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A Comparison of the Comfort and Convenience of Automatic Safety Belt Systems among Selected 1988-1989 Model Year Automobiles

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This publication reports the results of the first of two studies involving selected 1988-1989 model year automobiles. The companion volume to this report describes the Installation of Child Safety Seats in Selected 1988-1989 Model Year Automobiles.

16. Abstract

A nonrandom sample of 120 disproportionately short, tall, and overweight drivers compared the comfort and convenience of the automatic safety belt systems used in seventeen automobiles. Nine vehicles had motorized shoulder belts with manual lap belts; five had non-motorized shoulder and lap belts; and three had non-motorized shoulder belts only. The study was designed to identify problems of comfort and convenience in order to improve an already acceptable technological advance. The study compared comfort and convenience features among different automatic belt types and specific vehicle installations. The study did not evaluate comfort and convenience against an absolute standard or compare comfort and convenience with features of manual systems. The motorized system and the two-point non-motorized system had the fewest or least severe problems. Some drivers found comfort and convenience problems with each belt system tested. Women, short drivers, and overweight drivers all had more problems than drivers who were male, or average height or tall, and not overweight.

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Table of Contents

A COMPARISON OF THE COMFORT AND CONVENIENCE OF AUTOMATIC SAFETY BELT SYSTEMS AMONG SELECTED 1988-1989 MODEL YEAR AUTOMOBILES

List of Exhibits

Preface

This publication presents the results of the first of two studies conducted by Abt Associates Inc. in 1988-1989. This study was a comparison of the comfort and convenience of the automatic safety belt systems in seventeen 1988-89 model year automobiles. The companion study was an examination of the compatibility of child safety seats with these same automobiles.

A Comparison of the Comfort and Convenience of Automatic Safety Belts among Selected 1988-1989 Model Year Automobiles

Executive Summary

Federal Motor Vehicle Safety Standard 208 requires the installation of automatic protection systems in all new cars effective with model year 1990. Most manufacturers are meeting the standard by equipping their automobiles with automatic safety belts (the rest are using air bags). In light of this development, the National Highway Traffic Safety Administration (NHTSA) identified a need to determine the extent to which problems with comfort and convenience of these new devices might discourage their use.

To achieve this goal, NHTSA contracted in 1988-1989 with Abt Associates Inc. to conduct a study to compare the comfort and convenience of the automatic belt systems in seventeen current model automobiles.

This study was purposely designed to identify problems associated with a relatively recent technological innovation in highway traffic safety--automatic safety belts. Studies had already shown that this innovation saves lives and has met with consistent driver approval. However, there was a need to identify any current problems with automatic safety belts so that what have already been shown to be a life-saving technology might be improved still further.

Study Goals

The comfort and convenience features among different automatic safety belt systems and specific vehicle installations were compared in seventeen 1988-1989 model year automobiles. The comparison was intended to achieve three goals:

1. To identify types of automatic safety belt systems that create discomfort or inconvenience for drivers.

2. To identify specific aspects of automatic safety belt systems that create discomfort or inconvenience for drivers.

3. To determine the relationship between discomfort or inconvenience and selected driver characteristics, including gender, body size (height and weight), age, and frequency of safety belt use.

The study compared features of comfort and convenience among different automatic belt types and specific vehicle installations. The study did not evaluate the comfort and convenience of automatic safety belt systems against any absolute standard, or compare the comfort and convenience of automatic systems with features of manual systems.

Study Design and Procedures

In order to increase the opportunity to identify current problems with automatic belt systems, a deliberate effort was made to oversample drivers who were most likely to have such problems. Other research design features were incorporated to increase the chances of identifying problems. For example, subjects were forced to choose a positive or negative response to every question about comfort and convenience--"don't know" or neutral responses were not allowed. As a result of this narrow focus on problem identification, the study results do not represent an objective evaluation of actual levels of comfort and convenience of automatic safety belt systems. The study does, however, show where improvements are warranted.

One hundred and twenty licensed drivers were recruited through a field service as testers for the study. An effort was made to oversample tall, short, and overweight individuals, since previous studies of safety belt use have suggested that these drivers have more comfort and convenience problems with safety belts than do other drivers, and the purpose of the study was to bring these problems to light.

Each driver sat in the driver's seat of each of 17 automobiles and answered a series of questions about the comfort and convenience of each vehicle's automatic safety belt system. The test took place over four days, with a different group of 30 drivers recruited for each day.

Thirty experimenters, also recruited through the field service, were trained to administer a safety belt system questionnaire to the drivers. In addition to asking questions and recording the answers on the instrument, the experimenters also made and recorded specific observations of safety belt fit while the driver was seated in the test vehicles. Each experimenter was given a unique sequence of vehicles to follow during the testing so as to randomize the order in which the automobiles were tested by the drivers.

At the beginning of each day, drivers and experimenters were teamed for the day using a matched-number system. Each experimenter was also given the unique sequence of vehicles to follow during the testing. To conduct the test, each experimenter/driver pair compared each vehicle in the randomized order provided, going from automobile to automobile in unison at the command of a project staff person using a microphone to coordinate the simultaneous movement of all 30 pairs from one vehicle to the next.

Driver and Vehicle Samples

Sixty-one percent of the drivers were male, and 39 percent were female. Fourteen percent were under 25 years of age; 18 percent were over 60. Eight percent were less than 5' 3" tall; 37 percent were 5' 10" or taller. Twenty-three percent of the drivers were overweight.

Seventeen automobiles were tested, representing twelve different manufacturers. The vehicles were equipped with three different types of automatic safety belt systems:

1. Motorized shoulder belt with manual lap belt. Nine automobiles had a motorized device to place the shoulder belt around the driver as soon as he or she sits down in the front seat and closes the door. A bolster under the dashboard cushions and restrains the knees during any crash. These cars also had a manual lap belt which the driver must attach by hand.

2. Non-motorized shoulder and lap belt. Five automobiles had automatic systems in which the shoulder and lap belt are attached to the inside of the door.

3. Non-motorized shoulder belt. Three automobiles had a similar arrangement that included only a shoulder belt. These cars had no lap belt, automatic or manual. Rather, a bolster under the dashboard cushions and restrains the knees during any crash.

Analysis and Results

Nine comfort and convenience aspects were addressed in the study:

- Entry/exit
- Shoulder belt fit
- Shoulder belt comfort
- Shoulder belt convenience
- Lap belt fit
- Lap belt comfort
- Lap belt convenience
- Knee bolster convenience
- Shoulder belt retraction failure

The frequency of problems associated with each of the nine aspects was analyzed by determining the percentage of responses or trials where a problem was indicated by any of the questions related to that aspect. The severity of the problem is not reflected in these percentages--just the frequency with which problems were reported or observed. However, a composite index was constructed that combines frequency of problems with drivers' perceived severity of problems for each test vehicle averaged across all nine aspects.

The principal study findings were as follows:

- Some drivers found comfort and convenience problems with each belt system.
- Drivers reported the most frequent problems with shoulder belt convenience and lap belt convenience. Entry/exit problems were also a problem for many drivers.
- The motorized system and the two-point non-motorized system appear to have the least frequent and/or least severe comfort and convenience problems.

Regarding driver characteristics, the following findings emerged:

- Women have more comfort and convenience problems than men.
- Automatic restraint systems are most uncomfortable or inconvenient for short drivers and most comfortable or convenient for tall ones.
- Overweight drivers have more belt system problems than do their non-overweight counterparts.
- The youngest drivers (18 to 24 year) report the fewest problems; there are no differences in the composite index for drivers aged 25 years and over.

1

Introduction

This report presents the findings of a study conducted by Abt Associates Inc. in 1988-1989 to compare comfort and convenience features among different automatic safety belt systems and specific vehicle installations in selected 1988-1989 model year automobiles. This chapter presents the rationale for the study, its purposes, and the organization of the report.

Background

Safety belt usage has never been widespread in the United States. The National Highway Traffic Safety Administration (NHTSA) reported that 14 percent of the nation's drivers were using safety belts during 1983 (National Highway Traffic Safety Administration, 1983). According to the most recent NHTSA 19-city survey of safety belt use, usage rates had climbed to 47 percent between August and October of 1988, with rates in cities with safety belt usage laws reporting use levels of 51 percent (U.S. Department of Transportation, 1989).

One approach to increasing belt use is to equip automobiles with automatic safety belt systems that do not depend on the driver's (or front seat passenger's) initiative to fasten his or her belt. To promote this approach, the Department of Transportation reissued Federal Motor Vehicle Safety Standard (FMVSS) Number 208 for Occupant Crash Protection on July 17, 1984, to require the installation of automatic protection systems in all new cars effective with model year 1990, with a specified phase-in over a three-year period beginning on September 1, 1986. Although automatic occupant protection system alternatives include automatic safety belts and air bags, most manufacturers are meeting the new requirements by installing automatic safety belts.

Manufacturers have developed three automatic safety belt systems:

1. Motorized shoulder belt with manual lap belt. In this system, a motorized device to place the shoulder belt around the driver as soon as he or she sits down in the front seat and closes the door. (With some cars, the ignition must be turned on before the system operates.) A bolster under the dashboard cushions and restrains the knees during any crash. These cars also have a manual lap belt which the driver must attach by hand.

2. Non-motorized shoulder and lap belt. In this system the shoulder and lap belt are attached to the inside of the door. The belts unroll when the driver opens the door and roll up again when the driver closes the door, leaving the seated person automatically belted with both a shoulder and a lap belt.

3. Non-motorized shoulder belt. This system has a similar arrangement but includes only a shoulder belt. Many cars using this system have no lap belt, automatic or manual. Rather, a bolster under the dashboard cushions and restrains the knees during any crash.

Exhibits 1, 2, and 3 illustrate the three belt systems.

Automatic safety belt systems represent a new technology. Although Volkswagen provided the first automatic system as optional equipment in its 1975 model year Rabbits, few other manufacturers provided automatic belt systems until required by Federal Motor Vehicle Safety Standard 208.

Studies have indicated that this new technology is both effective in reducing automobile fatalities and well-liked by most drivers. A four-state study of over 27,000 front seat occupants of Volkswagen Rabbits (U.S. Department of Transportation, 1984) found that fatality rates in Rabbits with automatic belts (as used) compared to cars with manual belts (as used) was over 19 percent lower. The automatic VW Rabbit restraint system, when used, was estimated to be 39-54 percent effective in reducing fatalities compared to fatality rates for unrestrained occupants. A subsequent study of a car equipped with a motorized two-point automatic belt system with knee bolster and manual lap belt (Nash, 1988) found that the design was effective in reducing fatalities in crashes in the range of 35 to 38 percent.

There is already information suggesting that purchasers of cars with automatic belt systems overwhelmingly like their belt systems, and like them better than manual systems. In late 1987, a telephone survey of 943 purchasers of automobiles with automatic safety belt systems (U.S. Department of Transportation, 1988) found that these purchasers preferred their automatic safety belt systems to manual belts by a margin of approximately three-to-one, regardless of the type of automatic belt system. However, when asked to rate their reactions to their systems on a one-to-ten scale, owners of the two-point motorized system gave higher ratings than owners of the other two systems. The convenience of automatic safety belts was cited as a major factor in both the preference for the system and a favorable rating.

