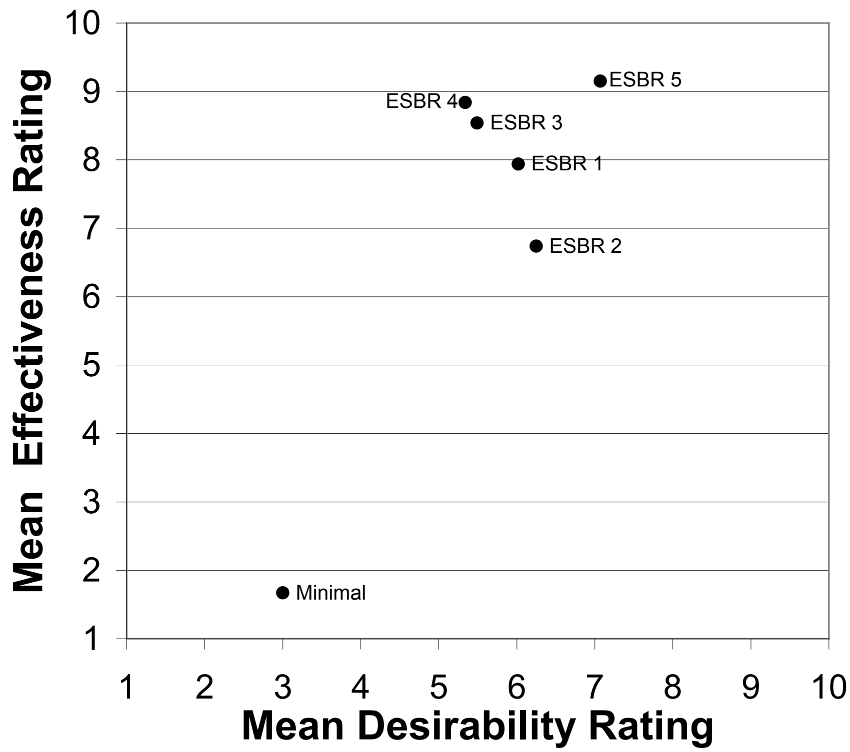


Figure 14. ESBR desirability ratings versus effectiveness ratings (driver data)

4.2 Simulated Drives (Groups Only)

The following section of analyses focuses on group characteristics and only uses data from the group condition. Separate analyses were done for participants that were belted and for those that were unbelted. This was necessary because the structure and content of certain questions varied depending on whether a participant was belted or not. Participants rated each ESBR during simulated drives for effectiveness, annoyance, and strength appropriateness. Immediately following the drives, participants also rated effectiveness and desirability. The independent variables were: (a) group composition (no passengers, one gender, mixed gender), (b) participant gender, (c) ESBR (systems 1 through 5 and the minimal system), and (d) seat position (driver, front passenger, rear passenger). Table 8 summarizes the outcomes of ANOVAs conducted on the ratings of group session participants who were unbelted during the presentation of a given ESBR. Detailed analyses are presented in Appendix D.

Table 8. Group drive (unbelted only)

Effect	Annoyance	Effectiveness	Strength
Group composition	+		
Gender		+	
ESBR	+	+	+
Seat position			
Gender X group composition			
ESBR X group composition	+		
Seat position X group composition			
ESBR X gender			
Seat position X gender			
ESBR X seat position	+		

+ = $p < 0.05$

For the mean annoyance ratings when a participant was unbelted, there was a significant main effect of ESBR, $F(6, 326) = 96.79$, $p < .05$. Mean ratings for each system are shown in Figure 15. As expected, the Minimal system was not annoying (1.14). Also, ESBR 4 and ESBR 5 were considered the most annoying systems (8.25 and 7.33, respectively). The rest of the systems were all in the middle of the scale range indicating moderate annoyance. There was also a main effect of group composition, $F(1, 63) = 4.92$, $p < 0.05$, with homogenous gender groups having slightly higher annoyance mean ratings than heterogeneous mixed-gender groups (5.59 and 5.14, respectively). There was also a significant interaction of ESBR and group composition, $F(6, 326) = 2.49$, $p < 0.05$. This interaction is largely driven by the ESBR 3 and ESBR 6 systems being rated less annoying when the group gender composition was mixed than when it was homogeneous. There was also a seat position by ESBR interaction, with rear passengers considering ESBR 4 and ESBR 3 more annoying, but front passengers considered ESBR 6 less annoying, $F(10, 326) = 3.35$, $p < 0.05$. Note that these interactions are considered tenuous at best due to the sparse sample sizes within cells.

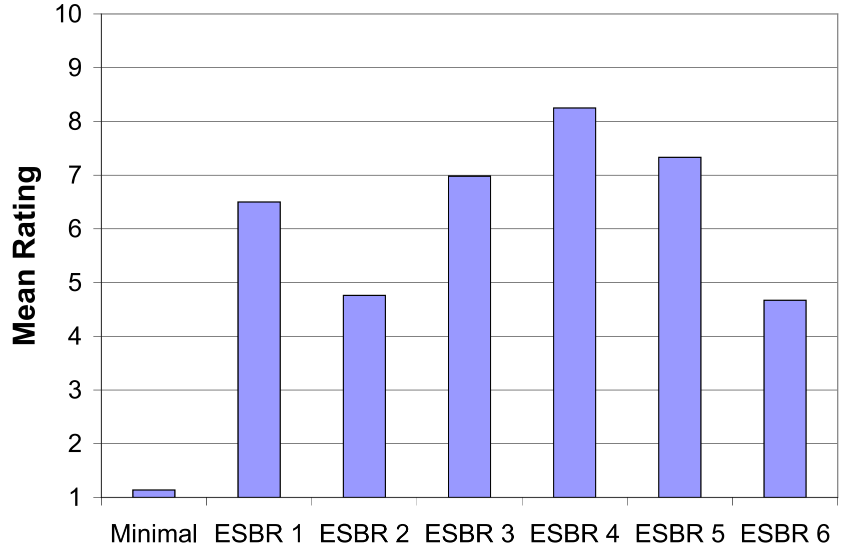


Figure 15. Mean annoyance ratings for each ESBR (unbelted group data)

For the effectiveness ratings when a participant was unbelted, there was a significant main effect of ESBR, $F(6, 326) = 95.07$, $p < 0.05$. Mean ratings for each system are shown in Figure 16. The minimal system (2.19) and ESBR 2 (5.60) were rated the lowest in effectiveness, whereas ESBR 4 (8.63) and ESBR 5 (8.92) were considered the most effective by participants. There was also a main effect of gender, $F(1, 61) = 4.12$, $p < .05$, with females giving higher effectiveness ratings than males (6.89 and 6.13, respectively).

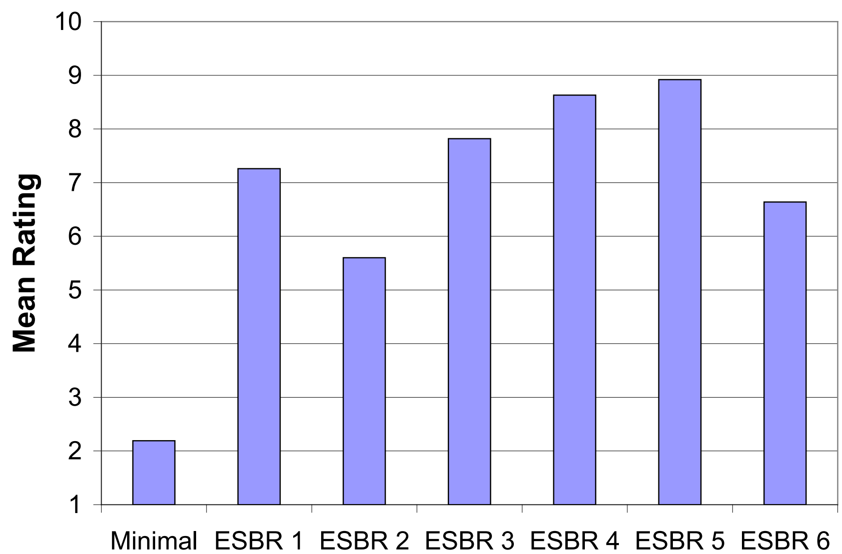


Figure 16. Mean effectiveness ratings for each ESBR (unbelted group data)

For the mean absolute deviation of strength appropriateness ratings when a participant was unbelted, there was a significant main effect of ESBR, $F(6, 326) = 34.15$, $p < 0.05$. Mean ratings for each system are shown in Figure 17. The minimal system had very low strength appropriateness ratings, and as a result had the farthest mean deviations from the center of the scale (3.60). There were no significant main effects or interactions for mean absolute deviation of the strength appropriateness measure.

Table 9 summarizes outcomes of ANOVAs conducted on the ratings of group session participants who were belted during the presentation of a given ESBR. Note that the minimal system is not included in these analyses because no participants were ever buckled during its presentation.

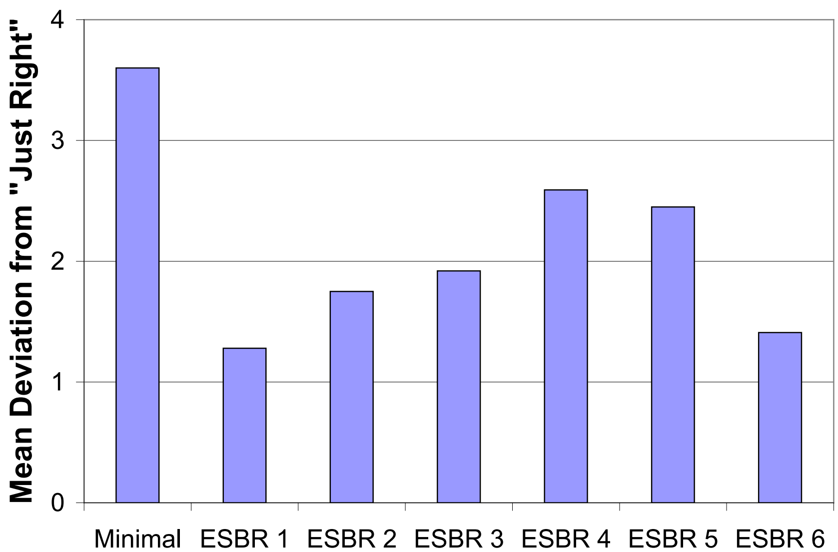


Figure 17. Mean absolute deviation of strength appropriateness ratings from "just right" for each ESBR (unbelted group data)

Table 9. Group drive (belted only)

Effect	Annoyance	Effectiveness	Strength
Group composition			
Gender			
ESBR	+	+	*
Seat position			
Gender X group composition			
ESBR X group composition	+		
Seat position X group composition			
ESBR X gender			
Seat position X gender	+		
ESBR X seat position			

+ = $p < 0.05$; * = $p < 0.10$

For the annoyance ratings when a participant was belted, there was a significant main effect of ESBR, $F(5, 223) = 10.85$, $p < 0.05$. Mean ratings for each system are shown in Figure 18. ESBR 2 and ESBR 5 were rated as less annoying than the other systems (3.54 and 3.51, respectively, on a scale from 1 to 10, with 1 being the least annoying and 10 being the most annoying). The rest of the systems were all in the middle of the scale range indicating moderate annoyance. There was also a significant interaction of ESBR and group composition, $F(5, 223) = 2.33$, $p < 0.05$. This interaction is largely driven by the ESBR 6 system being rated less annoying when the group gender composition was mixed than when it was homogeneous (3.99 and 5.35, respectively). There was also a Seat position by gender interaction, where males in the rear passenger position gave slightly lower annoyance ratings than females in the same position, $F(2, 78) = 3.48$, $p < 0.05$. Note that these interactions are considered tenuous at best due to the sparse sample sizes within cells.

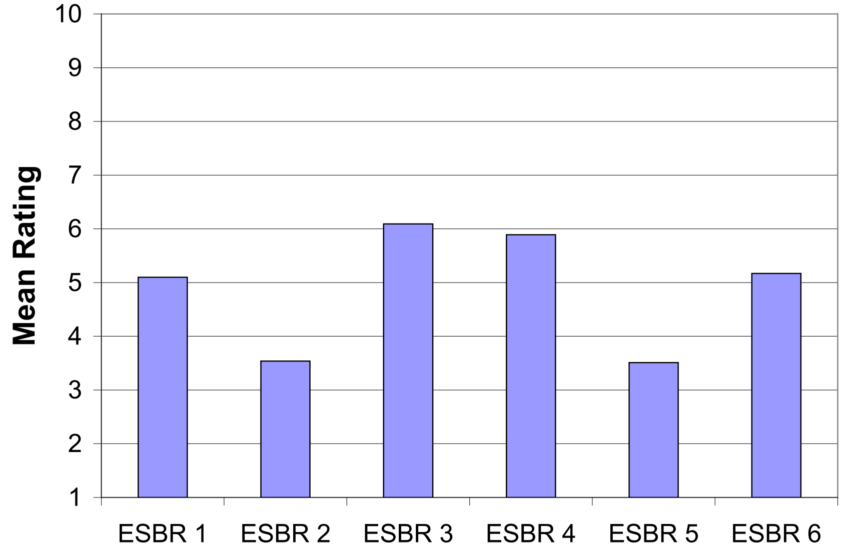


Figure 18. Mean annoyance ratings for each ESBR (belted group data)

For the effectiveness ratings when a participant was belted, there was a significant main effect of ESBR, $F(5, 225) = 11.46$, $p < 0.05$. Mean ratings for each system are shown in Figure 19. ESBR 2 was rated the lowest in effectiveness (4.60), and ESBR 4 (7.05), ESBR 3 (7.03), and ESBR 6 (6.97) were considered the most effective by participants. There were no significant interactions.

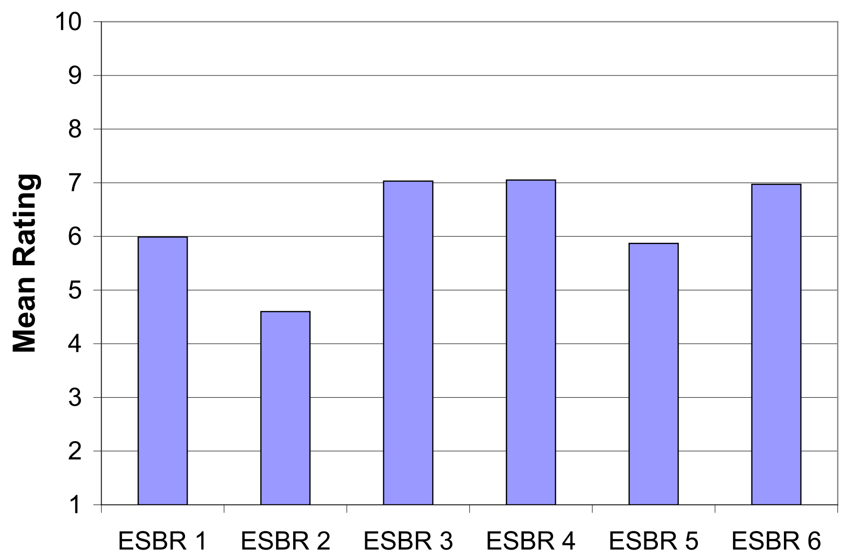


Figure 19. Mean effectiveness ratings for each ESBR (belted group data)

There were no significant main effects or interactions for mean absolute deviation of the strength appropriateness measure. Mean ratings for each system are shown in Figure 20. Although the effects were not significant, there is a trend toward a difference across ESBRs, $F(5, 284) = 1.96$, $p = 0.08$. This trend is driven by the ESBR 2 system yielding absolute deviation scores which were further from the mid-point than the other systems (2.18). The trend is likely not significant due to lower power in the group analyses, limited to only unbelted cases. But, the trend is consistent with other effects of ESBR on strength appropriateness ratings (which was also found in the data for the belted cases during the group drive).

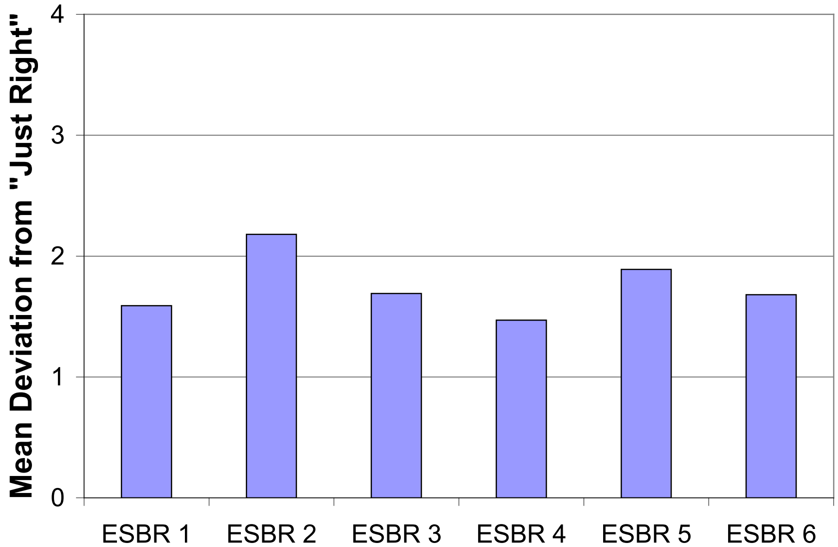


Figure 20. Mean absolute deviation of strength appropriateness ratings from "just right" for each ESBR (belted group data)

Table 10 summarizes the findings of ANOVAs conducted on group session post drive ratings of desirability and effectiveness of each ESBR. Separate analyses were conducted for participants who were belted and those who were unbelted.