Exhibit 1*

TWO-POINT MOTORIZED SHOULDER BELT WITH MANUAL LAP BELT

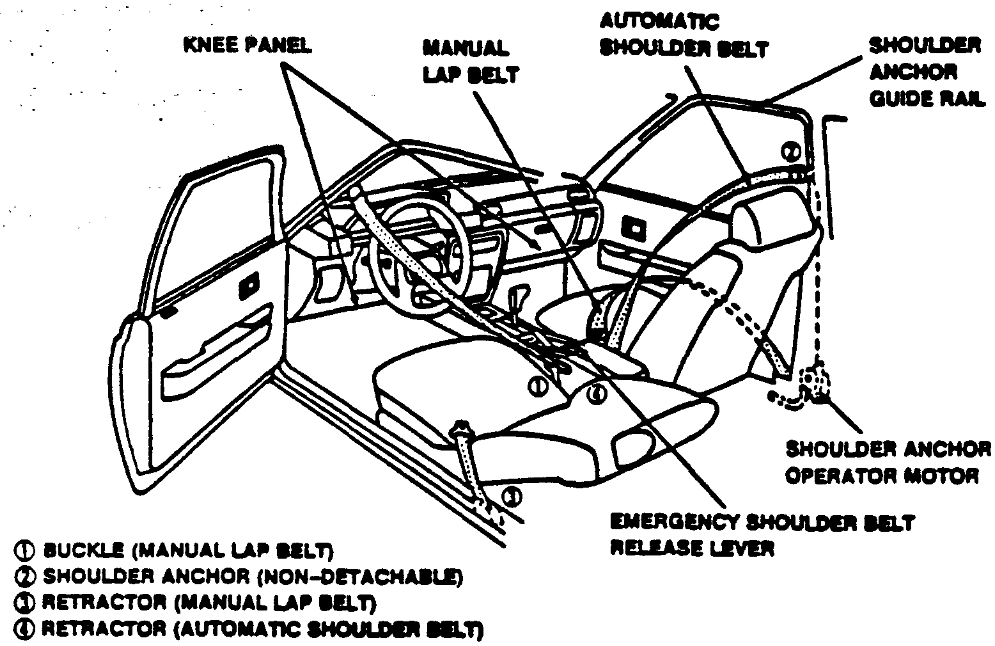


Exhibit 2*

THREE-POINT NON-MOTORIZED AUTOMATIC SHOULDER AND LAP BELT

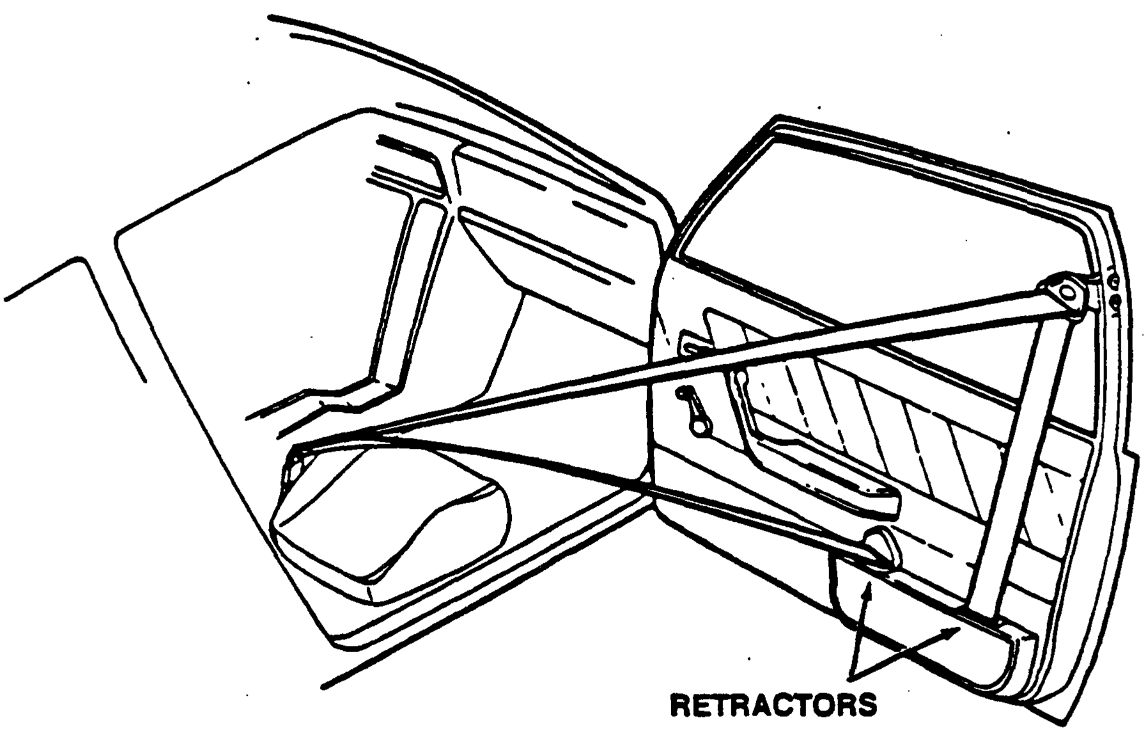
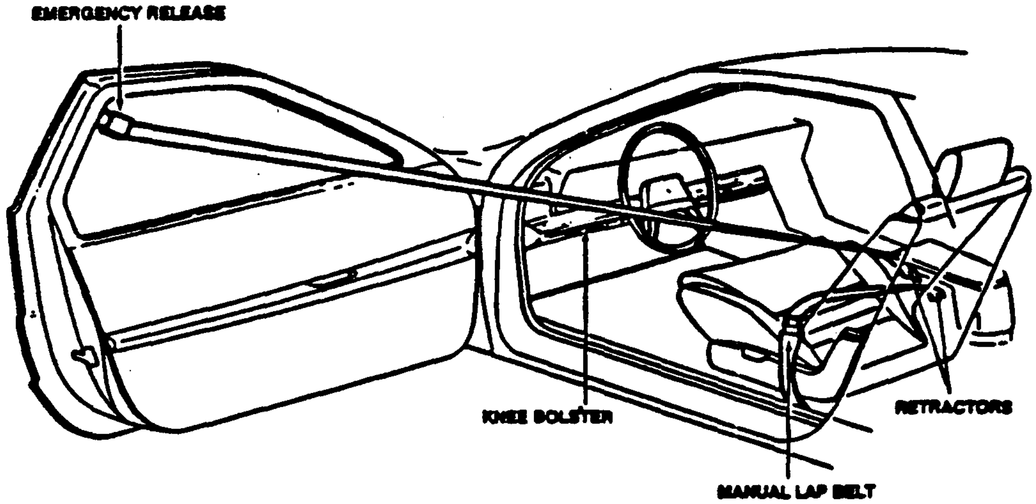


Exhibit 3*

TWO-POINT NON-MOTORIZED AUTOMATIC SHOULDER BELT



*Graphics reprinted from Industry and Consumer Response to New Federal Motor Vehicle Safety Requirements for Automatic Occupant Protection. Phase II Report: Survey of Consumer Preferences among Automatic Safety Belt Systems and Sales Impacts of Automatic Safety Belt Systems, U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, D.C., June 1988.

With experience, the preferences of automatic system purchasers for their belt systems over manual belts, and positive ratings of their feelings about their belt system, increased. Convenience, along with becoming accustomed to the system, accounted for the increase in both preference and ratings with experience.

The study also found that the level of use of safety belts differed significantly according to the type of automatic safety belt system. Specifically, only 65 percent of the purchasers of automobiles equipped with three-point non-motorized systems reported using their safety belts all the time, almost exactly the same usage level reported by purchasers of automobiles with manual belts. In contrast, based on self-reporting, 77 percent of purchasers of two-point non-motorized systems, and 98 percent of purchasers of two-point motorized systems, used their safety belts (in the automatic or manual mode) all the time.

Observational studies of seat belt use have confirmed differential usage rates among the three automatic seat belt systems. A large-scale 1987-88 observational study of 14,116 drivers of cars equipped with automatic safety belts systems found that between 96-99 percent of drivers in cars with motorized systems had their belts on, while between 71-85 percent of drivers with non-motorized automatic systems were buckled up (National Highway Traffic Safety Administration, 1989).

The Insurance Institute for Highway Safety (1987) found that among the three major American automobile manufacturers, Ford had the largest incremental gain in seat belt use among cars equipped with automatic belts. Drivers of General Motors cars had smaller increases. Curiously, Chrysler automobiles with automatic shoulder belts actually had lower use rates than other late model Chrysler models equipped with manual belts. Only 46 percent of the front seat riders in Chrysler cars equipped with automatic belts were using them, compared with 59 percent riding in cars with manual belts.

Another study by the Insurance Institute found clear preferences among drivers for different automatic safety belt systems (Williams et al., 1987): 60 percent of all Ford drivers in the sample reported they "liked it [the system] a lot" compared with only 27 percent of the General Motors drivers. More than one-third of the General Motors drivers said they disliked the system, while only 14 percent of the Ford drivers reported this reaction. General Motors drivers were more likely than Ford drivers to report difficulty when entering or exiting the car. These differences presumably reflect the different automatic safety belt systems the two manufacturers have installed in their cars. Ford automobiles use the motorized two-point shoulder belt that positions itself around the driver when the driver turns on the ignition. A manual lap belt and a knee bolster for lower body restraint are also provided. The shoulder belt can be disabled only in ways that make it permanently inoperative--for example, by cutting it. The GM system is a three-point combination lap and shoulder belt that is attached to the door. The system can readily be detached and used like a manual belt.

In summary, all new cars will have automatic safety belts or airbags as of model year 1990, and a majority will have automatic safety belts. Drivers have already demonstrated they use these systems more than they use manual systems, and studies have indicated that automatic systems are effective in reducing automobile fatalities. However, usage of the three automatic safety belt systems varies significantly among the three systems. It is important to determine why these differential rates in usage exist so that automobile manufacturers can improve systems where problems are uncovered and incorporate features shown to lead to the most acceptance of these systems.[2]

Purposes and Limitations of the Automatic Safety Belt Study

The study had three purposes:

1. To identify those types of automatic safety belt systems that create discomfort or inconvenience for drivers.

2. To identify those aspects of automatic safety belt systems that create discomfort or inconvenience for drivers.

3. To determine the relationship between discomfort and inconvenience and selected driver characteristics, including gender, body size (height and weight), age, and frequency of safety belt use.

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[2]It might appear that the increasing passage of state safety belt usage laws (SBULs) eliminates the need to motivate the public to fasten their manually operated belts, or not disconnect their automatic belt systems. However, studies in North America have consistently demonstrated that while usage rates following the introduction of SBULs increase dramatically, after several months they fall back to more modest levels--higher than what existed before the SBUL was enacted, but far too low to preclude the need to focus attention on ways to increase usage. Furthermore, it appears that those drivers least likely to buckle up in states with SBULs are those drivers who are the highest risk takers (Hunter et al., 1987). Thus, the SBULs may have their weakest effect with precisely those drivers who are most likely to get in an accident. These are probably also the drivers most likely to disconnect automatic safety belt systems, as well, unless the systems are comfortable and convenient to use.