Table 10. Group post-drive

	Belted		Unbelted	
Effect	**Desirability**	**Effectiveness**	**Desirability**	**Effectiveness**
Group composition	*			
Gender		+		+
ESBR	*	+	+	+
Seat position				
Gender X group composition				
ESBR X group composition		+		
Seat position X group composition				
ESBR X gender				
Seat position X gender				
ESBR X seat position				

+ = $p < 0.05$, * = $p < 0.10$

For the post-drive desirability ratings when a participant was belted, there were no significant main effects or interactions, although this may have been due to limited power and weaker effects on this variable. Mean ratings for each system are shown in Figure 21. The main effects of ESBR and group composition did approach significance ($p = 0.06$ in both cases). ESBR 5 was rated slightly more desirable than the rest (6.21), and heterogeneous gender groups gave slightly higher ratings than homogeneous mixed–gender groups (6.24 and 5.22, respectively). There were no significant interactions for this measure.

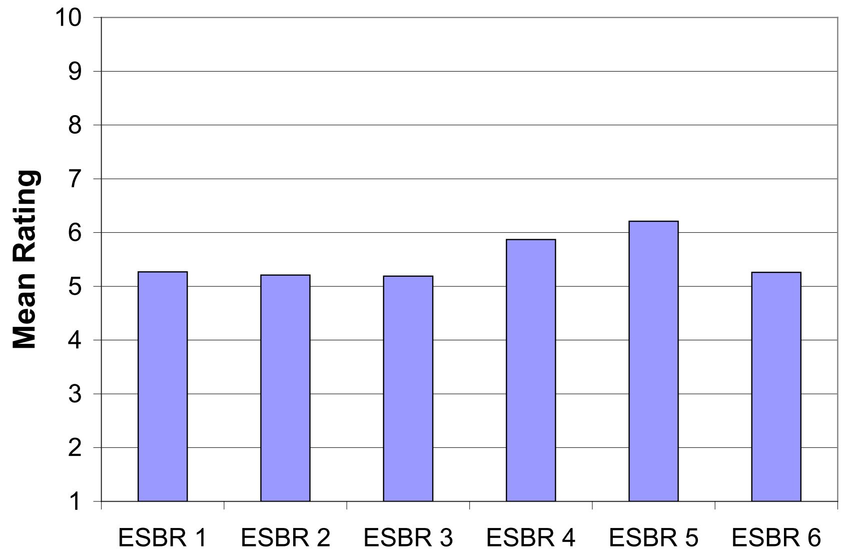


Figure 21. Post-drive ratings of desirability by ESBR (group belted data)

For the post-drive effectiveness ratings when a participant was belted, there was a main effect of gender, $F(1, 68) = 5.94$, $p < .05$, with females giving higher effectiveness ratings than males overall (7.47 and 6.40, respectively). There was also a main effect of ESBR, $F(5, 220) = 3.37$, $p < 0.05$. ESBR 4 (7.38), ESBR 3 (7.64), and ESBR 6 (7.44) were all rated as more effective than the other systems (which were clustered around the midpoint of the scale, with 1 being least effective and 10 being most effective). There was also a significant ESBR by group composition interaction, $F(5, 220) = 2.51$, $p < 0.05$, with ESBR 4 and ESBR 5 being rated more effective in heterogeneous groups, and ESBR 3 being rated less effective. Mean ratings for each system are shown in Figure 22. Note that this interaction is considered tenuous at best due to the sparse sample sizes within cells.

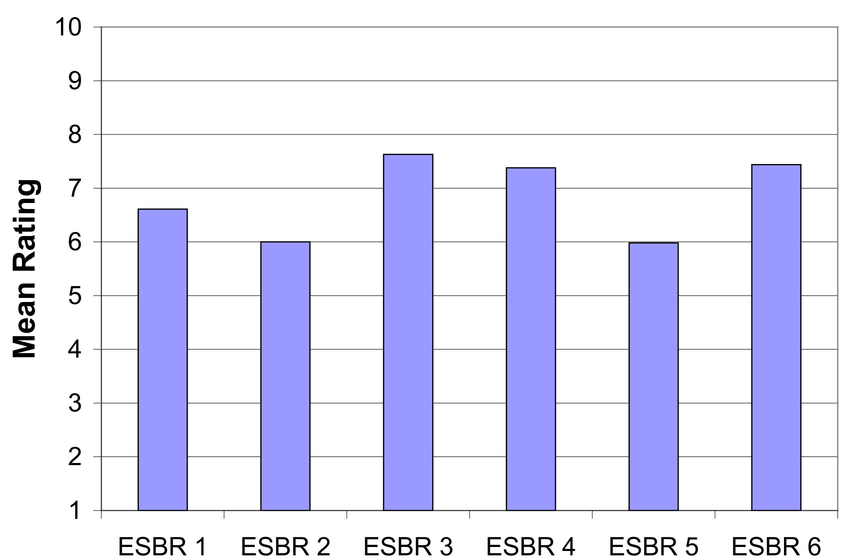


Figure 22. Post-drive ratings of effectiveness by ESBR (group belted data)

For the post-drive desirability ratings when a participant was unbelted, there was a significant main effect of ESBR, $F(6, 324) = 5.98$, $p < 0.05$. Mean ratings for each system are shown in Figure 23. ESBR 5 was considered more desirable than the other systems, while the minimal system was considered the least desirable (7.50 and 3.50, respectively). There were no significant interactions for this measure.

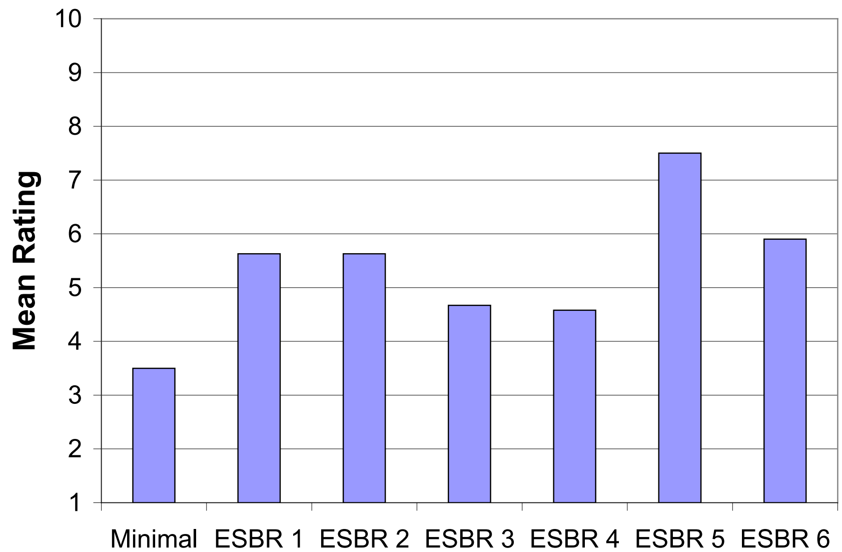


Figure 23. Post-drive ratings of desirability by ESBR (group unbelted data)

For the post-drive effectiveness ratings when a participant was unbelted, there was a main effect of gender, $F(1, 62) = 4.53$, $p < 0.05$, with females giving higher effectiveness ratings than males overall (7.37 and 6.71, respectively). There was also a main effect of ESBR, $F(6, 322) = 102.22$, $p < 0.05$. The mean ratings for each system are shown in Figure 24. ESBR 4 (8.84), ESBR 3 (8.58), and ESBR 5 (9.20) were all rated as most effective. The minimal system was rated as least effective (2.22). There were no significant interactions for this measure.

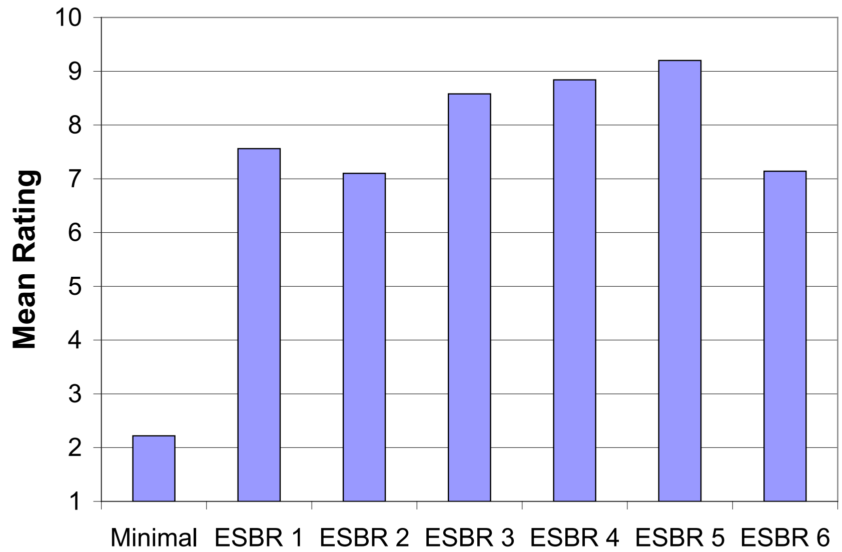


Figure 24. Post-drive ratings of effectiveness by ESBR (group unbelted data)

There was also a strong correlation across drive and post-drive effectiveness ratings. When participants were belted, there was a correlation of r = .81 between effectiveness ratings during the drive and for the post-drive. Similarly, when participants were unbelted, the drive and post-drive effectiveness ratings correlation was r = .92.

4.3 Brief ESBRs

Participants rated each brief ESBR for effectiveness, annoyance, and strength appropriateness. Analyses of variance were performance for each of these measures and are summarized in Table 11. In all three types of ratings, there was no significant main effect of gender, and no interaction of gender with brief ESBR. Males and females rated these brief ESBRs the same for effectiveness, annoyance, and appropriateness of strength. Detailed analyses are presented in Appendix D.

Table 11. Summary results for brief ESBRs rating ANOVAs

Factor	**Effectiveness**	**Annoyance**	**Strength**
Brief ESBR	+	+	+
Gender			
Brief ESBR*Gender			

+ = $p < 0.05$

For the effectiveness ratings, there was a significant main effect of brief ESBR, $F(11, 317) = 41.44$, $p < 0.05$. Mean ratings for each brief ESBR are shown in Figure 25. BR 1 (equivalent to the Minimal system) and BR 2 were rated the lowest in effectiveness, with a rating of 2.79 and 4.56, respectively. In contrast, BR 8 and BR 3 were rated as the most effective (9.02 for both).

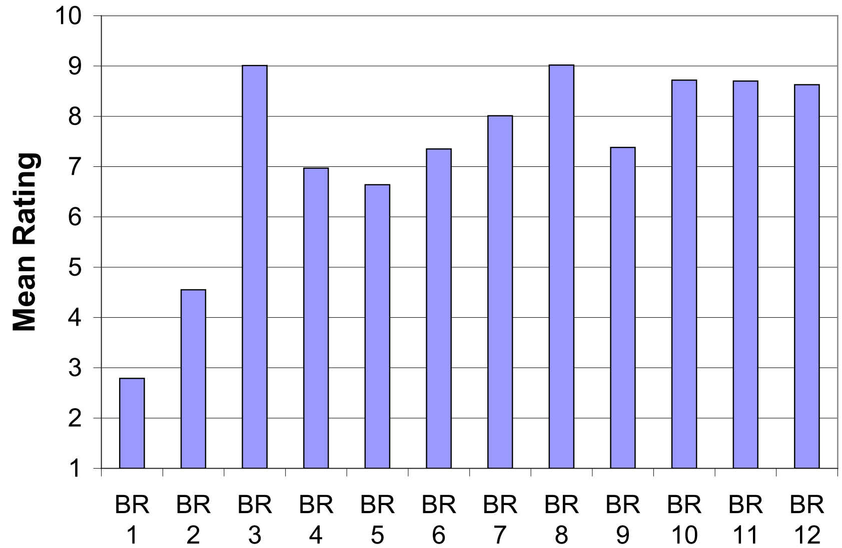


Figure 25. Mean rating of effectiveness for each brief ESB

For the annoyance ratings, there was a significant main effect of brief ESBR, $F(11, 317) = 38.95$, $p < 0.05$. The mean rating of each brief ESBR is shown in Figure 26. BR 1 and BR 2 were rated the lowest in annoyance, with ratings of 1.34 and 3.09, respectively. In contrast, BR 3, BR 11, and BR 8 were rated as the most annoying (8.24, 8.12, and 7.92, respectively).

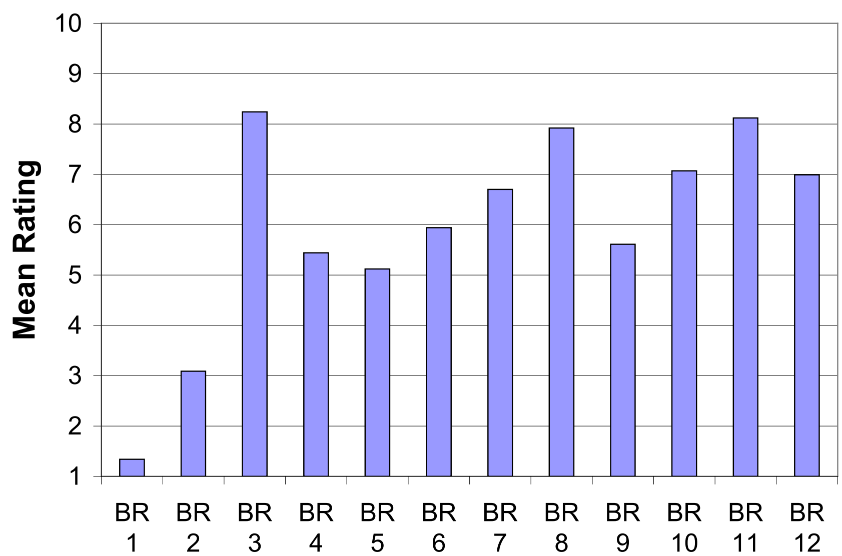


Figure **26. Mean rating of annoyance for each brief ESBR**

For the mean absolute deviation of the strength appropriateness ratings, there was a significant main effect of brief ESBR, $F(11, 317) = 9.53$, $p < 0.05$. Mean absolute deviations are shown in Figure 27. For this scale, note that it is the absolute deviation, which means the rating is measured on how far away from the ideal strength the brief ESBR falls on the scale. BR 1 and BR 2 were rated the least appropriate strength, with mean absolute deviations of 3.48 and 2.53, respectively. In contrast, BR 6, BR 8, and BR 4 were rated the most appropriate in strength, with mean absolute deviations of 0.99, 1.33, and 1.34, respectively.

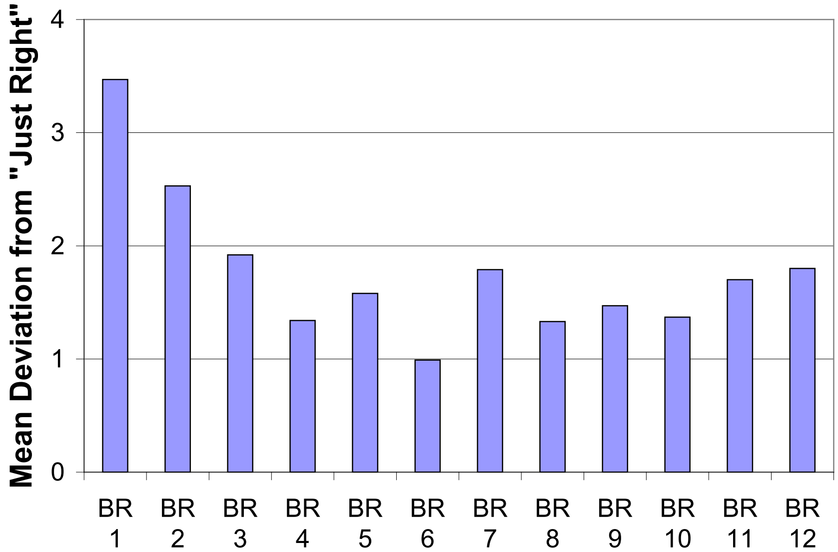


Figure 27. Mean absolute deviation of strength rating for each brief ESBR

The following figures (Figure 28, Figure 29, and Figure 30) show scatterplots of annoyance, effectiveness, and strength appropriateness ratings for the brief ESBR systems. There is a strong positive linear relationship among all of these measures. Effective brief ESBRs were also annoying and stronger than necessary. No ESBR deviated substantially from the general linear relationship, although BR10 and BR 12 were rated somewhat less annoying than other comparably effective ESBRs.