The study compared features of comfort and convenience of automatic safety belt systems among different automatic belt types and specific vehicle installations. The study did not evaluate the comfort and convenience of automatic safety belt systems against any absolute standard, or compare the comfort and convenience of automatic systems with features of manual systems.

The study was purposely designed to identify any current automatic safety belt comfort and convenience problems in an effort to improve an already acceptable technological innovation. In order to increase the opportunity to identify these problems, a deliberate effort was made to oversample drivers who were most likely to have comfort and convenience problems--specifically, tall, short, and overweight drivers (cf. Tom et al., 1981). Other research design features were incorporated to increase the chances of identifying problems. For example, subjects were forced to choose a positive or negative response to every question about comfort and convenience--"don't know" or neutral responses were not allowed. As a result of this narrow focus on problem identification, the study results do not represent an objective evaluation of actual levels of comfort and convenience of automatic safety belt systems. The study does, however, show where improvements are warranted.

Organization of the Report

Chapter 1 presents the background and purposes of the study. The study design and procedures are described in Chapter 2. A description of the samples is provided in Chapter 3. Chapter 4 presents the results and analysis of the study.

2

Test Design and Procedures

This chapter describes the test personnel, test schedule, test instruments, and procedure use to randomize testing of the vehicles examined in the study.

Test Personnel

The experiment was conducted using teams of two people: an experimenter and a driver (test subject). Thirty experimenters were recruited by a field service company and trained for one day before the test in how to administer the questionnaire.

The drivers were recruited by the same field service using detailed anthropometric, sex, and age specifications designed to provide adequate samples for statistical analysis of overweight, tall, short, male, female, and elderly testers. A different group of 30 drivers was recruited for each of the four test days. All were licensed drivers.

Test Schedule

The test took place over four days, lasting five to six hours each day. A different group of 30 drivers was recruited for each test day. Each day as the drivers arrived at the test facility, an experimenter measured their height and weight, recording the information on the Participant Information Form. The experimenter also asked the remaining questions on the form about safety belt usage and any upper body mobility problems, and also recorded the driver's sex. Each day after all 30 drivers had arrived, they were given an orientation on the purpose of the test, their role, and the procedures involved in comparing the vehicles.

At the beginning of each day, drivers and experimenters were teamed for the day using a matched-number system. Each experimenter was also given the unique sequence of vehicles to follow during the testing.

To conduct the test, each experimenter/driver pair compared each vehicle in the randomized order provided, going from automobile to automobile in unison at the command of a project staff person using a microphone to coordinate the simultaneous movement of all 30 pairs from one vehicle to the next. At the start of the test of each new vehicle, the driver was asked to sit in the automobile. The experimenter then (1) read the questions from the safety belt system questionnaire about the driver's perceptions of the belt system's comfort and convenience, (2) observed various aspects of the procedures, such as belt twisting and improper fit, and (3) recorded the driver's responses and his or her own observations on the response form.

Because the test facility was chilly, most drivers wore coats during the tests. As a result, some of the comfort measures may be more conservative in indicating problems than if the drivers had not been wearing coats. Belt systems that might have been irritating when in contact with just a shirt or blouse might not have been uncomfortable to drivers protected by a coat. By contrast, wearing coats may have increased the number of convenience problems associated with the test because the coats may have interfered with such tasks as reaching to buckle and unbuckle the manual lap belts.

Test Instruments

Three instruments were developed and used in the study:

- A Vehicle Data Form to provide descriptive information about each vehicle and belt system in the test, such as the type of safety belt system and number of doors (Appendix A).
- A Participant Information Form to record the drivers' age, height, weight, sex, any upper body mobility problems, and normal safety belt use practices (Appendix B).
- A Safety Belt System Evaluation Questionnaire to record information about the comfort and convenience of the vehicles' automatic safety belt system (Appendix C).

The safety belt system questionnaire contained two types of questions. One set required experimenters to ask a question of the driver and record his or her response. Some of these verbal questions required a Yes/No response, while others were answered using a scale of 1 to 7, where 1 was most convenient, comfortable, or easy to use, and 7 was most inconvenient, uncomfortable, or difficult to use. Drivers were not allowed to select a neutral response--the number 4 was omitted from the scale. A response card with the scale (Appendix D) was placed on the steering wheel of each test vehicle for the drivers to consult.

The second type of question included in the questionnaire involved instructions to the experimenter to observe specific behaviors by the driver and to record how the driver behaved. For example, one question required the experimenter to "Note if the arm or hand of the subject [driver] is entrapped by the [safety belt] system" after the driver entered the vehicle.

Randomization of Test Vehicles

A Latin square design was used to develop a unique sequence of vehicles for each experimenter to follow during the testing in order to randomize the order in which the automobiles were tested by the different drivers. These randomized sequences were used to reduce the effect of comparing the test vehicles in the same order, a procedure that could create bias in the comparisons. For example, if a very small (and no-frills) car were consistently tested after a very large (and luxurious) car, some drivers might give the small car poorer ratings than it merited because the car seemed less desirable on general grounds after the test of the large automobile.

Description of the Samples

This chapter describes the vehicles and testers used in the study.

Vehicle Sample

Seventeen 1988-89 model year automobiles were compared. Originally, the National Highway Traffic Safety Administration selected 25 vehicles for comparison based on anticipated sales and a desire to compare vehicles representing a range of manufacturers, body types, and two- and four-door automobiles. However, we were unable to find automobile dealers or automobile rental agencies within a thirty-mile radius of the test facility that would rent us eight of the targeted vehicles.

Exhibit 4 is a list of the 17 automobiles we compared by selected characteristics. As the display shows, the test vehicles represented twelve different manufacturers, including five General Motors cars, two Ford cars, and one car each from ten other manufacturers.

The vehicles used three different types of automatic safety belt systems:

1. Motorized shoulder belt with manual lap belt (nine automobiles)
2. Non-motorized shoulder and lap belt (five automobiles)
3. Non-motorized shoulder belt (three automobiles).[1]

Exhibit 5 shows the specific test vehicles that came provided with each automatic safety belt system. The exhibit also presents a number of other features of the test automobiles. For example:

- Thirteen vehicles had shoulder and lap belts in the rear outboard seats; the other four vehicles had lap belts only.
- Every car but four had an emergency-locking retractor in the rear outboard seats; the others had an automatic-locking retractor.[2]
- Eleven of the 17 vehicles had four doors; six had two.

---

[1]See Chapter 1 for a description and illustration of each system.

[2]A retractor is a device for storing part or all of the webbing in a seat belt assembly. An emergency-locking retractor incorporates adjustment hardware by means of a locking mechanism that is activated by vehicle acceleration, webbing movement relative to the vehicle, or other automatic action during an emergency. An automatic-locking retractor incorporates adjustment hardware by means of a positive self-locking mechanism.

Exhibit 4

Test Vehicle Make, Model, and Belt System Characteristics

TEST VEHICLES		Number of doors		Belt System			Front Outboard Retractor		Number of Positions/ Rear Seat		Belt Type Outboard Rear Seat		Type Retractor Outboard Rear Seat	
Make	Model	2	4	motorized shoulder with manual lap belt	non-motorized shoulder and lap belt	non-motorized shoulder belt	emergency lock	automatic lock	2	3	lap belt only	lap & shoulder belt	emergency	automatic
CHEVROLET	BERETTA	X			X		X			X		X	X	
DODGE	SHADOW		X	X			X			X		X	X	
FORD	ESCORT		X	X				X	X		X			X
FORD	TEMPO		X	X				X		X	X			X
HYUNDAI	EXCEL GLS		X			X	X			X	X			X
MAZDA	626		X	X			X			X		X		
MITSUBISHI	MIRAGE	X		X			X			X		X	X	
NISSAN	MAXIMA		X	X			X			X		X	X	
PEUGOT	405-S		X	X			X			X		X	X	
PONTIAC	BONNEVILLE		X		X		X			X		X	X	
PONTIAC	GRAND AM	X			X		X			X		X	X	
PONTIAC	GRAND AM		X		X		X			X		X	X	
PONTIAC	GRAND PRIX	X			X		X			X		X	X	
SAAB	TURBO	X		X			X			X		X	X	
TOYOTA	CAMRY		X	X			X			X		X	X	
VOLKSWAGEN	JETTA		X			X	X			X		X	X	
YUGO	GV	X				X	X		X		X			X
TOTAL		6	11	9	5	3	15	2	2	15	4	13	13	4

Exhibit 5

Automobile Make and Model Classified by Automatic Belt Systems

System	Test Vehicles	Number of Test Vehicles
Motorized shoulder belt with manual lap belt	Dodge Shadow Ford Escort Ford Tempo Mazda 626 Mitsubishi Mirage Nissan Maxima Peugot 405 S Saab Turbo Toyota Camry	9
Non-motorized shoulder and lap belt ("3-point" system)	Chevrolet Beretta Pontiac Bonneville Pontiac Grand Am (2 door) Pontiac Grand Am (4 door) Pontiac Grand Prix	5
Non-motorized shoulder belt ("2-point" system)	Hundai Excel GLS Yugo GV Volkswagen Jetta	3

Driver Sample

A field service recruited 120 licensed automobile drivers as testers for the study. As noted above, an effort was made to oversample tall, short, and overweight individuals, since previous studies of safety belt use have suggested that these populations have more comfort and convenience problems with safety belts than do other drivers, and our purpose in the study was to bring these problems to light.

Exhibit 6 shows the distribution of the drivers by height, weight, and other characteristics. As the data show, 61 percent of the drivers were male, and 39 percent were female. Fourteen percent were between 18-24 years old; 23 percent were 25-29 years old; 45 percent were 30-59 years old; and 18 percent were between 60-72 years old. Eight percent of the drivers were less than 5' 3" tall; 29 percent were 5' 3" to 5' 6" tall; 26 percent were 5' 7" to 5' 9" tall; and 37 percent were 5' 10" or taller. Twenty-three percent of the drivers were overweight.[1]

Forty-three percent of the drivers reported they almost always wear safety belts; 18 percent said they almost never wear them.

Although not shown on Exhibit 6, drivers were asked if they had any upper body mobility problems; only two reported they did (in both cases due to arthritis).

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[1]Males were classified as overweight if they were between 67-71 inches tall and weighed more than 210 pounds, and if they were 66 inches tall or less and weighed more than 170 pounds. Females were classified as overweight if they were between 62-67 inches tall and weighted more than 175 pounds, and if they were 61 inches tall or less and weighted more than 145 pounds.