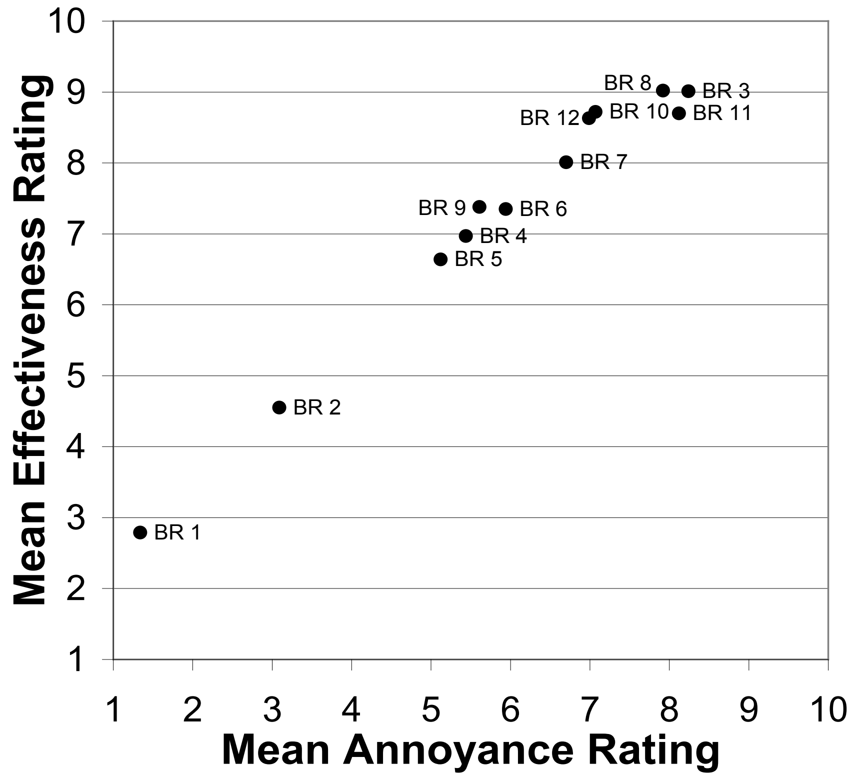


Figure 28. Scatterplot of annoyance versus effectiveness ratings for brief ESBRs

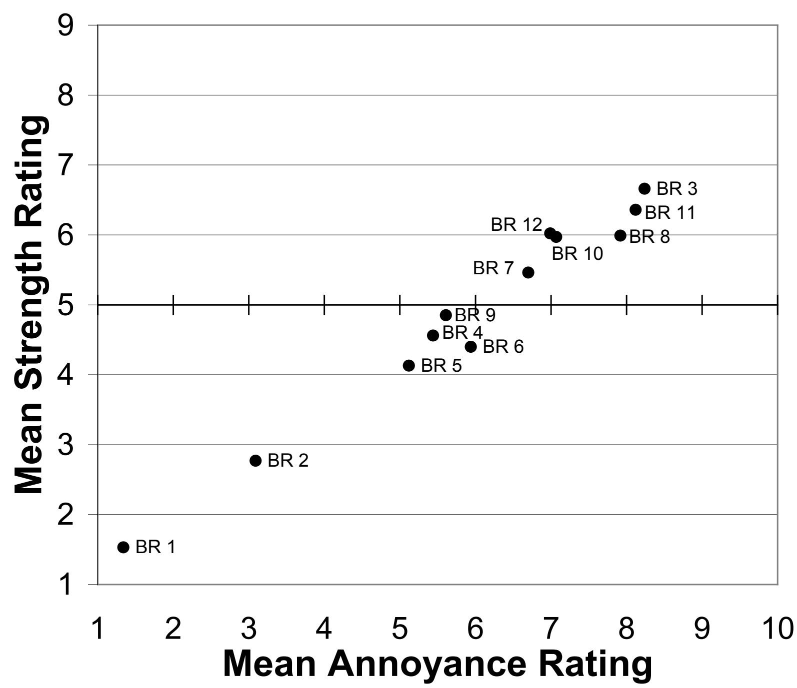


Figure 29. Scatterplot of annoyance ratings versus strength appropriateness ratings for brief ESBRs

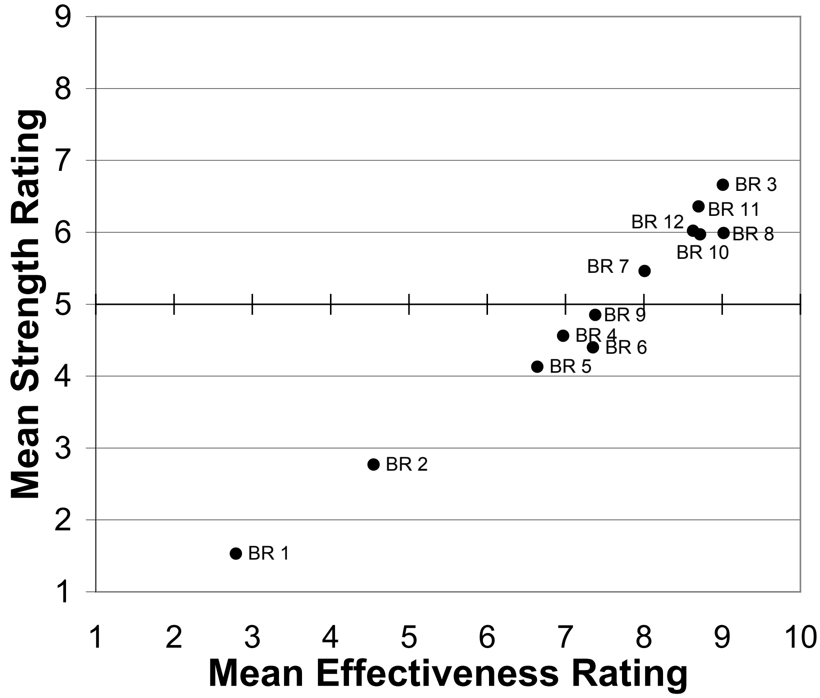


Figure 30. Scatterplot of effectiveness ratings versus strength appropriateness ratings for brief ESBRs

4.4 Individual Alerts

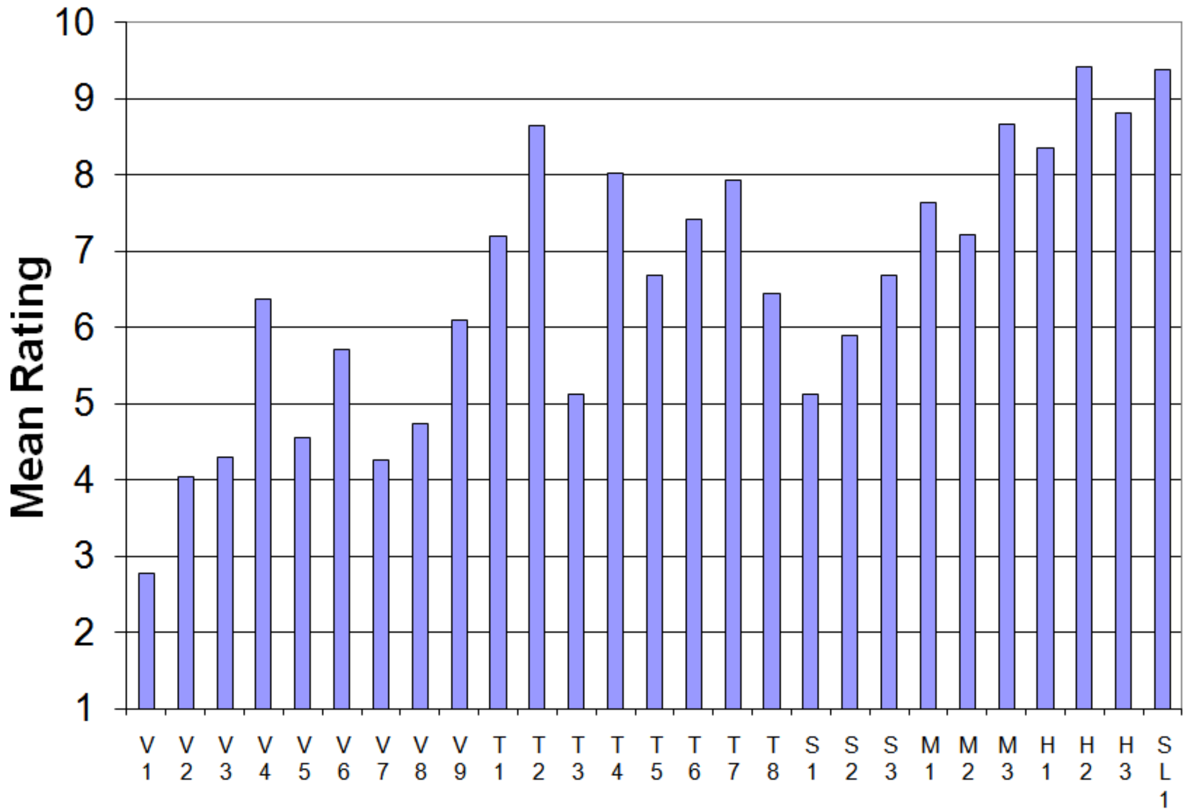
Participants rated each individual alert for effectiveness and annoyance. Analyses of variance were performed for each of these measures and are summarized in Table 12. Detailed analyses are presented in Appendix D.

Table 12. Summary results of individual alerts rating ANOVAs

Factor	**Effectiveness**	**Annoyance**
Alert	+	+
Gender		
Alert*Gender		

+ = $p < 0.05$

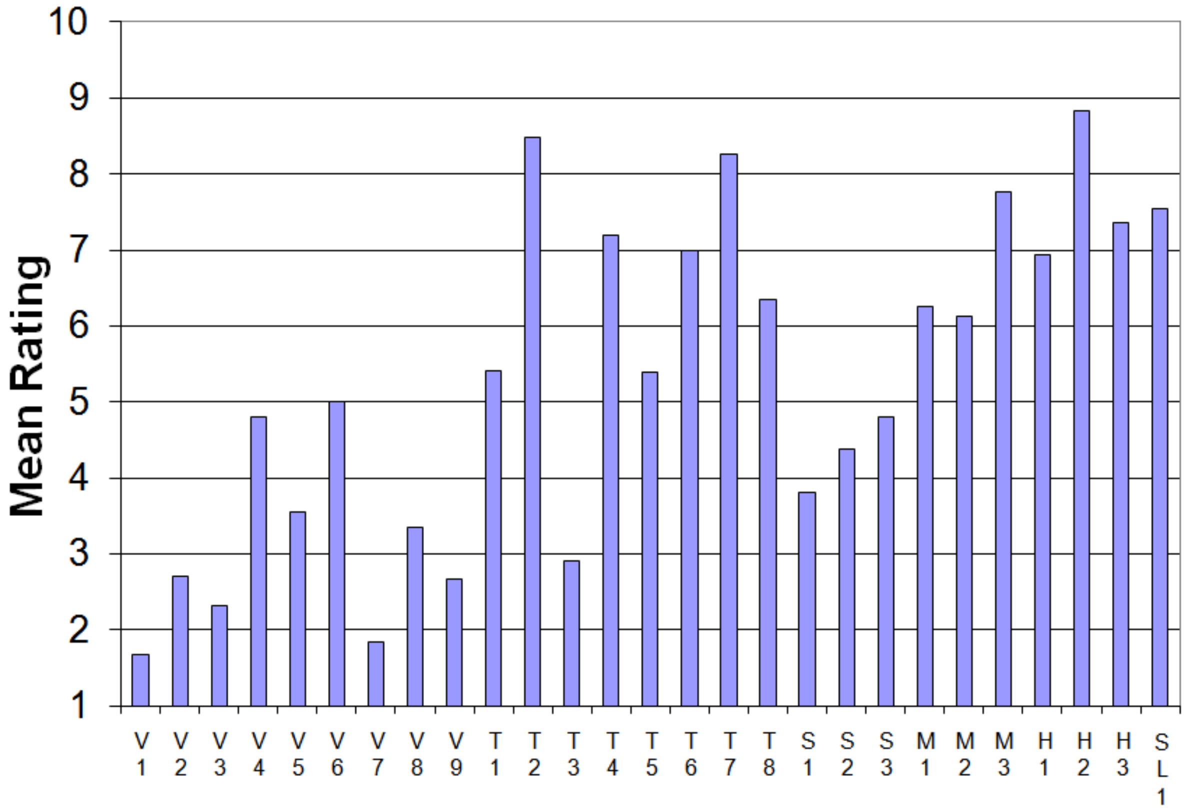
For the ratings of buckle effectiveness, there was a significant main effect of alert type, F (26, 753) = 32.75, $p < 0.05$. There were no significant interactions with gender, and gender itself was not significant as an effect on system effectiveness ratings. Figure 31 shows the mean effectiveness ratings for each individual alert. For alert type, the means range from 2.72 (V1: dashboard icon) to 9.41 (H2: seat vibration with a 1-second duty cycle and fast chime) on a ten-point scale. Visual alerts were generally rated relatively low. The highest-rated alerts generally included haptic elements and/or were multimodal. The stereo lockout system was also rated highly effective.



V = visual; T = tone; S = speech; H = haptic; M = multimodal; SL = stereo lockout
(see Table 5 for complete descriptions of individual alerts)

Figure 31. Mean effectiveness rating for each individual alert

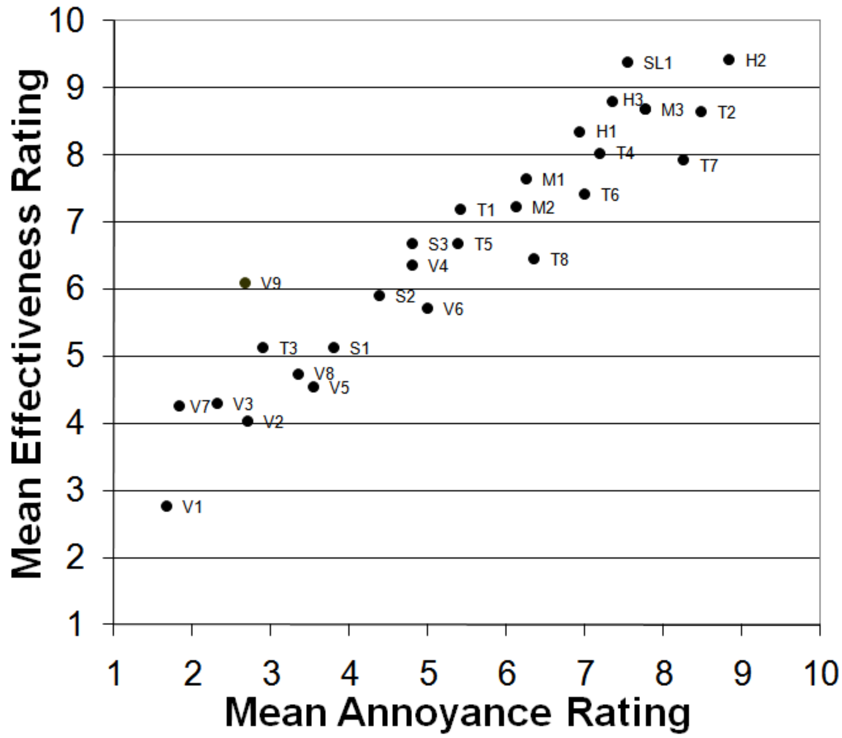
For the ratings of annoyance, there was also a significant main effect of alert type, F (26, 753) = 37.66, $p < 0.05$. Overall, males and females rated alert type similarly, and there was no significant interaction between gender and alert type ratings. Figure 32 shows the mean annoyance ratings for each individual alert. The annoyance rating means ranged from 1.64 (V1: dashboard icon) to 8.85 (H2: seat vibration with a 1-second duty cycle and fast chime) on a 10-point scale. There are several systems with very low ratings (V1: dashboard icon; V7: center console - buckle seat belt icon/text; V3: dashboard icon/text) and several with fairly high annoyance ratings (T2: slow chime (loud); T7: high urgency; H2: seat vibration with a 1-second duty cycle and fast chime).



V = visual; T = tone; S = speech; H = haptic; M = multimodal; SL = stereo lockout
(see Table 5 for complete descriptions of individual alerts)

Figure 32. Mean annoyance rating for each individual alert

There was a strong relationship between annoyance and effectiveness ratings for the individual alerts (r = .71). Figure 33 shows a scatterplot of the annoyance by effectiveness ratings for the individual alerts. The point that deviated the most from the general linear relationship was the visual center console display showing a schematic of seat positions (V9). This alert was less annoying than its effectiveness would indicate, although other, non-visual alerts were more effective.



V = visual; T = tone; S = speech; H = haptic; M = multimodal; SL = stereo lockout
(see Table 5 for complete descriptions of individual alerts)

Figure 33. Scatterplot of annoyance versus effectiveness ratings for individual alerts

Given the high number of various individual alerts, it was necessary to create several composite variables along dimensions of interests to better assess the different individual alert features (modality, loudness, etc.). Table 13 provides a list of different alert characteristics grouped by dimensions of interest.

Table 13. Significance of alert dimensions by ratings of effectiveness and annoyance

Dimension	Comparisons	Effectiveness	Annoyance
Mode	Visual (all) X Tone (all) X Speech (all) X Haptic (all)	+	+
Volume	Tone 1 X Tone 2	+	+
Speech urgency	Speech 1 X Speech 2	+	
Auditory rate	Tone 1, Tone 3 X Tone 4, Tone 5 X Tone 6	+	+
Flash	Visual 1, Visual 5 X Visual 2, Visual 6	+	+
Visual location	Visual 1-4 X Visual 5-6, Multimodal 3 X Visual 7-9	+	+
Visual type	Visual 8 X Visual 9 X Multimodal 3	+	+
Haptic	Haptic 1 X Haptic 2 X Haptic 3	+	+

+ = $p < 0.05$

SAS PROC MIXED was used to analyze effectiveness and annoyance ratings. Participant and stimulus (alert modality or other comparison groupings) were included as random effects while gender was entered into the model as a fixed effect. The column entitled "effectiveness" shows the significance of effectiveness for each dimension. Similarly, the "annoyance" column shows whether or not annoyance ratings differed significantly for a particular dimension. As indicated in Table 13, there were statistically significant effects of every dimension on both effectiveness and annoyance ratings, with the single exception of speech urgency on annoyance.

As shown in Table 13, the mode across individual alerts significantly influenced effectiveness ratings, $F(3, 650) = 53.51$, $p < 0.05$. Visual alerts were rated as the least effective (5.15), followed by speech alerts (5.09) and tone alerts (7.19). Alerts that included seat vibration were rated as the most effective (8.36). Similarly, vibration alerts also had an effect on annoyance ratings, $F(3, 650) = 65.15$, $p < 0.05$. Vibration alerts and tone alerts were considered the most annoying (6.94 and 6.38, respectively). Visual alerts were rated as least annoying (3.57) and speech alerts slightly higher in annoyance (4.33).

Volume of individual alerts had a significant effect on effectiveness ratings, $F(1, 31) = 11.40$, $p < 0.05$. Slow chime (loud) (T2) was rated as more effective than the slow chime at normal volume (T1), 8.65 and 7.19, respectively. Similarly, there was a main effect of volume on annoyance ratings, $F(1, 31) = 58.65$, $p < 0.05$. Slow chime (loud) (T2) was rated as more annoying than the slow chime at normal volume (T1), 8.48 and 5.42, respectively.

Speech message urgency had a significant effect on effectiveness ratings, $F(1, 31) = 5.46$, $p < 0.05$. The urgent "warning: buckle seat belt" speech message (S2) was rated as more effective than the non-urgent "buckle seat belt" message (S1), 5.90 and 5.13, respectively. There was not a significant effect of speech urgency on annoyance ratings.

Auditory rate of individual alerts had a significant impact on effectiveness ratings, $F(2, 124) = 11.87$, $p < 0.05$. Slow chimes (T1 and T3) were rated as less effective than fast chimes (T4 and T5) or the slow-to-fast chime (T6), 6.16 vs. 7.36 or 7.42, respectively. Similarly, slow chimes (mean rating 4.16) were rated as less annoying than fast chimes (mean rating 6.29) or the slow-to-fast chime (mean rating 7.00), $F(2, 124) = 29.91$, $p < 0.05$.

The presence of a flash as part of the individual alert had a significant effect on effectiveness ratings, $F(1, 93) = 11.71$, $p < 0.05$. Individual alerts with a flash (V2 and V6) were rated more effective than those without (V1 and V5), 4.87 and 3.66, respectively. Similarly, for annoyance ratings, there was a significant main effect of having a flash present, $F(1, 93) = 11.19$, $p < 0.05$. Having a flash present was rated as more annoying than not having a flash present, 3.86 and 2.61 respectively. Note that both effectiveness and annoyance ratings were relatively low overall.

There was a significant main effect of visual location on effectiveness ratings, $F(2, 278) = 21.12$, $p < 0.05$. B-pillar light alerts (V5-6) were rated most effective (6.31), while driver dashboard visual alerts (V1-4) were rated the least effective (4.36). Center console alerts (V7-9) were rated as moderately effective (5.03). As for annoyance ratings, B-pillar light alerts were rated as much more annoying (5.44) than either center console alerts (2.62) or driver icon visual alerts (2.87).

Type of visual alert had a significant effect on effectiveness ratings, $F(2, 62) = 9.79$, $p < 0.05$. Of the 3 types of center console displays, the vehicle schematic (V9) was rated as most effective (6.10), followed by flashing warning text (V8) (4.74), and then seat belt icon/text (V7) (4.26). Interestingly, the flashing warning text was rated most annoying (3.36), followed by vehicle schematic (2.68), and then seat belt icon/text (1.84), $F(2, 62) = 7.51$, $p < 0.05$.

Alerts that included seat vibration differed in effectiveness ratings, with the addition of a fast chime (H2) (9.42) being rated as more effective than no additions (H1) (8.36) or flashing center console icon/text additions (H3) (8.81), $F(2, 62) = 7.59$, $p < 0.05$. Similarly, fast chime added to the haptic alerts was rated as more annoying (8.84) than either of the other alerts that included seat vibration (6.94 and 7.36, respectively), $F(2, 62) = 14.20$, $p < 0.05$.

4.5 Parent Opinions of ESBRs

Twenty-five parents of teen drivers participated in a study in which they experienced a set of conceptual ESBRs designed for use by novice teen drivers. Parents then participated in group discussions, moderated by the experimenter, in which they discussed their thoughts about teen belt use and ESBR preferences.

4.5.1 System Ratings

After experiencing each ESBR system, parents provided written ratings about the system. Responses to each question are described below.

"**How would this system affect your teen's seat belt use?**" The distribution of responses is shown in Figure 34. Across all ESBRs, about half of parents thought that the ESBR would have no effect because their teens already wear seat belts all of the time. Overall, all ESBRs were seen as more likely to increase seat belt use than the basic reminder. All of the ESBRs were rated similarly in terms of increasing seat belt use, but ESBRs 3 and 4 were seen as most likely to "definitely" increase seat belt use.

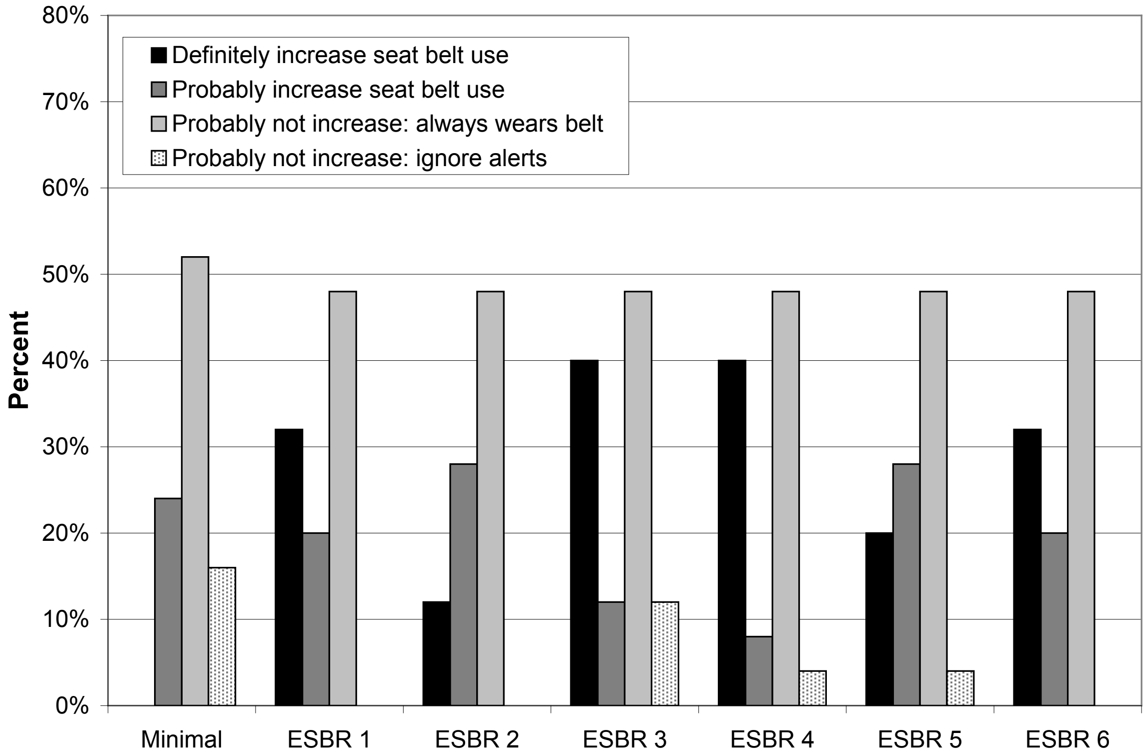


Figure 34. Perceived effect of ESBRs on parents' own teens' seat belt use

"**How would this system affect teens who *rarely wear a seat belt*?**" This question was asked because many parents do not consider their own children to be seat belt nonusers. Responses are shown in Figure 35. The figure shows that all ESBRs, with the exception of ESBR 2, were overwhelmingly seen as effective in increasing the seat belt use of teens who are generally seat belt nonusers. The basic system, however, was seen as ineffective by 80 percent of parents.

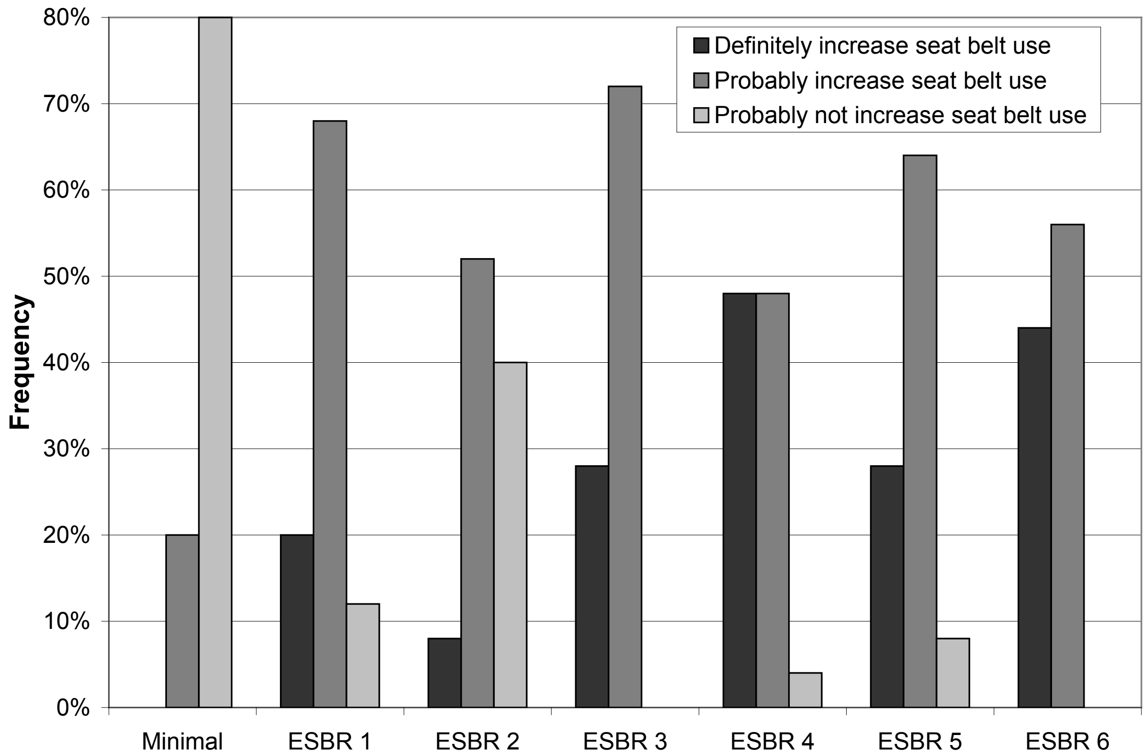


Figure 35. Perceived effect of ESBRs on the seat belt use of teens who *rarely* wear seat belts

"**How appropriate is the strength of the alerts?"** For this question, parents were asked to think about how much motivation it would take to get their own teens to wear their seat belts in situations where they are driving alone or with teen passengers. Parents gave ratings on a scale of one to nine, where 1 means that the alerts are not nearly strong enough, 9 means that the alerts are much stronger than is necessary, and 5 means that it provides just enough motivation to get their teens to buckle up. Mean responses are shown in Figure 36. The means show that, on average, ESBR 1 was considered to be closest to "just right" in terms of strength of alerts. ESBRs 3 and 4 were generally seen as excessive, while the basic system was seen as not nearly strong enough to elicit seat belt use.

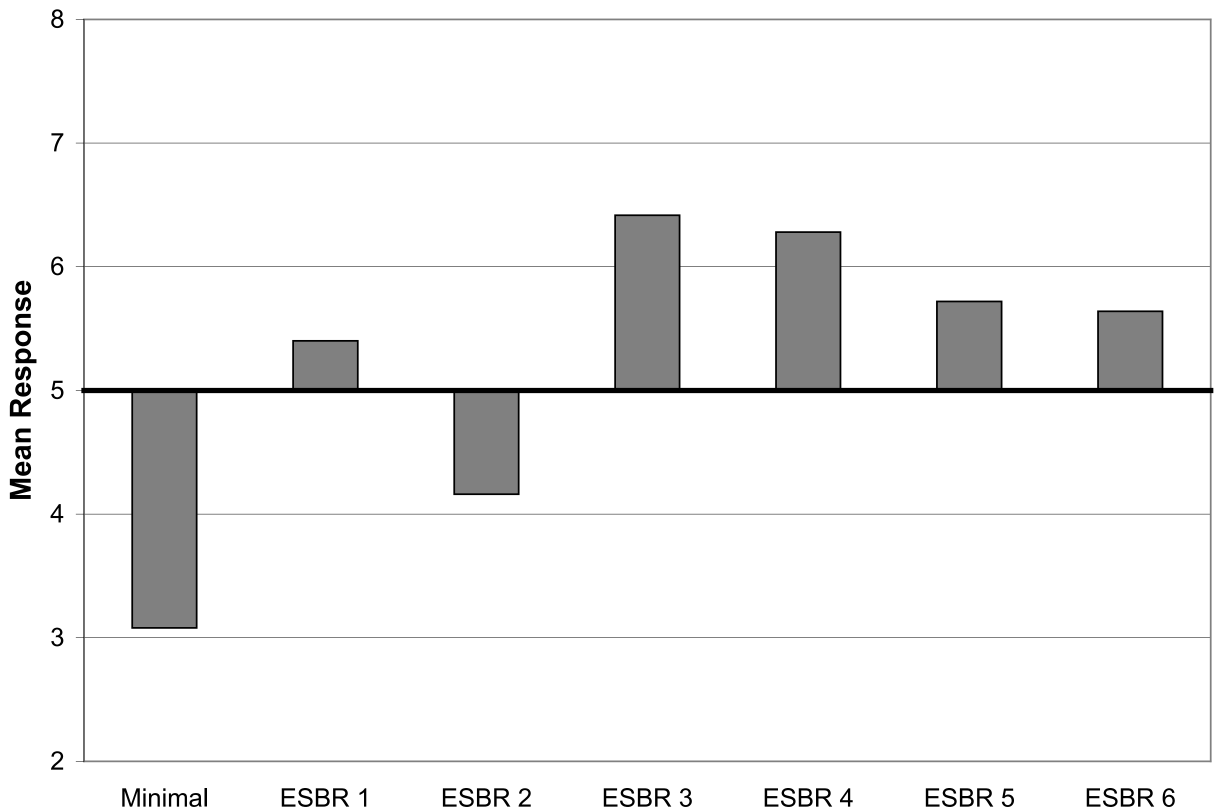


Figure 36. Parents' perceived appropriateness of the strength of the alerts

“**If you were shopping for a new car for your teen and this system were available as an option…**” This question addresses system desirability by asking parents to indicate whether they would be willing to pay for the ESBR, take it for free, or take it for an insurance discount of $10 per month. The distribution of responses for each system is shown in Figure 37. Results show that parents were generally willing to accept all of the ESBRs. Between 68 percent and 88 percent of participants were willing to take each ESBR if it were free or at an additional cost. More than a third of participants were willing to pay extra for ESBRs 1, 3, 4, and 6.

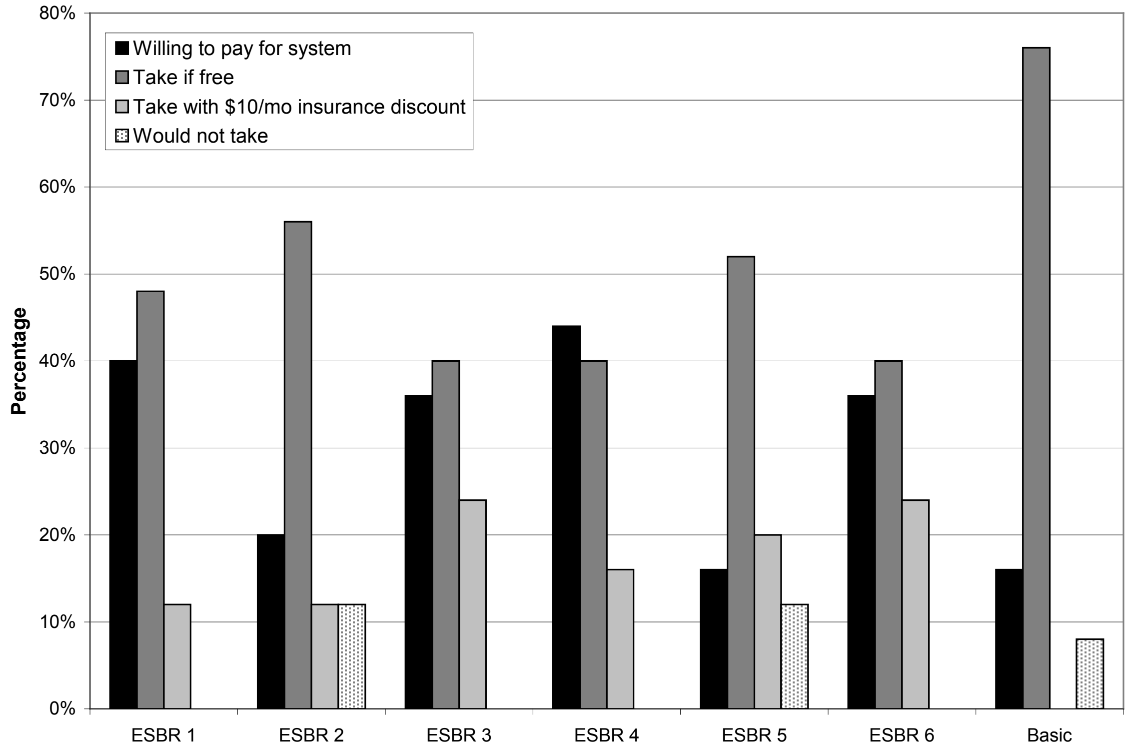


Figure 37. ESBR desirability

4.5.2 Comparison of Teen and Parent Reactions to ESBRs

Teens in group sessions and parents both experienced the set of six ESBRs and the minimal reminder system. Although the procedures were different in the teen and parent sessions, some comparisons can be made to help understand differences and similarities in how each group reacts to the various ESBRs. Figure 38 shows a scatterplot comparing teens' and parents' mean strength appropriateness ratings for each ESBR. Note that parents were rating the appropriateness for *their own* teens. The figure shows that there was moderately good agreement between teens and parents (correlation: $r = 0.71$), though teens' mean ratings were distributed over a wide range on the scale, especially at the high end, whereas parents' mean ratings were more tightly compressed around the center point (5). There was less consistent agreement among parents and teens in how they judged the potential effectiveness of the various systems. Comparing the teens' mean effectiveness rating (see Figure 16) with the percentage of parents who felt a given system would definitely increase their teens' seat belt use (see Figure 34) there was clear agreement that the Minimal system was the least effective and ESBR 2 was the next least effective. There was less agreement in ranking the other systems. The greatest disagreement was for ESBR 5, which teens saw as the most effective system, which was not the case for the adults.