Exhibit 6

Characteristics of the Driver Sample

(n = 120)

Characteristic		Number	Percentage
sex	Male	73	61%
	Female	47	39%
height	58-62 inches	10	8%
	63-66 inches	35	29%
	67-69 inches	31	26%
	$\geq$ 70 inches	44	37%
age[a]	18-24 years	17	14%
	25-29 years	27	23%
	30-59 years	53	44%
	60-72 years	23	19%
weight	Not Overweight	93	23%
	Overweight[b]	27	77%
safety belt use[c]	Almost always	51	43%
	Occasionally or once in a while	43	36%
	Almost never	22	18%

[a]These age ranges represent a combination of standard age cut-off points used in traffic safety research (e.g., under 25 years of age, 60 or over) and the creation of groupings with enough drivers to permit statistical comparisons among age groupings.

[b]Males were classified as overweight if they were between 67-71 inches tall and weighed more than 210 pounds, and if they were 66 inches tall or less and weighed more than 170 pounds. Females were classified as overweight if they were between 62-67 inches tall and weighed more than 175 pounds, and if they were 61 inches tall or less and weighed more than 145 pounds.

[c]Four drivers did not answer this question.

4

Analysis and Results of Driver Comparisons

This chapter discusses the procedures used to analyze the data and presents the results of the analysis. The principal objectives of the analysis were to (1) identify and compare the major comfort and convenience problem areas for the test vehicles and (2) determine the relationships between perceived comfort and convenience and various driver and vehicle characteristics. Consistent with the study's purpose to maximize the opportunity to identify comfort and convenience problems, the presentation of the findings below discusses the difficulties the test drivers found with the automatic safety belt systems, not the positive features of the systems. As will also be seen, the findings involve comparisons of the problems found among different automatic belt systems and specific vehicle installations rather than any evaluation of problems against an absolute standard, or a comparison of automatic belt systems with manual belt systems.

Analytic Approach

Frequency of Comfort and Convenience Problems

The study examined problems with nine specific aspects of comfort and convenience:

- Entry/Exit
- Shoulder belt fit
- Shoulder belt comfort
- Shoulder belt convenience
- Lap belt fit
- Lap belt comfort
- Lap belt convenience
- Knee bolster convenience
- Shoulder belt retraction failure.

For several of these aspects, more than one question was asked and/or driver behavior observed. Exhibit 7 lists the questions and observations from the safety belt system questionnaire that pertain to each aspect.

Exhibit 7

Groupings of Questions from the Safety Belt System Questionnaire* by Comfort and Convenience Aspect

Comfort and Convenience Aspect	Column on Questionnaire Where Question May Be Found*	Associated Question(s)	Driver Response	Experimenter Observation
Entry/Exit	14	Does the belt system look easy to use?	X	
	15	Did the tester enter the car correctly?		X
	16	Was the tester's arm or hand entrapped in the system?		X
	17	Did the belt system make entering the car easy or difficult?	X	
	18	Did the belt system make it easy or difficult to close the door?	X	
	56	Did the belt system make it easy or difficult to get out of the car?	X	
Shoulder Belt Fit		What was the fit of the belt?		X
	23	-- at the shoulder?		
	24	-- at the sternum?		
Shoulder Belt Convenience				
• mechanics	19	Is the distance between the moving belt and your head acceptable or unacceptable? [Motorized systems]	X	
	20	Is the movement or speed of the belt acceptable or unacceptable to you? [Motorized Systems]	X	
• interference	21	Did the belt system make adjusting the seat difficult or easy [after the driver moved the seat forward and back]?	X	
	43	Does any part of the belt system interfere with your vision out of the left side of the car [after driver has placed his/her hands on the steering wheel and looked to the left rear as far as possible]?	X	
• emergency release	46	Was the buckle easy or difficult to unbuckle?	X	
	47	Was the belt easy or difficult to buckle?	X	

*See Appendix C for a copy of the questionnaire.

Exhibit 7

Groupings of Questions from the Safety Belt System Questionnaire*
by Comfort and Convenience Aspect
(continued)

Comfort and Convenience Aspect	Column on Questionnaire Where Question May Be Found*	Associated Question(s)	Driver Response	Experimenter Observation
Shoulder Belt Comfort	25	How does the should belt fit across your chest and shoulder?	X	
	26	Does the shoulder belt press on your body uncomfortably?	X	
	42	Was there scuffing or rubbing of the belt against your shoulder [after reaching for the glove box]?	X	
Lap Belt Fit	35	What was the fit of the belt across the stomach. Was it high?		X
Lap Belt Comfort	36	Does the lap belt press on your body comfortably or uncomfortably?	X	
Lap Belt Convenience	28	Were two hands or one hand used to buckle the belt?		X
	30	How easy or difficult was it to find the buckle?	X	
	31	Was it easy or difficult to move the latchplate over to the buckle?	X	
	32	How easy or difficult was it for you to grasp the latchplate?	X	
	33	Was it easy or difficult to fasten the buckle?	X	
	50	Was it easy or difficult to release the lap belt?	X	
Knee Bolster Convenience	53	Is the knee bolster causing you any discomfort?	X	
	55	Did the knee bolster make it easy or difficult to get out of the car?	X	
Shoulder Belt Retraction Failure	41	Was there excessive slack or looseness in the shoulder belt [after the driver reached for the glove compartment]?	X	

*See Appendix C for a copy of the instrument.

Frequency of problems associated with each of the nine aspects were analyzed by determining the percentage of responses or trials where a problem was indicated by any of the questions related to that aspect. Responses to questions asked of drivers were coded on an interval scale of 1 to 7, with "1" being easiest or most comfortable and "7" being most difficult or most uncomfortable. (The scale omitted the mid-point--number "4"--to prevent drivers from choosing a neutral response. See Appendix D for a copy of the response card.) For purposes of this analysis, a "problem" was defined as a rating of 5 or more. The fit of the shoulder belt was classified as a problem if it was very close to the driver's neck or shoulder. (These positions correspond to positions 1 and 5, respectively, shown on page 2 of the questionnaire in Appendix C.) If any of the questions relating to a particular aspect fell into the problem category, that feature was assigned a "1" for that driver/vehicle combination. Thus, the severity of the problem was not reflected--just the frequency with which problems were reported or observed.

Composite Index Construction

A Composite Index was developed to reflect drivers' perceived severity of problems for each test vehicle averaged across all nine aspects. The Composite Index was constructed as follows:[1]

(1) The severity of problems for each aspect was determined for each vehicle-driver combination by performing the following steps:

   (a) For each question used to define the aspect based on a 1 to 7 scale, subtract 4 from each aspect score that had a value of 5 or more. Responses with values of 3 or less are set at zero. This shifts the values of the problem scores to lie between zero and three. Questions with binary responses are coded as '0' (no problem) or '1' (problem).

   (b) Add the results of step (a) together for all items in the aspect and divide by the number of items in the aspect. This insures that each aspect will contribute equally to the Composite Index.

(2) A composite rating for each vehicle-driver combination was determined by adding the nine severity scores, from step (b) above, and dividing by nine. This provides an average severity score, ranging in value between 0 and 2.5. The rating was then adjusted to result in an index with possible values of 0 to 100.

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[1] A more detailed discussion of the construction of the Composite Index is provided in Appendix E.

> The Composite Index reflects the average severity of problems across all aspects for each driver-vehicle combination, with 0 signifying no problem with <u>any</u> aspect and 100 signifying the <u>maximum</u> problem with <u>each</u> aspect.

Unlike the 1980-81 study of manual seat belt systems (Tom et al., 1981), which calculated two types of aspect and composite indices--a problem index and an average index--this analysis focuses on the problem index only. This means that favorable rankings (under 4) have been essentially ignored. The problem index is designed to highlight problems in vehicles' comfort and convenience features, whereas the average index assumes that good points offset bad ones. We found that the problem index was more useful and policy-relevant than the average index, since the latter index could easily suggest no problems exist when in fact they do.

Tests of Significance

Comfort and convenience were analyzed with respect to vehicle and driver characteristics, as well as by individual test vehicle. For the aspect analyses, Chi-Square tests were performed to identify statistically significant differences in the number of problems reported by vehicle and driver characteristics. For the composite index, two different statistical tests were conducted. The first tested whether the index was significantly different from zero based on a t-statistic. As described above, the composite index has a possible range from 0 (no problems) to 100 (the most severe problem for every aspect.) Hence, if this index is significantly different from zero, comfort and convenience problems are indicated. The second statistical test used analysis of variance (ANOVA) to determine whether a particular characteristic was significant in explaining differences in the index. It should be noted that since both the sample of vehicles and the sample of drivers were not randomly selected, the results of this analysis are not generalizable to the population as a whole.[1] Therefore, a statistically significant result should be interpreted as indicating only that observed differences were unlikely to have occurred by chance. That is, we would expect to obtain similar results if the experiment were repeated using vehicles and drivers drawn from the same populations.

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[1]The test vehicles were selected (1) to be generally representative of manufacturers and (2) based on model sales within manufacturers. The sample of drivers was designed to overrepresent short, tall, and overweight drivers since previous studies have suggested that these groups have more comfort and convenience problems

Results

Overview

Below, the principal findings of the comparison are summarized.

- All three belt systems tested showed significant comfort and convenience problems.
- Drivers reported the most problems with shoulder belt convenience and lap belt convenience. Entry/Exit problems were also a problem for many drivers.
- Composite index scores were significantly greater than zero in total and by all vehicle and driver characteristics.
- The motorized system and the two-point non-motorized system appear to have the fewest and/or least severe comfort and convenience problems.

Turning to driver characteristics, the following statistically significant findings emerged:

- Women have more comfort and convenience problems than men.
- Automatic restraint systems are most uncomfortable or inconvenient for short drivers and most comfortable or convenient for tall ones.
- Overweight drivers have more belt system problems than do their non-overweight counterparts.
- The youngest drivers (18 to 24 years) report the fewest problems; there are no differences in the composite index for drivers aged 25 years and over.
- While belt use frequency has a significant effect on several aspects, it does not affect the overall perception of automatic restraint comfort and convenience as measured by the composite index.

Vehicle Characteristics

Exhibit 8 presents the results of the aspect and composite index analyses in total and by type of safety belt system and number of car doors.