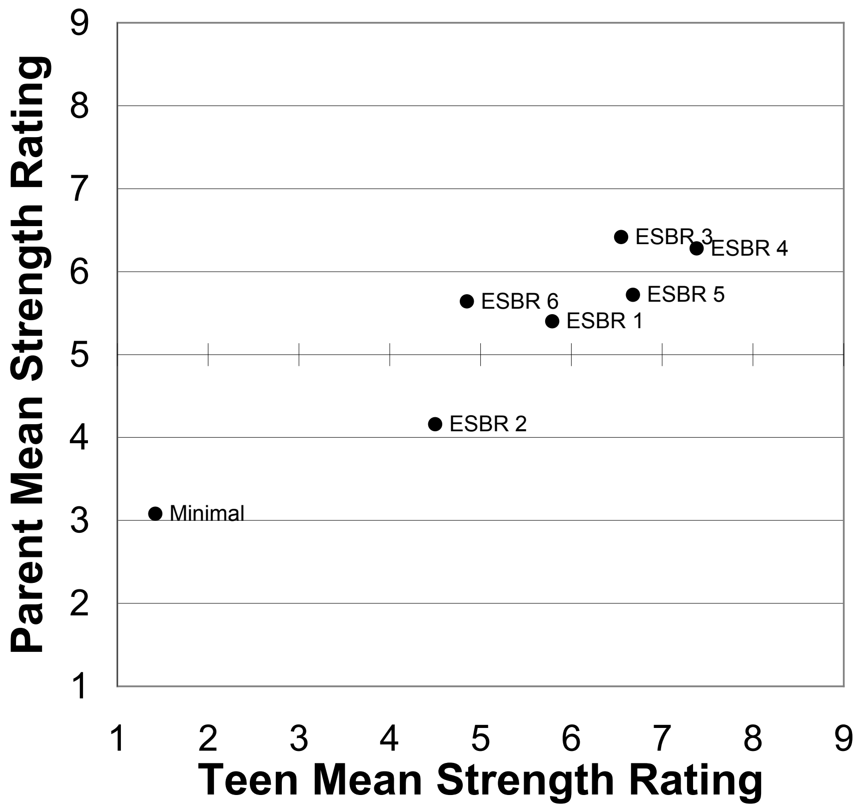


Figure 38. Scatterplot comparing teens' (unbelted group participants) and parents' mean strength appropriateness ratings for each ESBR

4.5.3 Parent Discussion Summary

Seat belt use: Almost all parents in the group discussion sessions considered their teens to be regular seat belt users. Some noted that their teens have grown up always wearing seat belts: "It's like putting on their pants or their shirt to them because they've always done it." Nonetheless, many parents were concerned about their teens' belt use because it is impossible for parents to know for sure whether teens are buckled when they are driving without parents in the car. One participant noted that teens have not established their driving habits, "and they need that extra little push for now until it sinks in." Many parents were most concerned about groups of teens together in the car. Even some parents who were confident in their teen's belt use acknowledged some concern about their teens' seat belt use among groups of friends. Although parents did not express concern about overt peer pressure to not buckle up, they were concerned about a more subtle follow-the-leader effect in which teens take cues from the behavior of others. One parent described the groupthink that occurs when teens get together as "exponential stupidity" and another said that "Teens, especially in cars, are inherently stupid and when they're with friends they get inherently stupider." Parents were also concerned about their teens' friends' belt use, often more so than their own teens' belt use. Many parents were concerned that their teens would not tell friends in the car with them to buckle up.

Seat positions and group dynamics: Parents overwhelmingly wanted ESBRs to provide alerts for all seat positions in a vehicle. This could create positive peer pressure for groups of teens to buckle up: "Teenagers do not like to be singled out … . I think that's a motivator for all teens to play along and buckle up." Each occupant should be able to see and hear alerts. It is especially important for the driver to be informed when passengers are unbuckled because it is difficult for the driver to see if rear seat occupants are buckled. If drivers notice an ESBR alert indicating that passengers are unbuckled, it might help teens to overcome their hesitance to encourage others in the car to buckle: "It would give her more confidence to get the rest of them to buckle up." Some parents thought this would be great for parents as well, so they could easily know whether or not their children are buckled in the back seats. For this reason, parents were strongly in favor of the vehicle overlay icon that showed which occupants in the car were unbelted: "It allows the driver to immediately see who doesn't have their seat belt buckled, because they often feel funny about turning around and checking or asking people … ." Because of its large size and central location, it was visible to all occupants, though some parents noted that the display location might not be visible to all occupants in larger vehicles with three rows of seats. For vehicles without a central display screen, some parents suggested that a smaller, simpler display could be placed on the dashboard for the driver's use.

ESBR timing: Another concern shared by most parents was that the demonstration ESBRs took too long to begin the initial "reminder" and subsequent "motivator" phases and that the gaps between phases were too long. It was a top priority for parents to have their teens buckled before getting on the road because crashes can happen anywhere at any time, and because trying to buckle while moving can be dangerous. Most parents wanted aggressive reminders to begin within a few seconds after the initial reminder or as soon as the vehicle is put in gear: "As soon as you hit the gas pedal something should happen … ." Whereas most of the demonstration ESBRs had gaps of 20 to 30 seconds between reminder phases, participants generally wanted gaps of 10 seconds or less. Some wanted nonstop reminders. To prevent drivers from tuning out nonstop reminders, some parents suggested that the alerts change over time, possibly becoming more aggressive. A few parents disagreed with this assertive approach because they considered their teens to be reliable seat belt users and thought that such aggressive and annoying alerts were unnecessarily harsh and punitive. One parent thought that ESBRs do not need to begin aggressively reminding right away, making an analogy to training an animal: teens will learn that reminder will occur if they don't put on the belts, and put them on to avoid reminders rather than waiting until they occur and reacting to them. Another parent, however, compared ESBR alerts to telling a teen to clean his room: he won't do it if he knows you're only going to tell him once. Some parents who were in favor of aggressive reminders were simultaneously concerned that ESBRs must not go so far as to distract, agitate, or overstimulate drivers. The initial alerts themselves (slow chime) were seen as ineffective because teens are distracted when they get in a car (by friends, checking hair in mirror, cell phone, etc.) and the chime can get lost in the background. Parents also agreed that alerts should continue indefinitely until all occupants are buckled; they should not end after some preset time has elapsed.

B-pillar light and rear view mirror icon: The B-pillar light was generally unpopular. Some parents did not realize that the light was part of the ESBR system. No one realized that the intent was to highlight the belt retractor location, possibly because the location was behind drivers' field of view, though some drivers were aware of it: "I could see something back there but I couldn't tell what it was." Only parents who were in rear seats noticed the light; most assumed it was intended as an ESBR component for rear seat passengers. Some thought that it was effective while others considered it annoying and distracting. A few parents, however, noted that the light would be visible to outside observers and that teens might be motivated to buckle if police could use the light to detect unbuckled occupants. Similarly, there was little enthusiasm for the rear view mirror icon and text. Most parents considered it hard to notice or distracting. One parent liked it because she thought it might get teens' attention if they look at themselves in the mirror.

Auditory alerts: Parents generally preferred the "buckle seat belt" voice message to the chimes. The voice was considered to be authoritative, commanding, and specific, whereas the chimes did not adequately convey urgency or relevance to seat belt use. One parent noted that chimes could relate to many other vehicle conditions, such as door ajar, low fuel, or even a cell phone ring tone. Another noted that the modern environment is so full of chimes and tones that it is easy to tune them out: Bells are too pleasant a sound … . People get accustomed to it." One recommendation was to select a more unique and attention-getting sound that could cut through the auditory clutter. Some parents wanted the tone of the voice to be more aggressive or to identify the seat positions of unbuckled occupants: "If a teen isn't comfortable saying something to the passengers, the car does it for them." One parent, however, thought that the voice alert was too aggressive: "Give me a friendly reminder and then I won't hate the car … . Personally, I wouldn't buy a car like that because I just need to be reminded." One group of parents suggested that voices should be customizable so drivers can select different languages. Some parents were concerned that auditory alerts, and especially the voice, could be drowned out by loud music. A few suggested that the stereo should be muted when auditory alerts play or that the auditory alerts should play at a higher volume.

Visual alerts: Parents generally thought that visual alerts were important components in any seat belt reminder system. Some thought that the seat belt icon on the dashboard is attention-getting, especially when flashing, while others thought that it could easily be ignored or overlooked in the context of all the other things that have teens' attention in a car. Some participants preferred the "buckle seat belt" text instead of the icon because the message is clear and noticeable: "We're all so used to that little symbol [seat belt icon] that it doesn't grab our attention anymore." "It's almost like a command." Parents were not very enthusiastic about the large seat belt icon and text in the center console, but thought that its size and location made it visible to all vehicle occupants. Parents wanted a visual seat belt alert for each seat location. They generally approved of the front seat and rear seat passenger visual alerts in the demonstration vehicle, with some recommendations for improvements. A few parents thought that the text adjacent to the seat belt icons should read "buckle seat belt" instead of "passenger." "It didn't indicate that I wasn't wearing [the seat belt] so I wasn't sure what that was for." Some parents also noted that the rear seat belt visual display should be red instead of green because green indicates "OK" whereas red indicates danger or urgency. Although many found the location of the rear seat visual display sufficiently noticeable, some parents recommended that rear seat visual displays should be located in the backs of the front seat head rests to put them within occupants' line of sight.

Seat vibration: Parents had mixed reactions to the seat vibration. They agreed that it was very noticeable but disagreed on whether it is appropriate as a seat belt reminder. Some felt that haptic alerts could provide another sensory experience to supplement visual and auditory alerts. One parent thought it would be effective for keeping drowsy drivers awake. The majority, however, felt that it was inappropriate because it could be distracting or disorienting to the driver, or because teens might enjoy the vibration and intentionally avoid buckling up to experience it. As an alternative, one parent suggested a system that makes the seat uncomfortable, though it was unclear exactly how this could be done. There was somewhat more interest in using vibration in passenger seats because there was less concern about startling passengers than drivers.

Entertainment system interlock: Parents reacted very enthusiastically to the entertainment system interlock. Many parents were excited when they were first shown the entertainment system interlock and thought that it would be a powerful motivator for seat belt use: “If you cut my son’s music off, he’d probably do anything to get that music to come back on.” Many parents reacted similarly, saying that the first thing teens do when they get in the car is to find a song they like. The entertainment system interlock is also beneficial because it prevents teens from turning up the music volume to drown out auditory ESBR alerts. Given the choice between having the entertainment system cycle on and off or stay off completely, most parents preferred the latter, though a few thought that the cycling entertainment system interlock would provide more incentive for teens to buckle if they knew they were missing a song they want to hear. Some parents, however, noted that a loudly chatting group of teens might not miss the radio very much, and that the entertainment system interlock would be ineffective for deaf teens or in cars with broken radios. Some stubborn teens might also just bring a portable music device into the car. If teens are unaware of the entertainment system interlock, they might just think that the radio is not working correctly, so a link should be made between the entertainment system interlock and seat belt use, possibly using a text message on the dashboard or in the entertainment system’s digital display screen. One parent suggested a dashboard icon showing a music note inside a slashed circle. A few parents wanted a system that would limit speaker volume in the car at all times when a teen is driving. Although the entertainment system interlock was considered to be a very effective ESBR by itself, most parents thought that visual and auditory alerts should be presented simultaneously.

Vehicle ignition interlock: All groups raised the concept of a vehicle ignition interlock or gearshift interlock without any prompt from the moderator. Many parents thought that an interlock that disables the vehicle would be the best system for teens because it guarantees seat belt use. Most would even want such a system on their own cars. Although many parents realized that their regular routine involves starting the car and sometimes backing down a driveway before buckling, they considered changing their behavior to conform with an interlock to be a minor inconvenience for the sake of safety: “I think the advantages would outweigh the disadvantages or the changing of your habits.” Most parents wanted the interlock in effect for all seats in the car. Despite the enthusiasm for interlocks, some parents were concerned about what would happen if occupants unbuckled while the vehicle was in motion, if baggage on seats causes the vehicle to be disabled due to false occupant detections, or if the system fails and the car is unable to start even when seat belts are buckled.

ESBR customization: Participants had mixed opinions about allowing teens to customize or personalize an ESBR system. Some thought it was a good way to get teens to take interest in their safety: “If they can customize it the way that they like it then they would be more willing to go along with the system and see it less as an annoyance and more as an enhancement.” Others thought that customization was an invitation for teens to make ESBRs fun, or at least insufficiently effective at encouraging seat belt use: “Driving in a car is such a dangerous thing that I really don’t care about my kids’ feelings. I would rather have them alive and annoyed than mellow and dead.” Others thought that teens wouldn’t have any interest in customization: “They just want to get in the car and drive.” While some parents saw a parallel with allowing teens to customize their cell phone ring tones and suggested possible hip hop or pop culture themes, other parents were opposed: "This is not your phone, this is not your iPod, this is a serious thing that could kill you." All those in favor of customization stated that there must be limits to customization; allowing teens to play a favorite song as a seat belt reminder would clearly be ineffective: "it has to be the best of the worst [most aggressive]." Some parents acknowledged that the best ESBR for one teen may not be the best for another, so customization could be used by parents to configure the best set of alerts for a particular teen. Popular customization options among parents were having a personalized voice message recorded by a parent that could even identify the driver by name. Parents were very amused by this idea and thought it would be very effective in getting teens to buckle. Other voice ideas included allowing teens to record their own voice message or allowing them to choose a celebrity voice.

Value of ESBRs: Most parents put a high value on having an ESBR for their teen driver, though they couldn't easily name the price that they were willing to pay. Rather, they considered it as just one of many safety features they would look for in a vehicle, along with air bags, antilock brakes, crash ratings, and so forth. Some parents liked the idea of a rating system to identify vehicles with the best ESBRs, but they were skeptical that the benefits of ESBRs could be quantified. Some thought that it would be best to have a base seat belt reminder system and allow parents to select the enhanced features that they wanted for their teens. Some parents, however, noted that many teens get older cars as hand-me-downs and that these cars have older technologies and that they were not purchased with consideration that their child would inherit it years later.

Conclusions: To varying degrees, all parents were in favor of ESBRs for teen drivers. Some parents considered them unnecessary for their own teens who wear their seat belts all the time, but acknowledged the importance for other teens. Most parents who were confident in their teens' belt use still wanted their teen to have an ESBR just for added assurance. On many aspects of ESBRs, two schools of thought emerged. Some parents wanted ESBRs to be maximally annoying to ensure seat belt use and overcome willful seat belt nonuse. Others favored a more moderate approach that balances effectiveness and annoyance. Parents in this latter group tended to be those who were most confident in their teens' seat belt use and thought that their teens only need a reminder in rare cases of forgetfulness. They were also more interested in allowing their teens to customize alerts.

5 Discussion

This section discusses some of the major findings of the research effort. The study employed a wide range of procedures, dependent variables, and independent variables, which precludes a simple summary. However, some key points emerge across these findings and are highlighted here.

There were strong and consistent effects of the ESBR system on ratings of effectiveness in prompting seat belt use and in terms of the annoyance of the alerts. Effectiveness and annoyance were in fact highly correlated. This correlation was seen for all three procedures: simulated drives with complete ESBR systems, brief ESBRs (first 30 to 40 seconds of a system), and individual alerts. No system or feature emerged as dramatically more effective than would be expected based on its annoyance, although some were somewhat better than others in this regard.

The minimal belt reminder system, meeting FMVSS No. 208 requirements but with no enhanced feature, was rated much lower in effectiveness than any other system. It was also the least desirable of all the systems and its display was rated the least appropriate in terms of signal strength. All of the ESBR systems performed substantially better in terms of effectiveness and appropriateness of signal strength than the Minimal system. The remaining systems themselves differed from one another on the various ratings. System 2 was consistently seen as less effective, but also less annoying, than the other enhanced systems. Teens and parents were in general agreement regarding the relative effectiveness and appropriateness of signal strength of the ESBR systems included in this study.

Factors other than the type of ESBR system were typically not statistically significant and rarely interacted with the ESBR system's measures of belt use effectiveness, annoyance, signal strength appropriateness, or desirability. These additional factors included participant gender, driver alone versus with passengers, seat position, group composition, and seat belt condition (unbuckled or buckled). The absence of such effects, and particularly interactions with the ESBR system, simplifies the interpretation of the findings and the implications for system design. In other words, the relative performance of systems or features was approximately the same for teen males and teen females, drivers and passengers, and solo drivers and those with peers present. Therefore, proposed systems that function well for one vehicle occupant should perform well for others.

Overall acceptability of the concept of an enhanced ESBR system was good for both teens and their parents. There was little strong negativity seen among the group of teen participants although it is possible that persistent nonusers of seat belts might be more opposed. All of the participants in this study were at least occasional nonusers of seat belts, but few were consistent nonusers. Parents were favorably disposed toward ESBRs and would welcome them as available safety features.

In the group sessions, some occupants were belted for some trials. In contrast to unbelted participants, who rated how effective the system would be in getting them to buckle up, *belted* participants rated how likely they would be to say something to one of the unbuckled occupants to encourage them to buckle up. Based on this self-report, it appears that well-designed ESBRs can have the desired effect of giving peers an opportunity to encourage others to wear their seat belts. Parents saw this as a likely outcome as well. Social facilitation of proper seat belt use is a key goal, since belt use is lower for groups of teens, and multiple occupants are typical of serious teen crashes.

Considering the individual alerts and the brief ESBR systems, visual displays in general were less effective and less annoying than other modalities. Findings were generally consistent with the findings of the adult-oriented systems investigated in Lerner et al. (2007). ESBR's effectiveness and annoyance were related to signal intensity, temporal aspects, voice urgency, visual display type, and mode. Haptic alerts (seat pan vibration) were seen as most effective. While also rated relatively high in annoyance, it was rated no more annoying than other, less effective alerts. The ESBR system incorporating driver seat vibration was rated as the most desirable system by drivers in the experiment. It may merit further exploration for the ESBR application, particularly if haptic capabilities are made present in vehicles for more general applications. Parents did express some concerns about this mode, including whether it might engender startle effects or whether it might not provide sufficient motivation to buckle.

Voice messages were positively received, despite common concerns about user acceptance. The automobile industry's poor early experience with use of voice messages resulted for some time in a reluctance to consider this mode. The present findings suggest that teen drivers and parents may be more accepting of properly designed voice messages now and these may warrant consideration for the belt reminder application.

The visual display showing a schematic of vehicle occupants and their belt status was well received by teens. Although it was not rated as effective as various reminders using tones or voice, it was quite effective relative to its low annoyance. Teens and parents also felt it would help promote positive interactions to encourage others to buckle up. Console display areas are becoming common in vehicles and could support such displays. A smaller, simplified version of the display could also be included in vehicles without a center console screen.

Most teens and parents were open to the idea of customizable reminders for the initial stage of an ESBR, within reasonable limits. Customized reminders might be salient without being punitive and might also promote awareness of belt use. However, there could be misuse or negative effects and the concept should be carefully explored.

The research methods used in this study were successful in yielding data that were sensitive to ESBR manipulations. Based on feedback from the subjects, the simple simulation was compelling in providing a meaningful driving trip experience. The group procedure appeared successful in achieving the typical sorts of behaviors and interactions seen in teen peer groups. This procedure was developed to address the concern that many experimental procedures used to study teen drivers have excluded the very conditions that typify teen driver crashes (Lerner, 2001). Peer group influence is certainly one of these factors, as teen driver risky behaviors and crash involvement rates have both been shown to increase when teen passengers are present. Although the experimental methods used in this study appeared successful, it should be kept in mind that the measures are subjective and not behavioral. They rely on the subjective report of the participant's judgment of effectiveness during simulated driving, which is presumed to reflect the actual tendency to use the seat belt. The method and findings have not been validated in a field study with operational ESBR systems. Furthermore, the very concept of a teen-oriented ESBR system implies that such a system would be more effective for teens than a system designed for the general driving public, but this was not tested.

6 Recommendations for Teen-Oriented Enhanced Seat Belt Reminder Systems

Based on the findings of the project, a set of preliminary recommendations for ESBRs specifically oriented to teenage drivers and their passengers was developed. The recommendations were drawn primarily from the research conducted under this project (including the simulation-based study of teen driver and passenger response to alternative ESBRs and displays, as well as discussion groups with teens and parents of teens), as well as other findings and recommendations in the literature.

The preliminary recommendations put forth here assume that the vehicle recognizes the presence of a teenage driver, for example through "smart" keys or biometric sensing, or by being designated as a teen-driven vehicle. The particular means of driver recognition is not the concern here. Rather, the issue is that assuming a teen driver is recognized, what features beyond or in place of normal (adult driver-oriented) enhancements should be put in place for teens?

The recommendations describe the features and characteristics that a teen-oriented ESBR system should possess. They take into account both the response of teen drivers and passengers to the ESBR systems and also the attitudes and preferences of parents of teen drivers regarding system features. There is no attempt to design a specific version of such a system as "the" recommended design. The recommendations are described as "preliminary" in that systems with the suggested features have not been field evaluated.

As part of the evaluation of the design recommendations, feedback was sought from the automobile industry. As the ultimate implementers of ESBR systems, they may offer valuable insights on issues such as product compatibility, barriers to implementation, acceptability, and consideration of additional design suggestions. The recommendations were sent to a number of automobile companies with a request for comments.

In Section 6.1 that follows, the recommendations are presented. Section 6.2 then describes how feedback was sought from industry and the industry comments are summarized.

6.1 Preliminary Recommendations

The recommendations are provided in a hierarchical manner. A particular general requirement is followed by more specific recommendations. A brief rationale statement is provided for each recommendation.

Driver specificity: The seat belt reminder system should be able to determine when the vehicle is operated by a novice teen driver.

Rationale: Seat belt reminder system design requires some trade-off of effective motivators of belt use versus intrusiveness, annoyance, and general consumer acceptance. Because they have different crash risk and belt use characteristics, a teenage driver population may generate different optimal design decisions than adult drivers. For purposes of these recommendations, the method of identifying the driver is not important. Possibilities may include smart keys, biometric recognition, or selectable programming of vehicle options by the parent.

Graded alerts: The ESBR system should include two phases in addition to the FMVSS No. 208 requirement. The "reminder" phase should be an effective, but not highly annoying reminder. The subsequent "motivator" phase should be more assertive and motivate belt use.

Rationale: In addition to the required FMVSS No. 208 reminder, two enhanced phases are suggested, which are termed the “reminder phase” and the “motivator” phase. A vehicle occupant can fail to use a seat belt either through oversight or by intent. In order to promote consumer acceptance, reduce annoyance, and limit efforts at defeating the system, the reminder phase should be based on the assumption of unintentional nonuse and designed to make the occupant aware of being unbelted. If that reminder fails to prompt belt use, then the assumption is that the teen is aware and intentionally not using the seat belt. At that point, the feedback must be more assertive in motivating compliance. Some proposed ESBR systems have several “enhanced” stages or graded signals. For teens, it is proposed that there be only two enhanced stages. Parental focus groups indicated that parents want effective action to happen “right away” if their teen is not belted, before the vehicle enters the roadway or reaches higher speeds. Therefore the motivator phase of the system should not build sequentially, but initiate at its optimal level.

Criteria for initiating phases of the ESBR system: The reminder phase, which follows the FMVSS no. 208-required system, should occur about 8 seconds following engine ignition, assuming the vehicle is stationary. The more assertive motivator phase should start no more than 15-20 seconds after engine ignition or as soon as the vehicle exceeds a minimum speed threshold, whichever comes first. The minimum speed threshold should be that at which sustained motion can be reliably confirmed.

Rationale: Data suggest that most drivers who are going to buckle up do so within 8-10 seconds of engine ignition (Malenfant & Van Houten, 2005). Therefore a reminder deferred to about this time will prevent most unnecessary alerts (i.e., the driver was going to buckle up anyway), yet still get the forgetful driver a reminder to buckle up before reaching the speed threshold. Data also suggest that nearly all drivers who have not buckled up within 20 seconds following ignition remain unbelted. That provides a rational trigger point for a more aggressive warning. However, a solely time-based criterion may not be appropriate for teen drivers, since parents feel strongly that they do not want their teens attempting to buckle the seat belt while the vehicle is in motion. Therefore two criteria for initiating a more aggressive phase are suggested: a time-based (15-20 s) criterion and a speed-based criterion. The speed-based criterion should be the minimum speed at which sustained vehicle motion can be reliably confirmed. This minimum speed criterion may be different from that which is appropriate for adult drivers. There may be cases of low-speed (e.g., 5-6 mph) operation for which one would allow the driver to use their discretion about the use of seat belts (e.g., moving the vehicle a short distance in a private parking area, moving the vehicle in a repair lot). However, this does not seem appropriate for novice teen drivers, who lack vehicle control and attention skills and whose activities while traveling at low speeds may be inappropriate.

Subsequent to an initial cycle of the motivator phase, the vehicle should be in motion for the algorithm to continue. Timing should be suspended while the vehicle is stationary and not in forward or reverse gear.

Rationale: It may be appropriate for occupants to be unbelted in a stationary vehicle that is not in forward or reverse gear. Therefore, it would not be desirable for the enhanced reminders to continue subsequent to an initial alert cycle while the vehicle is stopped and not in gear. If the vehicle is in gear but not moving, for purposes of the teen warning algorithm, this should be treated as motion, since the vehicle could begin moving and the occupants should be belted. Even if the vehicle is stationary, the more assertive stage of the system should initiate through one warning cycle, as a reminder, but it should not continue.

Alert levels should not be speed dependent.

Rationale: Some proposed ESBR systems suggest that warning intensity should increase with vehicle speed. However, relative to adults, teens do more of their driving on lower speed roads, where crash risk is typically higher than on high-speed limited access roads and where they often drive too fast for conditions. Furthermore, in general belt use is observed to be lower on low speed local trips and thus adequate motivation to buckle up is particularly required for such trips. Therefore the intensity of the reminder display for teens should be fully provided at all speeds (as long as some minimal speed threshold is not exceeded).

The motivator phase should cycle at a frequency of at least once every 30 seconds (a cycle length or period of at most every 30 seconds), with at least 5 seconds of auditory (signal or voice) alert per cycle.

Rationale: Research both with adult drivers and with teens found that systems with a higher frequency of cycling of auditory alerts (speech or voice) were rated as more effective. The 30 second period appeared quite effective; longer intervals were less effective. Parents of teens have expressed preferences for even shorter intervals. Although visual displays may remain continuous, auditory alerts should be periodic, though relatively frequent.

The motivator phase of the reminder system should continue for as long as the teen driver is unbelted.

Rationale: Some reminder systems intended for the general driving public only continue for a fixed number of cycles. The driver is essentially allowed to "outwait" the system. Teen drivers should not have this option. Furthermore, research indicates that teens reported themselves to be more likely to buckle up when the motivator phase was one that continued indefinitely.

Modality: Visual displays are necessary but not sufficient. Auditory signals (sounds or speech) are essential, particularly for the motivator phase. Haptic alerts may be useful supplements. At this point, it is not known whether haptic stimuli are sufficient to replace auditory signals.

Rationale: Research experiments have found that visual displays are far less effective than auditory signals in promoting belt use, and this clearly is the case for teen occupants. Visual displays are necessary and can contribute to effectiveness, but they are not highly attention getting and do not motivate as strongly as auditory signals. Even systems with continuous flashing visual displays do not appear as effective as systems with moderate periodic auditory signals. Research suggests that seat pan haptic vibration may also be effective, but operational experience is limited.

Auditory signals should take into account the following research findings:

- **Auditory signals are rated as more effective with faster repetition rates and greater sound pressure level. Effectiveness is highly correlated with annoyance.**
- **Voice messages appear comparable in effectiveness, but somewhat less annoying, than other auditory signals (chimes, tones). They were positively received by teens and the parents of teens also liked the voice option, finding it unambiguous and authoritative and unlikely to be confused with other sounds that may be present in the vehicle. Voice messages should be given strong consideration for teen-oriented reminder systems. Voice messages must be audible in the operational environment, which may include multiple teens and infotainment system use at loud levels.**
- **Auditory signals for seat belt reminders should be distinct from and not confusable with other in-vehicle alerts.**

Visual displays should take into account the following research findings:

- **Flashing displays are perceived to be more attention-getting and effective at motivating seat belt use than steady displays**
- **Flashing displays are perceived to be less effective at motivating seat belt use than all but the most moderate auditory signals, but are also less annoying**
- **Center console screens, by virtue of their size and location, are rated as a particularly effective means of presenting visual displays and are seen as desirable by teen drivers.**

Haptic alerts should take into account the following research findings:

- **Teens rated haptic alerts relatively highly for effectiveness and desirability, particularly as used in conjunction with speech messages. The haptic alert used in the research was seat pan vibration, but various other haptic alerts could be considered.**
- **Teens and parents both expressed concern that seat vibration could startle teen drivers. Data are lacking on this issue, but if haptic alerts are used, design consideration should be given to potential startle reactions by drivers, particularly inexperienced ones.**

<u>Passenger Status and Display</u>: A teen-oriented ESBR system should be able to sense the belt use status of passengers in all seat positions. The system should be designed to directly encourage unbelted occupants to buckle up and to encourage belted occupants to speak up to unbelted occupants.

<u>Rationale</u>: Seat belt use is a particular problem when there are multiple teens in the vehicle. Belt use rates are lower with multiple teen passengers yet crash rates are substantially higher with passengers. Teens who are regular belt users when driving by themselves or with adults show less tendency for consistent belt use when in a group. There is also a group dynamic effect, such that if one teen can be encouraged to buckle up, others are more likely to do so as well. However, teens also often show reluctance to speak up, as either a driver or passenger, when others are

unbelted. Therefore an effective teen-oriented belt reminder system should directly inform and motivate unbelted occupants and should encourage speaking up by belted companions. Research results have indicated that both belted and unbelted teen passengers are sensitive to the characteristics of reminder systems in motivating belt use or speaking up to others. Passenger effects on teen drivers depend on the age and relationship of the passengers. Teen peers increase the risk of both belt nonuse and crashes. Adult passengers have crash-reducing effects. In the absence of any ability to sense the age of vehicle occupants, the safety-conservative assumption should be that the other occupants are age-peers.

Unbelted passengers should receive a sustained flashing visual display.

Rationale: The signal to an unbelted passenger should be obtrusive enough to motivate belt use. A flashing light is far more effective than a steady visual display. The flashing display should not be directly visible to the driver and auditory signals for passengers are not encouraged. If a passenger-directed flashing or auditory signal is perceptible to drivers, passenger displays might be overly annoying or distracting to inexperienced teen drivers, given that they might not be able to control the passenger's belt use or that the signal might be a false alarm due to cargo, pets, etc. Therefore, a flashing display directed specifically at the passenger appears the most appropriate means of communicating to the passenger.

Passenger belt status should be visually displayed to the driver.

Rationale: Status displays that inform the driver about unbelted passengers were highly rated by both teens and parents. It allows the teen driver to be aware of passenger belt status without the socially uncomfortable or distracting need to turn around and check on their peers. A display that identifies the seating location of each unbuckled occupant is ideal, but a display that simply denotes the presence of an unbuckled occupant without denoting the location is sufficient. Both teens and parents liked iconic vehicle displays on a large center console, since it is both highly visible and compelling.

The presence of any unbelted occupant should provide some periodic signal that is perceptible to all occupants.

Rationale: One of the important functions of a teen-oriented ESBR is to foster a situation that reduces the social inhibitions about asking peers to put on their seat belts. The presence of some recurring signal provides an excuse to intervene. If the driver is the unbelted occupant, all of the passengers will hear the auditory signal, thus meeting this requirement. If the driver is belted but one or more passengers are not, the design issue is more complex, because an overly aggressive system may distract or disturb an inexperienced driver, who has no direct control of the situation. One option is to periodically or continuously flash the seat position icon on a console display. Another possibility is to periodically provide a voice message or moderate auditory signal. The key factor is to produce a signal that is salient enough to provide an excuse for speaking up, without making it so intense that it provides a source of distraction in the vehicle.

Vehicle adaptation: If a teen driver is not belted, aspects of vehicle performance may be modified, through lock-outs or limiters.

Rationale: Vehicle adaptation strategies that may be too restrictive for the general consumer population may nonetheless be appropriate for the high-risk teen group that has questionable risk decision making skills. Vehicle functions or performance attributes may be altered, either as motivation for the teen to buckle up or to preclude risky driving situations. Research indicates that teens see infotainment system lockouts or restraints (e.g., sound level limiter) as effective motivators to buckle up and parents likewise view these as potentially quite effective. While this strategy appears likely to contribute to a system's effectiveness, there is a possibility that it could promote the use of nomadic personal communication devices (e.g., media players) which may not be well designed for use while driving, particularly by novices. Another vehicle adaptation strategy that has been suggested is a speed limiter. However, there is a question of whether this might interfere with potential emergency maneuvers. Further, if speed limiters are appropriate for teen drivers, this would seem to be desirable independently of whether the teen is belted or not. Evidence suggests that ignition interlocks can be effective in increasing seat belt use rates, though a variety of consumer acceptance and legal concerns have prevented vehicle manufacturers from providing them on vehicles (Transportation Research Board, 2003). Gear shift delays, if of adequate length, have been demonstrated to be effective in promoting adult belt use (Van Houten, Malenfant, Reagan, Sifrit, & Compton, 2009) and may be appropriate for teens. If a driver is unbelted, the vehicle will not shift from Park into Drive or Reverse for some fixed delay interval. If this interval is long relative to the time it takes to engage a seat belt (e.g., 15 to 20 seconds), then it is likely to encourage belt use.

> **An indicator display should be continuously presented if a vehicle feature has been locked out or limited. The display should indicate both the feature that has been altered and that seat belt use is required to restore the function.**
>
> Rationale: Drivers should be informed when a vehicle feature has been locked out or modified and should be aware that seat belt use is required to restore normal function. This information must be conveyed to reduce potential driver confusion and distraction in trying to restore function. It will also provide a clear motivation for buckling up.

Customization: There may be a driver-selectable or adult-selectable component to the reminder phase of the ESBR system, but not the features of the subsequent motivator phase.

Rationale: The purpose of the reminder phase of an ESBR system is to catch the attention of unbelted occupants and remind them to buckle up. It should be minimally annoying and minimally intrusive. A majority of adult and teen research participants expressed interest in the concept of driver-selectable (or parent selectable) sounds (within constraints) for the reminder phase of the system. These may be highly salient for individuals, but not excessively annoying, and thus serve as effective reminders. Selectable sounds, however, should not be permitted for the motivator phase, where motivational aspects are paramount. The concept of customizable reminders, however, has not been evaluated in practice and could potentially conflict with efforts to promote recognition of alerts across vehicles and drivers. Driver-selectable aspects of the reminder phase is put forth here as a feature to consider, but not as a specific recommendation, given the absence of evaluation.