Overall results. Across all vehicles and drivers, shoulder belt convenience and lap belt convenience presented the most frequent problems. Approximately half of the responses on both of these aspects fell into the problem category. Entry/exit ranked a

Exhibit 8

Percentage of Trials with Problems Associated with Comfort and Convenience Aspects by Test Vehicle Characteristics[1]

ASPECT

	Exit/Entry		Shoulder Belt Fit		Shoulder Belt Comfort		Shoulder Belt Convenience		Lap Belt Fit	
	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems
Belt System										
Motorized Shoulder With Manual Lap	1073	15.4[a]	1064	10.7[a]	1073	16.7[a]	1073	41.2[a]	924	9.2
Non-Motorized with Automatic Shoulder and Lap	595	81.9[a]	584	23.1[a]	595	33.5[a]	595	66.7[a]	511	8.4
Non-Motorized with Shoulder Only	359	37.1[a]	341	7.6[a]	359	14.8[a]	359	46.5[a]	--	n/a
Number of Doors										
Two	715	51.5[a]	700	15.4	715	26.3[a]	715	54.6[a]	510	6.9
Four	1312	31.8[a]	1289	13.0	1312	18.5[a]	1312	47.0[a]	925	10.1
TOTAL/AVERAGE	2027	38.7	1989	13.8	2027	21.3	2027	49.6	1435	8.9

ASPECT

	Lap Belt Comfort		Lap Belt Convenience		Knee Bolster Convenience		Retraction Failure		Composite[b] Index	
	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	Index
Belt System										
Motorized Shoulder With Manual Lap	1063	3.6[a]	1070	51.4	1073	4.4[a]	1003	6.4	1073	6.4[a]
Non-Motorized with Automatic Shoulder and Lap	583	8.8[a]	--	n/a	595	7.4[a]	536	9.7	595	15.2[a]
Non-Motorized with Shoulder Only	--	n/a	--	n/a	359	5.0[a]	342	6.7	359	6.4[a]
Number of Doors										
Two	585	6.0	237	48.5	715	6.2	651	8.8	715	10.8[a]
Four	1061	5.1	833	52.2	1312	5.0	1230	6.7	1312	8.0[a]
TOTAL/AVERAGE	1646	5.4	1070	51.4	2027	5.4	1881	7.4	2027	8.8[a]

[1] In this table, "N" refers to the number of observations (number of drivers times the number of vehicles tested, less missing values) used in the analysis. The numbers shown under "%" are the percentages of observations where at least one problem was indicated.

[a] Vehicle characteristic (type of belt system or number of doors) is statistically significant at the 95% level of confidence.

[b] All composite indices are significantly different from zero at the 95% level of confidence.

close third--almost 40 percent of the drivers had at least one problem in getting into or out of the vehicles. Problems associated with shoulder belt comfort (21 percent indicating problems) and shoulder belt fit (14 percent reporting problems) ranked fourth and fifth, respectively. Problems were indicated in less than 10 percent of the cases for the remaining four aspects.

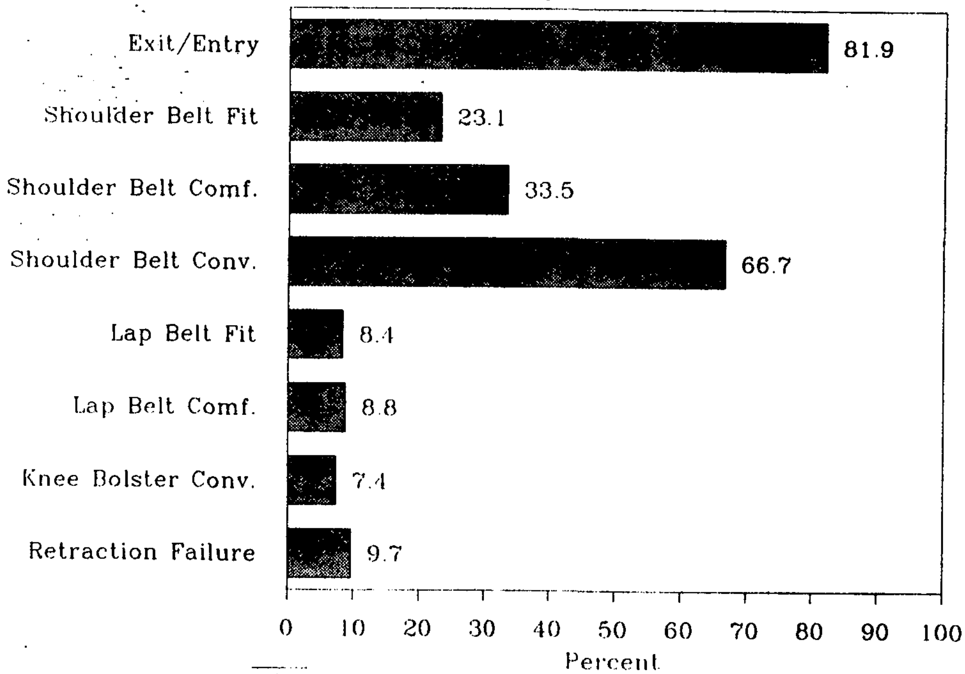
Within the shoulder belt convenience aspect, the two most frequent complaints were interference with vision out of the left side of the car (54 percent of responses falling into the shoulder belt convenience problem category indicated this problem) and difficulty in buckling the emergency release (51 percent of responses indicating a shoulder belt convenience problem identified this as a problem.) The single overriding problem in lap belt convenience was the need to use two hands to buckle the lap belt; 69 percent of responses in the problem category cited this problem. Looking at difficulties getting into and out of the vehicle shows that there were three frequent problems: (1) a perception that the system looked difficult to use (69 percent of problem responses); (2) difficulty in getting into the vehicle (59 percent of problem responses); and (3) difficulty in getting out of the car (66 percent of problem responses).

Type of belt system. Exhibits 9, 10, and 11 summarize the problems associated with the three types of automatic safety belt systems. Of the three types of automatic belt systems, the three-point non-motorized system is the most uncomfortable and inconvenient. For this belt system, there are substantial difficulties getting into and out of the vehicle; over 80 percent of the drivers tested experienced exit/entry problems. (See Exhibit 9.) The most frequent problems were those cited above: Approximately 80 percent of drivers experiencing entry/exit problems thought that the shoulder belts looked difficult to use and caused problems getting into and out of the vehicle. The shoulder belts were also thought to be inconvenient and somewhat uncomfortable: two-thirds of the drivers reported problems associated with shoulder belt convenience, and over one-third noted problems in shoulder belt comfort. The most common shoulder belt convenience problem was interference with vision out of the left side of the car (70 percent of drivers citing shoulder belt convenience problems). For shoulder belt fit, the most frequent complaint was poor fit across the driver's chest and shoulder.

The two-point non-motorized belts also present problems associated with exit/entry and shoulder belt convenience. (See Exhibit 10.) Exit/entry problems were recorded for approximately 37 percent of the drivers tested. The most common problem was the driver's perception that the system looked difficult to use; almost 66

Exhibit 9

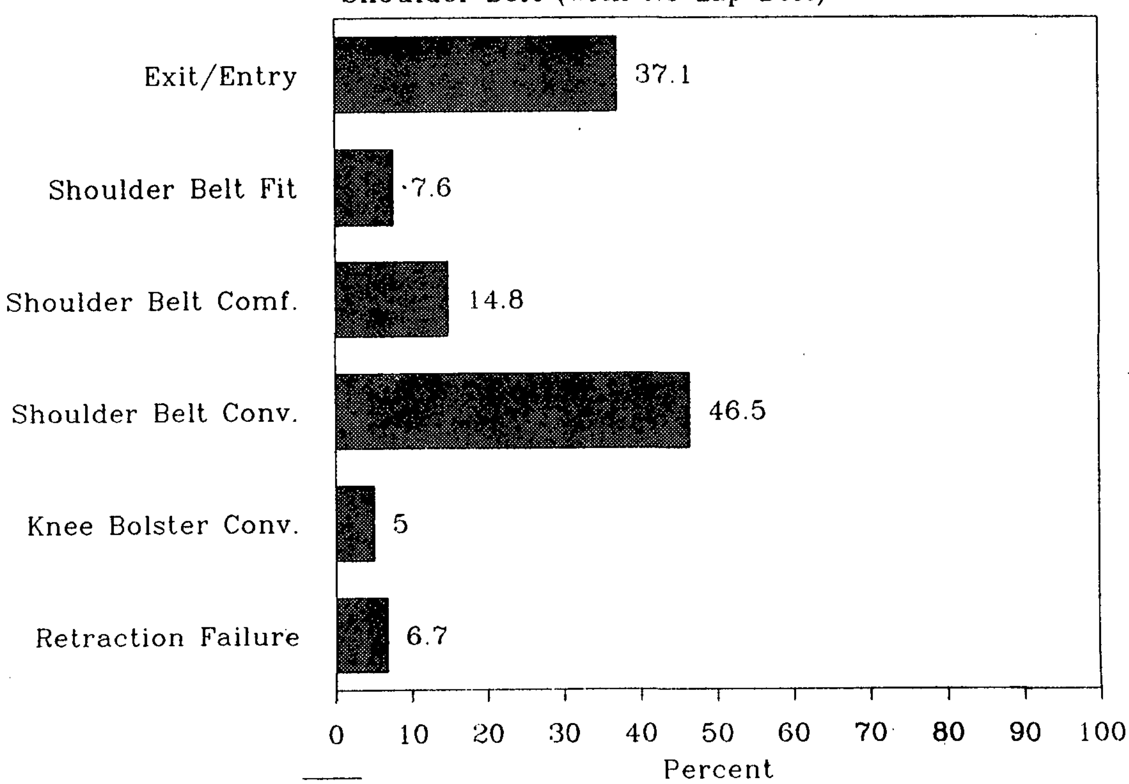
Percentage of Trials with Problems:
Three-Point Non-Motorized
(with Automatic Lap Belt)[1]



[1] Percent of observations where at least one problem was indicated.

Exhibit 10

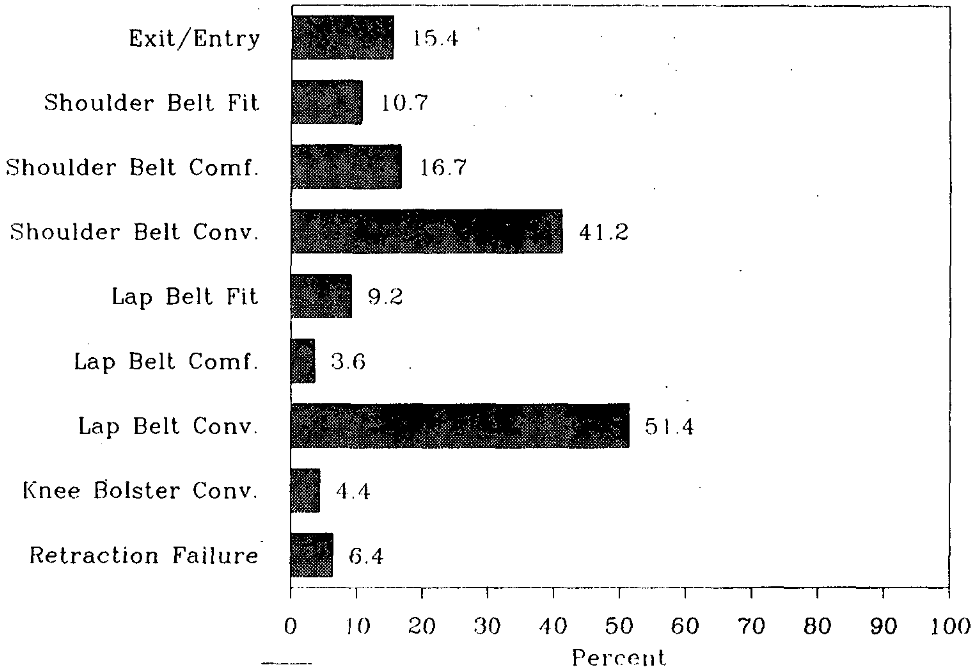
Percentage of Trials with Problems:
Two-Point Non-Motorized
Shoulder Belt (with No Lap Belt)[1]



[1] Percent of observations where at least one problem was indicated.