6.2 *Automotive Industry Feedback*

6.2.1 Solicitation of Industry Comments

A request for comment on the recommendations was sent to nine major automobile manufacturers. The request document provided a brief overview of the purpose of the project and some background information. It then provided the set of recommendations, followed by a questionnaire. The request acknowledged that there may be proprietary concerns or other considerations that limit responses to some items and that the researchers appreciate whatever opinion and insight the respondent was able to provide. It was also indicated that there would be no attribution of individual comments. Reviewer opinions were to be integrated and synthesized for reporting.

The questionnaire consisted of the following nine questions:

1. Would a teen-oriented seat belt reminder system be of interest in your company? What considerations might enhance company interest in pursuing this further?
2. Do you believe a system incorporating some or all of the recommendations made here would be effective in promoting teen driver and passenger seat belt use? Would it be more effective than more typical enhanced reminder systems designed for the broader driving public?
3. We are interested in your opinion of the specific recommendations made for the teen-oriented system? For each, please indicate whether you agree or disagree with the recommendation. If you disagree, please explain why.
    - Driver specificity
    - Two-phase graded alerts (reminder phase and motivator phase)
        - Criteria for phasing
        - Requirement for vehicle motion
        - Alert levels not speed dependent
        - Motivator phase cycle length
        - Continuous cycling of motivator phase
    - Display modality
    - Passenger status and display
        - Display for unbelted passengers
        - Driver visual display of passenger belt status
        - Perceptible signal to all occupants
    - Vehicle adaptation
        - Indicator display for vehicle adaptation
    - Reminder phase customization

4. We are interested in the compatibility of these recommendations with your product line and plans. Please indicate any aspects that may present particular problems. For any such problems, can you offer a more compatible approach?
5. Are there aspects of any of the recommendations that you consider impractical? For each that may be impractical, please explain why.
6. Do you see any significant implementation r barriers to teen-oriented seat belt reminder systems in general or to any recommended system features in particular?
7. Do you recommend any further steps that the National Highway Traffic Safety Administration should take that would promote more effective reminder systems for teens or encourage further interest by industry?
8. Do you recommend any further steps that the National Highway Traffic Safety Administration should take to encourage further interest by industry in effective reminder systems for teens?
9. Are there any additional comments or suggestions you would like to make?

6.2.2 Synthesis of Feedback

Responses were received from seven of the nine companies contacted. The replies ranged from extensive commentary and responses to each question to more general comments and response to only some selected items. A number of the comments were descriptions of the particular company's current ESBR features, rather than comments on the recommendations or explicit points regarding differences in approach. In summarizing the comments, specific current product descriptions were omitted unless they directly addressed a design issue. In synthesizing the responses, the comments were paraphrased and any references to the company were deleted. No attribution of comments to individuals or companies is provided. Industry feedback did not lead to any changed to the set of recommendations.

General Concept of a Teen-Oriented ESBR

Regarding the general concept of a teen-oriented seat belt reminder system, four respondents indicated that they thought it was a good idea or a potentially good idea that deserved more exploration. Several respondents pointed to the Ford MyKey system as an interesting example. However, two respondents were not in favor of the concept. The arguments were: (1) unique approaches for different age groups would create complexities; (2) systems designed for one target group might be too intrusive for others and cause user acceptance problems; (3) all occupants deserve benefit from seat belt systems equally; (4) loss of life to a non-teen occupant that had not been reminded to wear a seat belt would be unacceptable in terms of risk management and respect for individual customers; (5) teens may feel that they are being unreasonably and unfairly targeted and may react negatively and find ways to circumvent the system.

In response, it should be clarified that the approach suggested here is not that there should be an enhanced system for teens but not others, but rather that the optimal features of an enhanced system may be different for teens, compared to the general population. It is also acknowledged that there is a need to empirically determine the benefits of such a system and whether they are substantially better than that from a system designed for the general population, in terms of belt use and system defeat.

Driver Specificity

It is a premise of the recommendations that there exists some means of determining when a teen driver is operating the vehicle. The means of doing this is not part of the recommendations, but it is assumed that there are reasonable means of implementing this. Several of the respondents pointed to the Ford MyKey system as an example that this is a realistic assumption. However, it was also noted that this "recognition" is based on a parent-controlled "teen key" that is programmed through a set up menu. There is no verification of the driver in a biometric sense. Also, in the future smart-card driver's licenses could indicate whether the driver is a novice, though again, some drivers might use others' licenses and there is currently no available means of verification.

Two-phase Graded Alerts

There was general support for a graded alert and several respondents indicated their companies were doing this (though not necessarily in the same manner as proposed). One respondent indicated that while the idea of the graded alert seems reasonable, the recommendation should not be based on research results without being studied in actual vehicles. Another respondent, pointing out that the suggested strategy was "complex," pointed to their need to review the data collected in this study (the information packet sent to the OEM's did not include the detailed methods and findings of the research portions of the project).

Some respondents pointed out that their systems have a minimum speed threshold (though not precisely that provided in the recommendations), although one respondent expressed a concern that if the system does not operate at low speeds, the driver might interpret this as indicating it is OK to be unbuckled at low speeds. However, the same respondent noted that they get "a lot of complaints" about the ESBR system, particularly for low speed (or zero speed) events, such as getting out of the vehicle in a driveway to pick up the mail, then having the system activate when they get back in the vehicle.

Display Modality

One respondent was concerned that teens would turn up the audio system to drown out the motivator phase signal. They suggested that the phase focus on audio mute instead of haptic or visual warning. Three respondents questioned the option of a haptic supplement to the auditory signal. Two disliked it because it was not shared with passengers (peer effect) while the other felt that there was no experimental support for haptic belt reminder alerts and that haptic alerts are best reserved for other safety-critical purposes. Also related to this, another respondent suggested that careful research be done to compare the effectiveness of different modalities, separately and in combination.

One respondent questioned the option of voice messages, citing the poor acceptance of voice messages in the 1980s. This respondent indicated that there was no problem of confusion of belt reminder signals with their other in-vehicle alerts and that the message center text conveys a specific message. However, it should be noted that voice is only suggested as a teen-specific option for the motivational stage, and that there are findings from the experimental portion of this project that suggest it may be effective for the teen occupant population. Given the history of automotive consumer experience with voice messages (even though dated), the respondent's caveat is important to consider and voice probably should be used cautiously without further assessment.

One respondent also pointed out that their company uses a different cycle/frequency of the alert, which they feel is the right balance between effectiveness and annoyance and differs from the example in the recommendations. The parameters presented in the recommendations appear reasonable based on the experimental findings but there is no intended suggestion that they are the only, or even the optimal, possibilities. The important point is establishing an appropriate balance for the teen driver and passenger situation.

Passenger Status and Display

Three respondents mentioned the difficulties of sensing rear seat passengers. One cited the problems of false alarms currently suffered (mainly due to cargo) with just the front passenger seat. Another pointed to the "significant costs" of buckle sensing and wiring and of occupant sensing. The estimate is that this would add about $45 to $80 of cost per vehicle for a traditional 2-row vehicle and $80 to $100 for a 3-row vehicle. Given these issues, the respondent raised the question of how much additional benefit there would be to rear seat systems, assuming there was an enhanced front seat passenger system. They speculated that the social dynamics of getting the front passenger to buckle up might promote belt use in the rear seat passengers.

One respondent, commenting on the recommendation of a flashing visual display for rear seat passengers, stated that the auditory modality is primary, and that visual displays are secondary and for driver information only (not for the passenger).

One respondent considered the recommendation that the driver have a visual display of passenger belt status to be "necessary" and pointed out that it was standard equipment on their current passenger vehicles.

One respondent stated that an audio system mute strategy (as opposed to an audio signal) is also perceptible to all vehicle occupants.

Vehicle Adaptation

Several respondents pointed to Ford's MyKey system as already providing an example of vehicle adaptation, through muting of the audio system. One respondent was negative about infotainment limitations imposed because of seat belt nonuse. They argued that this might encourage the use of nomadic devices, which they felt should be especially discouraged for drivers in the "habit-forming early stages of learning to drive." They also felt it might imply to the driver that "it is OK not to wear your seat belt as long as you are not distracted by the radio." They also suggested that the driver may feel "compelled" to switch on the radio whenever the system becomes available.

There were clear concerns about the use of lock-out mechanisms or vehicle adaptations that might limit vehicle performance in some way, raised by several respondents. There may be security or health-related emergencies where the driver is unable to fasten the seat belt but needs optimal vehicle performance. For example, if a teenager walking to their car in a parking lot feels threatened, they will want to get in their car and drive away quickly, but a gear lock-out might cause them to panic and prevent a quick escape. Other concerns expressed about performance limitations include: the need to access and modify the vehicle engine control unit might be difficult and introduce unnecessary risks; there may be issues of user acceptance; there may be additional failure modes and unintended consequences; if speed is limited by a speed controller, some may take the implication that it is OK to speed as long as you are wearing a seat belt or that its only necessary to wear a seat belt if you are speeding.

Most of the concerns raised here were also raised in the rationale section of the recommendation itself. The recommendation suggested only that vehicle adaptation may be considered. The perceptions about safety concerns with performance-limiting adaptations has been raised in focus group discussions and appears to be a user concern. Infotainment system lock-outs or volume limiters appear to be more acceptable and less of a safety issue, although the question of nomadic device use needs to be explored further.

<u>Reminder Phase Customization</u>

Although we anticipated considerable response to the suggestion of customization, only two respondents commented on this. One indicated that the idea seems "OK" as long as the flexibility to customize is within reason – it cannot be completely open. The comment from the other respondent was that customization "incorporates inherent risks and side effects." They cite as an example that "it is not always possible to positively identify a certain driver, either due to key sharing or other factors. This means that a customized warning that has been disabled for one driver may fail to reach its intended target. Worse, a driver who has become dependent on a certain threshold of seat belt reminder to fasten their seat belt may fail to buckle up without that level of reminder." It appears from this comment that the respondent viewed the customization as potentially involving the criteria for providing the warning, and the point is well taken if that is the case. However, it is less clear that this concern applies to the case of customizing the warning sound itself, which was the basic suggestion.

<u>Practicality, Compatibility, and Barriers to Implementation</u>

A number of respondents indicated that their companies already employ some of the recommendations in their ESBR systems and that there are few challenges posed by the recommendations. Occupant detection for the rear seat was raised as an issue by three respondents.

Several respondents pointed to lock-outs and vehicle adaptation approaches that limit vehicle performance. The concerns were with safety or health emergency situations, user acceptance, failure modes, and unintended consequences on behavior. One respondent raised recognition of a teen driver as a practical concern.

<u>Suggested NHTSA Activity</u>

One recommendation was that NHTSA publish and widely circulate the teen-oriented ESBR recommendations. Another recommendation was that NHTSA encourage OEMs to share ESBR strategies. Another recommendation was for an empirical evaluation of various ESBRs, which would provide clear answers to the outstanding questions. Another cited the effectiveness of Euro-NCAP in encouraging enhanced reminder systems.

<u>Other Comments</u>

One respondent argued that improved seat belt usage is ultimately a behavioral issue, not an engineering issue. More generally, several respondents discussed other approaches to improving belt use. Occupant behavior must be modified and adapted. Two respondents emphasized the need for more aggressive enforcement (including the provision of primary seat belt laws) and enhanced driver education for teens (and others). There were also suggestions of the need for better parental behaviors, ticketing the driver for passenger nonuse of seat belts, "graphic movies" shown in school classes, and public service announcements by teen models.

Another comment was that belt systems vary by manufacturer and that there is no one best way to implement them.

Several respondents pointed to the apparent success of their company's ESBR systems, although none of these specifically discussed teens' use.

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Appendix A: Experimental Teen ESBR System Specifications

This appendix describes the displays and timing of each seat belt reminder system presented to teens. Each row in a table represents one stage of system presentation. The duration of each stage is stated along with the cumulative duration since system activation. Individual display elements are described in Table 2 and Table 3 of this report. "CC" refers to the center console display. "BP" refers to the B-pillar light. Flashing visual displays flash at a rate of 3 Hz unless otherwise specified. The timing of the systems begins with vehicle "ignition," which in this study was simulated by participants turning the car key to the Start position without actually triggering ignition.

Practice System

Duration	Driver Displays	Front Passenger Displays	Rear Icon/Text
6s	chime, steady icon	chime, steady icon	none
14s (20s)	steady icon	steady icon	none
2s (22s)	fast chime, flashing icon	fast chime, flashing icon	none
20s (42s)	steady icon	steady icon	none
2s (44s)	fast chime, flashing icon	fast chime, flashing icon	none
20s (64s)	steady icon	steady icon	none
2s (66s)	fast chime, flashing icon	fast chime, flashing icon	none
20s (86s)	steady icon	steady icon	none
2s (88s)	fast chime, flashing icon	fast chime, flashing icon	none
20s (108s)	steady icon	steady icon	none
2s (110s)	fast chime, flashing icon	fast chime, flashing icon	none
20s (130s)	steady icon	steady icon	none

Basic System

Duration	Driver Displays	Passenger Displays
6s	chime, flashing icon	none
54s (60s)	steady icon	none
120s (180s)	none	none

ESBR 1

Duration	Driver Displays	Front Passenger Displays	Rear Icon/Text
6s	chime, steady icon	chime, steady icon	steady
10s (16s)	flashing icon, steady CC icon	steady icon	steady
2s (18s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
20s (38s)	flashing icon, steady CC icon	steady icon	steady
4s (42s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
20s (62s)	flashing icon, steady CC icon	steady icon	steady
4s (66s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
20s (86s)	flashing icon, steady CC icon	steady icon	steady
4s (90s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
20s (110s)	flashing icon, steady CC icon	steady icon	steady
4s (114s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
20s (134s)	flashing icon, steady CC icon	steady icon	steady
4s (138s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
20s (158s)	flashing icon, steady CC icon	steady icon	steady
4s (162s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
20s (172s)	flashing icon, steady CC icon	steady icon	steady
4s (176s)	fast chime, flashing icon, steady CC icon	fast chime, flashing icon	steady
6s (182s)	flashing icon, steady CC icon	steady icon	steady

ESBR 2

Duration	Driver Displays	Front Passenger Displays	Rear Icon/Text
6s	chime, steady icon	chime, steady icon	steady
50s (56s)	steady icon	steady icon	steady
6s (62s)	fast chime, flashing icon	fast chime, flashing icon	steady
25s (87s)	steady icon	steady icon	steady
6s (93s)	fast chime, flashing icon	fast chime, flashing icon	steady
25s (118s)	steady icon	steady icon	steady
6s (124s)	fast chime, flashing icon	fast chime, flashing icon	steady
25s (149s)	steady icon	steady icon	steady
6s (155s)	fast chime, flashing icon	fast chime, flashing icon	steady
25s (180s)	steady icon	steady icon	steady
6s (186s)	fast chime, flashing icon	fast chime, flashing icon	steady
14s (200s)	steady icon	steady icon	steady

ESBR 3

Duration	Driver Displays	Front Passenger Displays	Rear Icon/Text
6s	slow-to-fast chime, steady icon	slow-to-fast chime, flashing icon (1Hz)	steady
14s (20s)	steady icon	flashing icon (1Hz)	steady
2s (22s)	loud polite voice, steady icon, steady CC icon	polite voice, flashing icon (1Hz)	steady
10s (32s)	steady icon, steady CC	flashing icon (1Hz)	steady
2s (34s)	loud polite voice, steady icon, steady CC icon	polite voice, flashing icon (1Hz)	steady
10s (44s)	steady icon, steady CC	flashing icon (1Hz)	steady
2s (46s)	loud polite voice, steady icon, steady CC icon	polite voice, flashing icon (1Hz)	steady
10s (56s)	steady icon, steady CC	flashing icon (1Hz)	steady
2s (58s)	loud polite voice, steady icon, steady CC icon	polite voice, flashing icon (1Hz)	steady
10s (68s)	steady icon, steady CC	flashing icon (1Hz)	steady
2s (70s)	loud polite voice, steady icon, steady CC icon	polite voice, flashing icon (1Hz)	steady
10s (80s)	steady icon, steady CC	flashing icon (1Hz)	steady
2s (82s)	loud polite voice, steady icon, steady CC icon	polite voice, flashing icon (1Hz)	steady
10s (92s)	steady icon, steady CC icon	flashing icon (1Hz)	steady
90s (182s)	practice sound (2.5s on / 2.5s off), steady icon, flashing CC icon	practice sound (2.5s on / 2.5s off), flashing icon (3Hz)	steady

ESBR 4

Duration	Driver Displays	Front Passenger Displays	Rear Icon/Text
6s	slow-to-fast chime, steady icon, steady CC icon, steady mirror	slow-to-fast chime, flashing icon	steady
20s (26s)	steady icon, steady CC icon, steady mirror	flashing icon	steady
6s (32s)	fast chime, flashing icon, flashing CC icon, flashing BP, steady mirror	fast chime, flashing icon	flashing
20s (52s)	steady icon, steady CC icon, steady mirror	flashing icon	steady
6s (58s)	fast chime, flashing icon, flashing CC icon, flashing BP, steady mirror	fast chime, flashing icon	flashing
20s (78s)	steady icon, steady CC icon, steady mirror	flashing icon	steady
6s (84s)	fast chime, flashing icon, flashing CC icon, flashing BP, steady mirror	fast chime, flashing icon	flashing
20s (104s)	steady icon, steady CC icon, steady mirror	flashing icon	steady
6s (110s)	fast chime, flashing icon, flashing CC icon, flashing BP, steady mirror	fast chime, flashing icon	flashing
20s (130s)	steady icon, steady CC icon, steady mirror	flashing icon	steady
6s (136s)	fast chime, flashing icon, flashing CC icon, flashing BP, steady mirror	fast chime, flashing icon	flashing
20s (156s)	steady icon, steady CC icon, steady mirror	flashing icon	steady
6s (162s)	fast chime, flashing icon, flashing CC icon, flashing BP, steady mirror	fast chime, flashing icon	flashing
20s (182s)	steady icon, steady CC icon, steady mirror	flashing icon	steady
6s (188s)	fast chime, flashing icon, flashing CC icon, flashing BP, steady mirror	fast chime, flashing icon	flashing
end	steady icon, steady CC icon, steady mirror	flashing icon	steady