Exhibit 11

Percentage of Trials with Problems:
Motorized Shoulder Belt with
Manual Lap Belt[1]



[1] Percent of observations where at least one problem was indicated.

percent of drivers indicating entry/exit problems had this concern. Over 46 percent reported at least one problem associated with shoulder belt convenience. Interference with vision out of the left side of the vehicle was the most frequently cited problem. Almost 60 percent of the drivers tested had this complaint.

While the motorized systems appear to have significantly fewer exit/entry problems (15.4 percent reporting problems), they have considerable problems associated with shoulder belt convenience and lap belt convenience. (See Exhibit 11.) Approximately 41 percent of the drivers thought that the shoulder belt was inconvenient in at least one regard. While there was no single predominant problem for this aspect, approximately 46 percent of the drivers reporting any shoulder belt convenience problem had difficulty in buckling the emergency release. Over half of the drivers experienced a problem associated with lap belt convenience. In almost 70 percent of the cases where a problem was reported, two hands were required to buckle the lap belt.

The composite index scores support the aspect findings and indicate that (1) all belt systems have significant comfort and convenience problems and (2) the three-point non-motorized system is significantly more problematic than either of the other two systems. The composite problem index for the three-point system is more than twice those of the two-point non-motorized system and the motorized system.

Vehicle make and model. As discussed above, the type of belt system is clearly important in determining automatic safety belt comfort and convenience. However, it is also useful to examine scores for individual vehicles and to test for significant differences among vehicles with the same types of belt systems. Exhibit 12 shows the percentage of trials that had problems associated with each comfort and convenience aspect for each test vehicle. Within the motorized belt system group, there are significant differences among vehicles for all comfort and convenience aspects except lap belt comfort and lap belt convenience.[1] In addition, the composite index scores (also shown in Exhibit 12) are all significantly different from zero and are significantly related to vehicle make and model.

---

[1]All tests of statistical significance were conducted within a given belt system group. This allows us to examine differences among vehicles' comfort and convenience problems while effectively controlling for differences among belt system types. It should be noted, however, that no controls for the number of car doors were used. It is possible that some of the observed variation in vehicle make and model is attributable to the number of doors rather than to other model-specific characteristics.

Exhibit 12

Percentage of Trials with Problems Associated with Comfort and Convenience Aspects by Test Vehicle[1]

Belt System/Vehicle	Exit/Entry		Shoulder Belt Fit		Shoulder Belt Comfort		Shoulder Belt Convenience: Shoulder Belt Mechanics		Shoulder Belt Convenience: Convenience Interference		Shoulder Belt Convenience: Emergency Release		Overall Shoulder Belt Convenience	
	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems
Motorized Shoulder (with Manual Lap)														
Dodge Shadow	118	17.0[a]	117	15.4[a]	118	22.9[a]	117	15.4[a]	118	31.4[a]	118	46.6[a]	118	60.2[a]
Ford Escort	120	18.3[a]	120	15.8[a]	120	15.0[a]	119	9.2[a]	120	22.5[a]	--	n/a	120	25.8[a]
Ford Tempo	120	20.0[a]	118	9.3[a]	120	18.3[a]	119	10.1[a]	120	14.2[a]	--	n/a	120	22.5[a]
Mazda 626	120	10.8[a]	118	4.2[a]	120	6.7[a]	120	4.2[a]	120	21.7[a]	120	10.8[a]	120	29.2[a]
Mitsubishi Mirage	120	14.2[a]	119	5.9[a]	120	18.3[a]	120	10.0[a]	120	15.8[a]	120	33.3[a]	120	45.8[a]
Nissan Maxima	119	8.4[a]	117	9.4[a]	119	9.2[a]	118	5.1[a]	119	16.8[a]	119	13.5[a]	119	31.1[a]
Peugot 405S	119	16.8[a]	119	10.1[a]	119	22.7[a]	119	27.7[a]	119	9.2[a]	119	29.4[a]	119	47.1[a]
Saab 900 Turbo	117	9.4[a]	117	8.6[a]	117	16.2[a]	116	6.9[a]	117	16.2[a]	116	60.3[a]	117	68.4[a]
Toyota Camry	120	23.3[a]	119	17.7[a]	180	20.8[a]	120	18.3[a]	120	35.0[a]	--	n/a	120	41.7[a]
Subtotal	1073	15.4[a]	1064	10.7[a]	1073	16.7[a]	1068	11.9[a]	1073	20.3[a]	712	32.2[a]	1073	41.2[a]
Non-Motorized with Automatic Shoulder and Lap														
Chevrolet Beretta	119	79.8	116	29.3	119	46.2[a]	--	n/a	119	55.5[a]	117	43.6[a]	119	73.1[a]
Pontiac Boneville	118	78.8	117	23.9	118	29.7[a]	--	n/a	118	69.5[a]	116	7.8[a]	118	70.3[a]
Pontiac Grand Am (2 doors)	119	82.4	115	17.4	119	29.4[a]	--	n/a	119	37.8[a]	117	44.4[a]	119	61.3[a]
Pontiac Grand Am (4 doors)	119	87.4	118	20.3	119	32.8[a]	--	n/a	119	71.4[a]	118	52.5[a]	119	83.2[a]
Pontiac Grand Prix	120	80.8	118	24.6	120	29.2[a]	--	na/	120	40.0[a]	118	16.1[a]	120	45.8[a]
Subtotal	595	81.9	584	23.1	595	33.5[a]	--	n/a	595	54.8[a]	586	32.9[a]	595	66.7[a]
Non-Motorized with Shoulder Only														
Hyundai Excel	119	31.9	110	11.8[a]	119	16.0	--	n/a	119	40.3[a]	118	11.0[a]	119	46.2[a]
Volkswagen Jetta	120	37.5	116	4.3[a]	120	10.0	--	n/a	120	34.2[a]	119	44.5[a]	120	60.0[a]
Yugo	120	41.7	115	7.0[a]	120	18.3	--	n/a	120	17.5[a]	119	23.5[a]	120	33.3[a]
Subtotal	359	37.1	341	7.6[a]	359	14.8	--	n/a	359	30.6[a]	356	26.4[a]	359	46.5[a]
TOTAL/AVERAGE	2027	38.7	1989	13.8	2027	21.3	1068	11.9	2027	32.3	1654	31.2	2027	49.6

[1] In this table, "N" refers to the number of observations (number of drivers times the number of vehicles tested, less missing values) used in the analysis. The numbers shown under "%" are the percentages of observations where at least one problem was indicated.

[a] Make/Model is statistically significant (within each belt system type) at the 95% level of confidence.

[b] All composite incides are significantly different from zero at the 95% level of confidence.

Exhibit 12
(Continued)

Percentage of Trials with Problems Associated with Comfort and Convenience Aspects by Test Vehicle[1]

Belt System/Vehicle	Lap Belt Fit: Base (N)	Lap Belt Fit: % of trials with problems	Lap Belt Comfort: Base (N)	Lap Belt Comfort: % of trials with problems	Lap Belt Convenience: Base (N)	Lap Belt Convenience: % of trials with problems	Knee Bolster Convenience: Base (N)	Knee Bolster Convenience: % of trials with problems	Retraction Failure: Base (N)	Retraction Failure: % of trials with problems	Composite Index[b]: Base (N)	Composite Index[b]: Index
Motorized Shoulder (with Manual Lap)												
Dodge Shadow	102	2.9[a]	116	6.0	118	48.3	118	0.0[a]	111	6.3[a]	118	8.8[a]
Ford Escort	101	5.9[a]	120	4.2	119	50.4	120	6.7[a]	113	7.1[a]	120	6.4[a]
Ford Tempo	104	14.4[a]	120	4.2	120	50.0	120	9.2[a]	110	4.6[a]	120	5.6[a]
Mazda 626	103	3.9[a]	120	1.0	120	51.7	120	0.0[a]	111	11.7[a]	120	2.8[a]
Mitsubishi Mirage	104	8.7[a]	118	4.2	120	54.2	120	3.3[a]	114	14.9[a]	120	6.4[a]
Nissan Maxima	102	13.7[a]	117	3.4	117	513	119	2.5[a]	113	3.5[a]	119	4.0[a]
Peugot 405S	105	16.2[a]	118	5.9	119	56.3	119	11.8[a]	110	0.0[a]	119	7.2[a]
Saab 900 Turbo	101	6.9[a]	116	1.7	117	42.7	117	2.6[a]	105	5.7[a]	117	8.8[a]
Toyota Camry	102	9.8[a]	118	1.7	120	57.5	120	3.3[a]	116	3.5[a]	120	7.6[a]
Subtotal	924	9.2[a]	1063	3.6	1070	51.4	1073	4.4[a]	1003	6.4[a]	1073	6.4[a]
Non-Motorized with Automatic Shoulder and Lap												
Chevrolet Beretta	101	6.9	116	9.5	--	n/a	119	8.4	103	7.8	119	18.0[a]
Pontiac Boneville	100	10.0	115	11.3	--	n/a	118	5.1	109	7.3	118	14.0[a]
Pontiac Grand Am (2 doors)	101	5.9	118	8.5	--	n/a	119	9.2	110	7. 3	119	14.8[a]
Pontiac Grand Am (4 doors)	106	13.2	117	8.6	--	n/a	119	5.9	108	14.8	119	18.0[a]
Pontiac Grand Prix	103	5.8	117	6.0	--	n/a	120	8.3	106	11.3	120	12.0[a]
Subtotal	511	8.4	583	8.8	--	n/a	595	7.4	536	9.7	595	15.2[a]
Non-Motorized with Shoulder Only												
Hyundai Excel	--	n/a	--	n/a	--	n/a	119	3.3	113	11.5[a]	119	6.4
Volkswagen Jetta	--	n/a	--	n/a	--	n/a	120	6.7	116	3.5[a]	120	6.8
Yugo	--	n/a	--	n/a	--	n/a	120	5.0	113	5.3[a]	120	5.6
Subtotal	--	n/a	--	n/a	--	n/a	359	5.0	342	6.7[a]	359	6.4
TOTAL/AVERAGE	1435	8.9	1646	5.4	1070	51.4	2029	5.4	1881	7.4	2027	8.8

[1] In this table, "N" refers to the number of observations (number of drivers times the number of vehicles tested, less missing values) used in the analysis. The numbers shown under "%" are the percentages of observations where at least one problem was indicated.

[a] Make/Model is statistically significant (within each belt system type) at the 95% level of confidence.

[b] All composite incides are significantly different from zero at the 95% level of confidence.

Within the two-point non-motorized belt system group, significant differences among vehicles are found for five of the seven shoulder belt-related aspects--shoulder belt fit, shoulder belt interference, shoulder belt emergency release, overall shoulder belt convenience and shoulder belt retraction. Differences among vehicles for other aspects are not significant. Similarly, while the composite index scores are significantly greater than zero, they do not vary across the four cars in the two-point non-motorized belt system category.