ESBR 5

Duration	Driver Displays	Front Passenger Displays	Rear Icon/Text
6s	chime, steady icon	chime, steady icon	steady
14 s (20s)	steady icon	steady icon	steady
4s (24s)	vibe(1s) / polite voice(2s) / vibe(1s), flashing icon, steady CC icon	polite voice, flashing icon	steady
20s (44s)	steady icon	steady icon	steady
4s (48s)	vibe(1s) / polite voice(2s) / vibe(1s), flashing icon, steady CC icon	polite voice, flashing icon	steady
20s (68s)	steady icon	steady icon	steady
4s (72s)	vibe(1s) / polite voice(2s) / vibe(1s), flashing icon, steady CC icon	polite voice, flashing icon	steady
20s (92s)	steady icon	steady icon	steady
4s (96s)	vibe(1s) / polite voice(2s) / vibe(1s), flashing icon, steady CC icon	polite voice, flashing icon	steady
20s (116s)	steady icon	steady icon	steady
4s (120s)	vibe(1s) / polite voice(2s) / vibe(1s), flashing icon, steady CC icon	polite voice, flashing icon	steady
20s (140s)	steady icon	steady icon	steady
4s (144s)	vibe(1s) / polite voice(2s) / vibe(1s), flashing icon, steady CC icon	polite voice, flashing icon	steady
20s (164s)	steady icon	steady icon	steady
4s (168s)	vibe(1s) / polite voice(2s) / vibe(1s), flashing icon, steady CC icon	polite voice, flashing icon	steady
20s (188s)	steady icon	steady icon	steady

ESBR 6

Duration	Driver Displays	Front Passenger Displays	Rear Icon/Text
6s	chime, steady icon, steady BP	chime, steady icon	steady
14s (20s)	steady icon, steady CC seating chart, steady BP	steady icon	steady
2s (22s)	polite voice, flashing icon, steady CC seating chart, flashing BP	polite voice, flashing icon	flashing
20s (42s)	steady icon, steady CC seating chart, steady BP	steady icon	steady
2s (44s)	polite voice, flashing icon, steady CC seating chart, flashing BP	polite voice, flashing icon	flashing
20s (64s)	steady icon, steady CC seating chart, steady BP	steady icon	steady
6s (70s)	sound-voice-sound, flashing icon, flashing CC seating chart, flashing BP	sound-voice-sound, flashing icon	flashing
20s (90s)	steady icon, steady CC seating chart, steady BP	steady icon	steady
6s (96s)	sound-voice-sound, flashing icon, flashing CC seating chart, flashing BP	sound-voice-sound, flashing icon	flashing
20s (116s)	steady icon, steady CC seating chart, steady BP	steady icon	steady
6s (122s)	sound-voice-sound, flashing icon, flashing CC seating chart, flashing BP	sound-voice-sound, flashing icon	flashing
20s (144s)	steady icon, steady CC seating chart, steady BP	steady icon	steady
6s (150s)	sound-voice-sound, flashing icon, flashing CC seating chart, flashing BP	sound-voice-sound, flashing icon	flashing
20s (170s)	steady icon, steady CC seating chart, steady BP	steady icon	steady
6s (176s)	sound-voice-sound, flashing icon, flashing CC seating chart, flashing BP	sound-voice-sound, flashing icon	flashing
6s (182s)	steady icon, steady CC seating chart, steady BP	steady icon	steady

Appendix B: Brief ESBR Specifications

This appendix describes the displays and timing of each brief ESBR presented to teens. Each row in a table represents one stage of system presentation. The duration of each stage is stated along with the cumulative duration since system activation. Individual display elements are described in Table 2 and Table 3 of this report. "CC" refers to the center console display. "BP" refers to the B-pillar light. "High" refers to the high intensity (brightness or volume). Flashing visual displays flash at a rate of 3 Hz unless otherwise specified. Brief ESBRs did not include any passenger displays.

Brief 1

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
24s (30s)	steady icon	none	none

Brief 2

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
10s (16s)	steady icon	none	none
10s (26s)	flashing icon	none	none
10s (36s)	flashing icon (bright)	none	none

Brief 3

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
6s (12s)	flashing icon (1 Hz)	none	none
6s (18s)	flashing icon (1 Hz) (high)	fast chime	none
6s (24s)	flashing icon/text	none	none
6s (30s)	flashing icon/text (high)	fast chime (high)	none
6s (36s)	flashing icon/text (high)	none	flashing icon/text

Brief 4

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
14s (20s)	steady icon	none	none
2s (22s)	flashing icon	fast chime	none
2s (24s)	steady icon	none	none
2s (26s)	flashing icon	fast chime	none
2s (28s)	steady icon	none	none
2s (30s)	flashing icon	fast chime	none
2s (32s)	steady icon	none	none

Brief 5

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
10s (16s)	steady icon	none	none
2s (18s)	flashing icon	fast chime	none
10s (28s)	steady icon	none	none
4s (32s)	flashing icon	fast chime	none
4s (36s)	steady icon	none	none

Brief 6

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
2s (8s)	steady icon	none	none
2s (10s)	flashing icon	fast chime	none
10s (20s)	flashing icon (1 Hz)	none	none
6s (26s)	flashing icon	fast chime	none
6s (32s)	flashing icon (1 Hz)	none	none

Brief 7

Duration	Visual	Auditory	CC, Vibe
6s	steady icon, BP light	slow chime (BP)	none
14s (20s	steady icon, BP light	none	none
6s (26s)	flashing icon, flashing BP light	fast chime (BP)	none
6s (32s)	steady icon, BP light	none	none

Brief 8

Duration	Visual	Auditory	CC, Vibe
6s	steady icon, BP light	slow chime (BP)	none
9s (15s)	steady icon, BP light	none	none
5s (20s)	flashing icon, flashing BP light	buckle driver male voice (BP)	none
5s (25s)	flashing icon, flashing BP light	buckle driver male voice (BP)	none
5s (30s)	flashing icon, flashing BP light	buckle driver male voice (BP)	none

Brief 9

Duration	Visual	Auditory	CC, Vibe
2s	steady icon	none	none
2s (4s)	steady icon	buckle polite voice	none
10s (14s)	steady icon	none	none
2s (16s)	flashing icon	buckle polite voice	none
3s (19s)	steady icon	none	none
2s (21s)	flashing icon	buckle polite voice	none
3s (24s)	steady icon	none	none
2s (26s)	flashing icon	buckle polite voice	none
3s (29s)	steady icon	none	none
2s (31s)	flashing icon	buckle polite voice	none
3s (34s)	steady icon	none	none

Brief 10

Duration	Visual	Auditory	CC, Vibe
2s	steady icon	none	none
2s (4s)	flashing icon	buckle polite voice	none
10s (14s)	steady icon	none	none
1s (15s)	steady icon	none	vibe (steady)
2s (17s)	flashing icon	buckle polite voice	none
3s (20s)	steady icon	none	none
1s (21s)	steady icon	none	vibe (steady)
2s (23s)	flashing icon	buckle polite voice	none
3s (26s)	steady icon	none	none
1s (27s)	steady icon	none	vibe (steady)
2s (29s)	flashing icon	buckle polite voice	none
3s (32s)	steady icon	none	none

Brief 11

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
10s (16s)	flashing icon	none	steady icon/text
6s (22s)	flashing icon (bright)	fast chime (high)	steady icon/text
10s (32s)	flashing icon (1 Hz)	none	none
6s (38s)	flashing icon (1 Hz)	fast chime	none

Brief 12

Duration	Visual	Auditory	CC, Vibe
6s	steady icon	slow chime	none
10s (16s)	none	none	none
3s (19s)	flashing icon (bright)	none	steady icon/text, vibe (1Hz)
10s (29s)	none	none	steady CC
3s (32s)	flashing icon (bright)	none	steady icon/text, vibe (1Hz)

Appendix C: Closing Questions

Seat belt use by teen drivers and passengers has become a special concern. Teens have a much higher rate of crashes than other drivers and more than 60 percent of teens killed or injured in crashes were not wearing their seat belts. For these reasons, some safety groups have argued that more aggressive seat belt reminder systems should be used for inexperienced 16- and 17-year-old drivers. The vehicle would have to recognize who is driving, but this is possible through special car keys and other new technologies that can identify individual drivers. What do you think of the idea of special reminder systems only for teens with limited driving experience? What would you think about having one in your own car? Please explain your opinions.

Describe what you think would be the very best seat belt reminder system for when a teen driver does not buckle up. Your idea can be a variation on something you experienced during this study or an idea of your own. Please specify what sort of sounds or visual displays the system should have and how/when they should be presented.

What do you think of the idea of letting people customize their reminder sound, in the same way people can customize the ring of their cell phones? If this were an option, what sort of sound do you think you might select?

Appendix D: Results of Analyses of Variance

Driver only (drive ratings)—annoyance ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	2	45	1.79	0.1786
Sex_num	1	45	0.79	0.3779
System	5	225	50.84	<.0001
Sex_num*Occupant	2	45	0.54	0.5880
System*Occupant	10	225	1.09	0.3692
System*Sex_num	5	225	1.31	0.2624

Driver only (drive ratings)—effectiveness ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	2	45	0.12	0.8847
Sex_num	1	45	0.18	0.6764
System	5	225	77.10	<.0001
Sex_num*Occupant	2	45	0.30	0.7413
System*Occupant	10	225	1.59	0.1099
System*Sex_num	5	225	0.59	0.7068

Driver only (drive ratings)—strength appropriateness ratings (mean absolute deviation)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	2	45	0.10	0.9081
Sex_num	1	45	1.28	0.2632
System	5	225	16.91	<.0001
Sex_num*Occupant	2	45	0.25	0.7833
System*Occupant	10	225	1.05	0.4007
System*Sex_num	5	225	0.70	0.6259

Driver only (post-drive ratings)—desirability ratings

Type 3 Tests of Fixed Effects

Num Den

Effect	DF	DF	F Value	Pr > F
Occupant	2	38.5	0.21	0.8095
Sex_num	1	36.2	0.24	0.6267
System	5	303	6.24	<.0001
Sex_num*Occupant	2	38.5	0.56	0.5750
Occupant*System	10	303	0.92	0.5155
Sex_num*System	5	303	1.34	0.2488

Driver only (post-drive ratings)—effectiveness ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	2	43.2	0.30	0.7432
Sex_num	1	42.4	0.94	0.3390
System	5	303	81.07	<.0001
Sex_num*Occupant	2	43.2	1.31	0.2812
Occupant*System	10	303	1.07	0.3850
Sex_num*System	5	303	0.64	0.6672

Group (drive ratings unbelted)—annoyance ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	63.3	4.92	0.0301
Sex_num	1	63.3	0.12	0.7291
System_belt	6	326	96.79	<.0001
seatposition	2	62.1	2.52	0.0888
Sex_num*Occupant	1	71.9	1.29	0.2602
System_belt*Occupant	6	326	2.49	0.0227
Occupant*seatposition	2	62.1	0.49	0.6172
System_belt*Sex_num	6	326	1.53	0.1686
Sex_num*seatposition	2	62.1	0.96	0.3867
System_be*seatposition	10	326	3.35	0.0004

Group (drive ratings unbelted)—effectiveness

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	61.3	1.07	0.3054
Sex_num	1	61.3	4.12	0.0468
System_belt	6	326	95.07	<.0001
seatposition	2	60.8	2.52	0.0888
Sex_num*Occupant	1	65	0.20	0.6534
System_belt*Occupant	6	326	1.05	0.3932
Occupant*seatposition	2	60.8	0.14	0.8718
System_belt*Sex_num	6	326	2.12	0.0511
Sex_num*seatposition	2	60.8	1.53	0.2244
System_be*seatposition	10	326	0.57	0.8352

Group (drive ratings unbelted)—strength appropriateness ratings (mean absolute deviation)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	65.4	0.45	0.5070
Sex_num	1	65.4	0.71	0.4036
System_belt	6	326	34.15	<.0001
seatposition	2	63.5	1.09	0.3420
Sex_num*Occupant	1	79.6	0.31	0.5802
System_belt*Occupant	6	326	0.38	0.8909
Occupant*seatposition	2	63.5	0.02	0.9841
System_belt*Sex_num	6	326	1.46	0.1900
Sex_num*seatposition	2	63.5	0.98	0.3819
System_be*seatposition	10	326	1.33	0.2111

Group (post-drive ratings unbelted)—desirability ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	66.1	2.25	0.1383
Sex_num	1	66.1	0.15	0.6969
System_belt	6	324	5.98	<.0001
seatposition	2	64	0.39	0.6753
Sex_num*Occupant	1	82.5	0.85	0.3589
System_belt*Occupant	6	324	0.14	0.9899
Occupant*seatposition	2	64	0.53	0.5940
System_belt*Sex_num	6	324	0.51	0.7987
Sex_num*seatposition	2	64	0.08	0.9274
System_be*seatposition	10	324	1.51	0.1360

Group (post-drive ratings unbelted)—effectiveness ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	61.5	0.58	0.4474
Sex_num	1	61.5	4.53	0.0374
System_belt	6	322	102.22	<.0001
seatposition	2	61	1.54	0.2229
Sex_num*Occupant	1	65.9	0.37	0.5458
System_belt*Occupant	6	322	0.43	0.8589
Occupant*seatposition	2	61	0.19	0.8290
System_belt*Sex_num	6	322	1.09	0.3692
Sex_num*seatposition	2	61	0.68	0.5081
System_be*seatposition	10	322	0.68	0.7455

Group (drive ratings belted)—annoyance ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	67.6	0.46	0.5004
Sex_num	1	71.1	1.30	0.2580
System_belt	5	223	10.85	<.0001
seatposition	2	73.2	1.58	0.2127
Sex_num*Occupant	1	72.7	0.03	0.8731
System_belt*Occupant	5	223	2.33	0.0437
Occupant*seatposition	2	73.1	0.56	0.5741
System_belt*Sex_num	5	224	0.42	0.8318
Sex_num*seatposition	2	77.9	3.48	0.0357
System_be*seatposition	5	223	1.68	0.1395

Group (drive ratings belted)—effectiveness ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	63.9	0.00	0.9705
Sex_num	1	69.5	3.85	0.0538
System_belt	5	225	11.46	<.0001
seatposition	2	66.6	0.46	0.6317
Sex_num*Occupant	1	69.6	0.17	0.6827
System_belt*Occupant	5	225	1.84	0.1063
Occupant*seatposition	2	66.6	0.01	0.9854
System_belt*Sex_num	5	225	1.64	0.1495
Sex_num*seatposition	2	73.9	1.61	0.2073
System_be*seatposition	5	225	2.12	0.0645

Group (drive ratings belted)—strength appropriateness ratings (mean absolute deviation)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	81.8	1.79	0.1850
Sex_num	1	84.5	1.25	0.2661
System_belt	5	230	1.05	0.3910
seatposition	2	89.9	1.35	0.2648
Sex_num*Occupant	1	87.5	0.82	0.3666
System_belt*Occupant	5	230	0.53	0.7565
Occupant*seatposition	2	89.8	1.41	0.2489
System_belt*Sex_num	5	231	1.00	0.4174
Sex_num*seatposition	2	93.4	0.06	0.9408
System_be*seatposition	5	229	0.27	0.9268

Group (post-drive ratings belted)—desirability ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	78.2	3.61	0.0611
Sex_num	1	80.6	0.07	0.7922
System_belt	5	224	2.11	0.0651
seatposition	2	86.6	0.38	0.6824
Sex_num*Occupant	1	83.7	0.18	0.6704
System_belt*Occupant	5	224	1.40	0.2245
Occupant*seatposition	2	86.5	1.02	0.3647
System_belt*Sex_num	5	225	1.04	0.3924
Sex_num*seatposition	2	90	0.19	0.8234
System_be*seatposition	5	224	0.76	0.5824

Group (post-drive ratings belted)—effectiveness ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Occupant	1	62.9	0.92	0.3399
Sex_num	1	67.8	5.94	0.0174
System_belt	5	220	3.37	0.0059
seatposition	2	66.4	0.10	0.9054
Sex_num*Occupant	1	68.2	0.39	0.5357
System_belt*Occupant	5	220	2.51	0.0309
Occupant*seatposition	2	66.4	0.00	0.9951
System_belt*Sex_num	5	221	0.73	0.6043
Sex_num*seatposition	2	72.9	1.94	0.1510
System_be*seatposition	5	221	0.79	0.5575

Brief ESBRs—annoyance ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Sex_num	1	29	0.15	0.7017
System_short	11	317	38.95	<.0001
System_short*Sex_num	11	317	1.18	0.3028

Brief ESBRs—effectiveness ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Sex_num	1	29	0.50	0.4843
System_short	11	317	41.44	<.0001
System_short*Sex_num	11	317	0.46	0.9271

Brief ESBRs—strength appropriateness ratings (mean absolute deviation)

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Sex_num	1	29.1	1.17	0.2886
System_short	11	317	9.53	<.0001
System_short*Sex_num	11	317	0.52	0.8874

Individual alerts—annoyance ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Alert	26	753	37.66	<.0001
Sex	1	29	0.03	0.8687
Sex*Alert	26	753	1.35	0.1160

Individual alerts—effectiveness ratings

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
Alert	26	753	32.75	<.0001
Sex	1	29	1.14	0.2950
Sex*Alert	26	753	0.79	0.7614

DOT HS 812 173
August 2015

U.S. Department
of Transportation

**National Highway
Traffic Safety
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11214-081215-v3