Looking at the three-point non-motorized belt system group shows that the frequency of comfort and convenience problems varies significantly across vehicles for four shoulder belt-related aspects--shoulder belt comfort, shoulder belt interference, shoulder belt emergency release, and overall shoulder belt convenience. As with the two-point non-motorized systems, differences for other aspects are not significant. The composite index scores, however, do vary across vehicles in this group.

Driver Characteristics

This part of the analysis examines the bivariate relationships between individual driver characteristics and comfort and convenience problems. The characteristics considered include sex, height, weight, age, and belt use frequency. The results of the analysis are presented in Exhibit 13 and are discussed below.

Gender. With regard to driver sex, it was expected that females would have more comfort and convenience problems than would males. This expectation was only partially fulfilled by the data. Females experienced significantly more problems associated with shoulder belt fit, shoulder belt comfort, shoulder belt retraction, and lap belt fit. However, males cited more problems with lap belt convenience than did females. Differences for other aspects tend to be in the expected direction (e.g., women find the shoulder belt less convenient than men) but are not statistically significant. The composite index scores indicate that women have significantly more comfort and convenience problems than do men.

Height. It was expected that both shorter and taller drivers would have more comfort and convenience problems than drivers of average height. However, the results of the analysis suggest that while shorter drivers have the most problems, taller drivers have the fewest. This is particularly true for aspects of shoulder belts. For example, while shoulder belt fit, comfort, and convenience all vary significantly with height, the percentage of problem responses decreases as height increases.[2] Shorter drivers

[2]The two tallest subjects were 6'6" and 6'2".

Exhibit 13

Percentage of Trials with Problems Associated with Comfort and Convenience Aspects by Selected Driver Characteristics[1]

ASPECT

Driver Characteristic	Exit/Entry		Shoulder Belt Fit		Shoulder Belt Comfort		Shoulder Belt Convenience		Lap Belt Fit	
	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems
Sex										
Male	1236	38.4	1222	10.5[a]	1236	17.3[a]	1236	47.9	908	6.2[a]
Female	791	39.2	767	19.2[a]	791	24.4[a]	791	52.3	527	13.7[a]
Height										
58-62 in.	168	32.1[a]	164	28.1[a]	168	33.9[a]	168	64.9[a]	121	2.5[a]
63-66 in.	590	43.1[a]	581	17.2[a]	590	26.6[a]	590	50.2[a]	382	15.7[a]
67-69 in.	524	38.7[a]	508	11.8[a]	524	18.7[a]	524	51.5[a]	378	7.7[a]
≥ 70 in.	745	36.8[a]	736	9.4[a]	745	16.0[a]	745	44.4[a]	554	6.5[a]
Weight										
Overweight	456	43.4[a]	436	20.4[a]	456	27.0[a]	456	52.2	322	14.0[a]
Not Overweight	1571	37.4[a]	1553	12.0[a]	1571	19.6[a]	1571	48.9	1113	7.5[a]
Age										
18-24 yrs.	287	31.7[a]	284	11.3	287	11.1[a]	287	33.5[a]	183	7.1
25-29 yrs.	456	37.3[a]	452	12.6	456	20.8[a]	456	50.9[a]	320	10.0
30-59 yrs.	896	40.6[a]	875	15.8	896	23.9[a]	896	54.1[a]	659	8.2
≥ 60 yrs.	388	41.2[a]	378	12.7	388	23.2[a]	388	49.7[a]	273	10.6
Belt Use Frequency										
Almost Always	864	39.4	853	12.5[a]	864	20.6	864	52.3[a]	647	8.0[a]
Occasionally	725	36.1	705	14.5[a]	725	22.6	725	48.6[a]	518	8.1[a]
Almost Never	370	43.5	363	13.0[a]	370	19.5	370	43.2[a]	219	14.2[a]
TOTAL/AVERAGE	2027	38.7	1989	13.8	2027	21.3	2027	49.6	1435	8.9

ASPECT

Driver Characteristic	Lap Belt Comfort		Lap Belt Convenience		Knee Bolster Convenience		Retraction Failure		Composite[b] Index	
	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	% of trials with problems	Base (N)	Index
Sex										
Male	1003	5.4	651	54.7[a]	1236	5.8	1159	5.8[a]	1236	7.6[a]
Female	643	5.4	419	46.3[a]	791	4.7	722	10.0[a]	791	10.8[a]
Height										
58-62 in.	134	3.7	88	46.6	168	8.9[a]	158	7.0	168	13.6[a]
63-66 in.	483	5.8	313	46.3	590	3.4[a]	557	8.4	590	10.4[a]
67-69 in.	425	3.5	274	55.5	524	5.2[a]	485	7.8	524	8.4[a]
≥ 70 in.	604	6.8	395	53.7	745	6.3[a]	681	6.3	745	7.2[a]
Weight										
Overweight	370	6.5	242	55.4	456	5.0	424	11.3[a]	456	11.2[a]
Not Overweight	1276	5.1	828	50.2	1571	5.5	1457	6.3[a]	1571	8.4[a]
Age										
18-24 yrs.	230	4.8	151	51.7[a]	287	3.1	275	6.9	287	6.4[a]
25-29 yrs.	372	7.8	243	55.1[a]	456	6.1	417	9.1	456	8.8[a]
30-59 yrs.	730	4.8	471	52.9[a]	896	4.4	829	7.8	896	9.6[a]
≥ 60 yrs.	314	4.5	205	43.4[a]	388	8.5	360	4.7	388	9.2[a]
Belt Use Frequency										
Almost Always	702	6.0	457	50.6[a]	864	6.0[a]	797	7.8	864	8.8
Occasionally	591	6.4	380	50.8[a]	725	5.4[a]	676	5.9	725	9.2
Almost Never	298	2.7	197	57.9[a]	370	3.0[a]	342	9.1	370	8.4
TOTAL/AVERAGE	1646	5.4	10.70	51.4	2027	5.4	1881	7.4	2027	8.8

[1] In this table, "N" refers to the number of observations (number of drivers times the number of vehicles tested, less missing values) used in the analysis. The numbers shown under "%" are the percentages of observations where at least one problem was indicated.

[a] Driver characteristic is statistically significant at the 95% level of confidence.

[b] All composite indices are significantly different from zero at the 95% level of confidence.

experience substantial interference from shoulder belts in looking out of the left side of the car. Almost 60 percent of drivers under 63 inches who had shoulder belt convenience problems report this difficulty. By contrast, shorter drivers have the fewest problems getting into and out of the car; drivers of average height appear to have the most difficulty. Similarly, lap belt fit is most problematic for drivers between 63 and 66 inches; drivers under 63 inches report the fewest problems. The composite index scores indicate that the number and severity of comfort and convenience problems are inversely related to height. Shorter drivers have significantly more problems than do average or taller ones.

Weight. Another expectation was that overweight drivers would have more comfort and convenience problems than non-overweight drivers. Generally, the data suggest that overweight drivers do have more problems, and many of the differences are significant. Significant differences were detected for exit/entry, shoulder belt comfort, shoulder belt convenience, shoulder belt retraction, and lap belt fit. The composite index scores also indicate that overweight drivers have significantly greater comfort and convenience problems than do their non-overweight counterparts.

Age. Differences by driver age were also examined. It was expected that older drivers might have more problems than younger ones. While this expectation was borne out for some aspects, there was no clear pattern in others. As might be expected, older drivers had more problems getting into and out of the vehicles than did younger drivers. However, the percentages of older and younger drivers who thought that the belt systems looked difficult to use were similar--almost 70 percent of drivers who report entry/exit problems. Older drivers more frequently cited shoulder belt comfort problems. In addition, drivers who were 25 year of age and older had more shoulder belt convenience problems than did those under 25 years. However, older drivers (60 years and over) reported fewer lap belt convenience problems than did drivers under 60 years of age. Looking at the composite index suggests that, overall, the youngest drivers (18 to 24 years) had the fewest comfort and convenience problems. Differences among the other three age groups are minimal and not significantly different from one another.

Normal belt use. It was expected that drivers who normally use their safety belts might experience fewer automatic restraint comfort and convenience problems than those who almost never use them. Indeed, drivers in the study who almost always use their safety belts cited significantly fewer lap belt fit and lap belt convenience problems than did those who almost never use them. However, belt users found the automatic shoulder belts to be significantly more inconvenient than did non-belt users.

Overall, the composite index scores show no significant differences by belt use frequency.

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Appendices

Appendix A

VEHICLE DATA FORM

1. Car Number:	______ ______	
2. Make/Manufacturer:	ENTER CHOICE: ______ ______	
3. Wheel Base	ENTER INCHES: ______ ______	
4. Number of Doors:	Two Four	1 1
5. Type of Front Seat:	Bench Bucket	1 1
6. General Descriptor for Belt System:	Motorized shoulder belt & manual lap belt	1
	2-point non-motorized with manual lap belt for child seat in front outboard seat	2
	2-point non-motorized without manual lap belt for child seat in front outboard seat	3
	3-point non-motorized with manual lap belt for child seat in front outboard seat	4
	3-point non-motorized without manual lap belt for child seat in front outboard seat	5

(continued over)

7.	Type of lap belt retractor in front outboard seats:	Emergency locking Automatic locking	1 2
8.	Number of seating positions in rear seat:	Two Three	1 2
9.	Type of belt in outboard rear seats:	2-point 3-point	1 2
10.	Type of retractor in outboard rear seats:	Emergency locking Automatic locking	1 2
11.	Type of retractor in center rear position:	Emergency locking Automatic locking No retractor No center seat	1 2 3 4

ID # 1-7/

Batch 8/

Appendix B

TESTER INFORMATION FORM

TESTER'S INITIALS ____ ____ ____	TESTER NUMBER: ___ ___ ___	9-11/

PLEASE BE HONEST AND INDICATE HOW OFTEN YOU USE A SAFETY BELT WHILE RIDING AS A DRIVER OR PASSENGER IN A CAR.	Almost always	1	12/
	Occasionally or once in a while	2	
	Almost never	3	

		MALE	FEMALE	
	1. SEX	1	2	13/
	2. AGE	____	____	14-15/
	3. WEIGHT	___ ___	___	16-18/
	4. HEIGHT (IN INCHES)	____	____	19-20/
		YES	NO	
	5. ANY UPPER BODY MOBILITY PROBLEMS?	1	2	21/

IF YES, DESCRIBE:

22-23/
24-25/

OMB Number 2127-053
I.D. # 1-6/
BATCH 7-8
9-11/B

Appendix C

AUTOMATIC SAFETY BELT SYSTEM EVALUATION

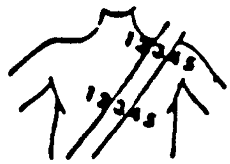
TESTER NUMBER: [ ][ ][ ]

CAR NUMBER: [ ][ ][ ]   ROUND NUMBER: [ ][ ] 12-13/

EXPERIMENTER INSTRUCTION	QUESTIONS	ANSWERS	
Ask the subject to open the door, but not get in. Ask question 1. Refer to the rating scale on the steering wheel.	1. On a scale from 1 to 7, does the belt system look easy or difficult to use? For example, is it clear how to get into the car?	1 2 3 5 6 7	14/
Ask the subject to enter the car and close the door. Note how the subject entered the car. Record the answer.		Correctly 1 Sat on Belt 2 Lifted Belt 3 Unbuckled Belt 4 Stepped Over Belt 5 Stepped Under Belt 6 Other 7	15/
Note if the arm or hand of the subject is entrapped by the system.		YES 1 NO 2	16/
Tell the subject, "If you feel it's needed, you may adjust the seat."			
Ask questions 2-3. Ask subject to refer to the scale on the steering wheel when answering the questions.	2. Did the belt system make entering and sitting in the car easy or difficult? Use the scale.	1 2 3 5 6 7	17/
	3. Did the belt system make it easy or difficult to close the door? Use the scale.	1 2 3 5 6 7	18/
For motorized systems, instruct subject to turn key until it "clicks." Then ask questions 4 and 5.	4. Is the distance between the moving belt and your head acceptable or unacceptable?	1 2 3 5 6 7	19/
	5. Is the movement or speed of the belt acceptable or unacceptable for you?	1 2 3 5 6 7	20/

EXPERIMENTER INSTRUCTION	QUESTIONS	ANSWERS	
Ask the subject to move the seat forward and back. Ask question 6.	6. Did the belt system make adjusting the seat difficult or easy? Please use the scale.	1 2 3 5 6 7	21/
Note if the belt was twisted. Correct the twisting.		YES 1 NO 2	22/
Note the fit of the belt:			
- At the shoulder		shoulder 1 2 3 4 5	23/
- At the sternum		sternum 1 2 3 4 5	24/
Refer the subject to the scale, and ask questions 7 and 8.	7. How does the shoulder belt fit across your chest and shoulder? For example, does it cross your body comfortably or uncomfortably, or does it rub against your neck or chest? Use the scale.	1 2 3 5 6 7	25/
	8. Does the shoulder belt press on your body comfortably or uncomfortably?	1 2 3 5 6 7	26/
For cars with a manual lap belt, ask the subject to put on the lap belt. Note if one or two hands were used to extend the latchplate.		ONE 1 TWO 2	27/
Note if one or two hands were used to buckle the belt.		ONE 1 TWO 2	28/
Note if the belt was twisted. Correct any twisting.		YES 1 NO 2	29/

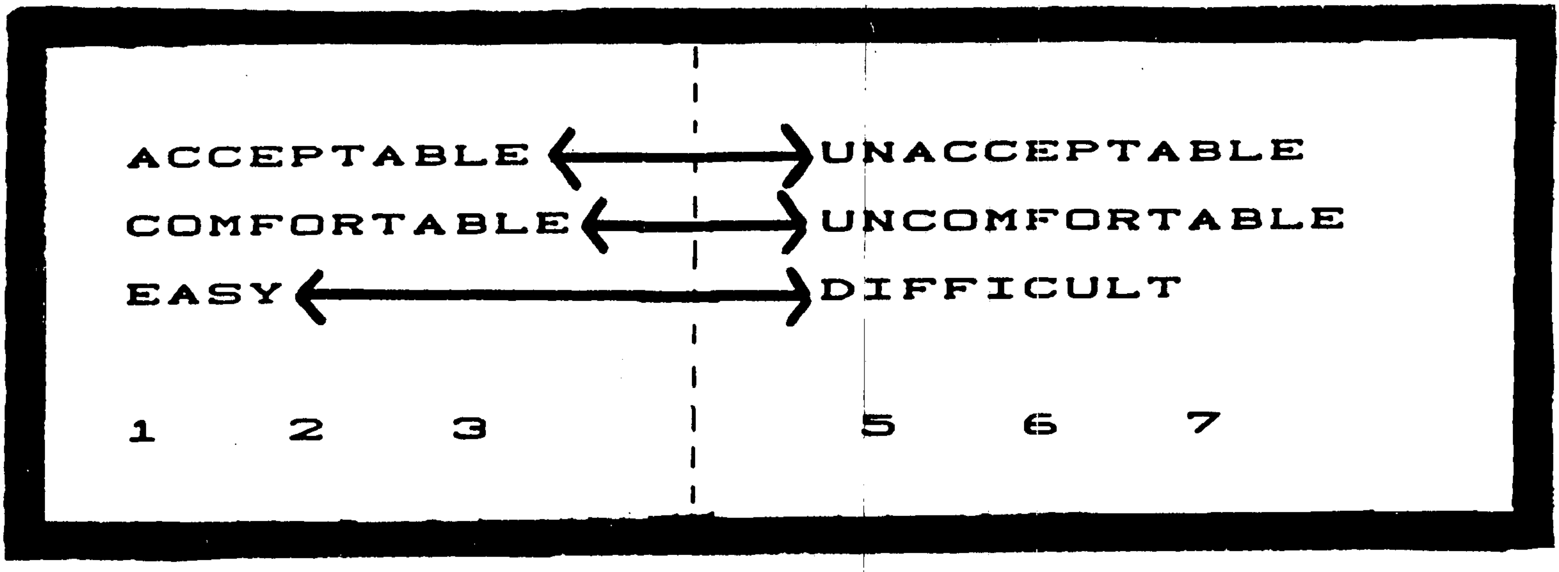
EXPERIMENTER INSTRUCTION	QUESTIONS	ANSWERS	
Refer the subject to the scale again and ask questions 9 through 12.	9. How easy or difficult was it to find the buckle? For example, was it hidden behind the seat? Please use the scale.	1 2 3 5 6 7	30/
	10. Was it easy or difficult to move the latchplate over to the buckle? For example, did the belt extend smoothly from the retractor?	1 2 3 5 6 7	31/
	11. How easy or difficult was it for you to grasp the latchplate? For example, was there anything blocking the path to the latchplate, or did you have to open the door to reach it?	1 2 3 5 6 7	32/
	12. Was it easy or difficult to fasten the buckle? For example, was the opening in the buckle easy to locate? Was it difficult to insert the latchplate into buckle?	1 2 3 5 6 7	33/
For manual and automatic lap belts: Note the fit of the belt:			
- Low (across pelvis)		YES NO 1 2	34/
- High (across stomach)		YES NO 1 2	35/
Now ask question 13.	13. Does the lap belt press on your body comfortably or uncomfortably? Use the scale.	1 2 3 5 6 7	36/
For all cars <u>other</u> than GM, skip to Experimenter Instruction that follows the next chest diagram. For all <u>GM</u> cars, follow the next instruction.			
(For GM cars only) Ask subject to set "window shade device" Observe is subject was successful.		YES NO 1 2	37/

EXPERIMENTER INSTRUCTION	QUESTIONS	ANSWERS	
After the device has been set properly, ask question 14.	14. Does the shoulder belt press on your body comfortably or uncomfortably now? Use the scale.	1 2 3 5 6 7	38/
Note the fit of the belt: - At the shoulder - At the sternum		shoulder 1 2 3 4 5 sternum 1 2 3 4 5	39/ 40/
For all cars, say "Please reach for the glove box, and return to the normal driving position." Record if there is now excessive slack or looseness in shoulder belt.		YES NO 1 2	41/
Ask subject to fix any slack or looseness in the shoulder belt. Ask question 15.	15. Was there scuffing or rubbing of the belt against your shoulder? Use the scale.	1 2 3 5 6 7	42/
Say, "Place your hands on the steering wheel and, without turning your body, look to the left rear as far as you can. Keep this this position." Ask questions 16 and 17.	16. Does any part of the belt system interfere with your vision out of the left side of the car?	YES NO 1 2	43/
	17. If yes, ask: what part of the system interferes?	Belt 1 Retractor 2 Anchor 3 Other 4	44/
Record if there is excessive slack or looseness in the belt. Ask subject to fix any slack.		YES NO 1 2	45/
For cars with an emergency buckle release, say: "Unbuckle the emergency release, then let go of the belt and rebuckle it." Ask questions 18 and 19.	18. Was the belt easy or difficult to unbuckle? Use the scale.	1 2 3 5 6 7	46/
	19. Was the belt easy or difficult to buckle: Use the scale.	1 2 3 5 6 7	47/

EXPERIMENTER INSTRUCTION	QUESTIONS	ANSWERS	
For cars without buckle release, say: "Release the emergency lever on the retractor on the center console and release the webbing." Ask question 20.	20. Was the webbing release easy or difficult to operate? Use the scale.	1 2 3 5 6 7	48/
Record if there is excessive slack or looseness in the shoulder belt?		YES NO 1 2	49/
Ask subject to fix any slack.			
Say: "Now release the lap belt" (where applicable). Ask question 21.	21. Was it easy or difficult to release the lap belt? Use the scale.	1 2 3 5 6 7	50/
For GM and Honda cars, skip to question 22.			
For cars without a lap belt, ask the subject to "use your ruler to measure the distance between your right knee and the bolster (the bottom of the dash board)." Record the number of inches.		Inches____ ____	51-52/
Ask question 22. Refer subject to the scale.	22. Is the knee bolster (that is, the bottom of the dashboard) causing you any discomfort? Use the scale.	1 2 3 5 6 7	53/
Say, "Open the door and get out of the car." Observe if physical contact was made with the belt system.		YES NO 1 2	54/
Ask question 23.	23. Did the knee bolster (that is, the bottom of the dashboard) make it easy or difficult to get out of the car? Use the scale.	1 2 3 5 6 7	55/
Ask question 24.	24. Did the belt system make it easy or difficult to get out of the car? Use the scale.	1 2 3 5 6 7	56/
Ask question 25.	25. Would you use or wear this belt whenever you drove if this car belonged to you?	YES NO 1 2	57/

Appendix D

RESPONSE CARD



Appendix E

Composite Index Construction

The composite index is a summary measure of comfort and convenience problems across all aspects for each driver/vehicle combination. It is similar to the aspect indices except that it takes into account the perceived severity of the inconvenience or discomfort. The composite index was calculated in three steps.

(1) A severity-based rating was computed for each aspect. Specifically, for each aspect i, a rating was calculated as:

$$\frac{\sum_{j} \text{SUM}\,[\text{Max}\,(Q_j - 4),0]}{N}$$

where:

Q_j = the jth question (pertaining to aspect i)

N = total number of questions (pertaining to aspect i).

Thus, the score for any driver who rated a problem as a 7 on the severity scale was recoded as a "3" (or 7-4); a 6 was recoded as a "2" (or 6-4); and a 5 was recoded as a "1" (or 5-4). Any rating below a 4 was coded a "0" (no problem). Observations using a two-point scale (problem/no problem) were coded as "1" if a problem was indicated, and zero otherwise. The severity-based aspect rating for a given aspect was calculated by taking the average of these numbers across all questions included in the scoring of that aspect. The average, rather than the total, was calculated because different numbers of questions were used in evaluating different aspects. For example, only three questions were used in evaluating Shoulder Belt Comfort, whereas six questions were used to evaluate Entry/Exit problems. (See Exhibit 4-1, Groupings of Questions by Comfort and Convenience Aspect.) Totaling the scores for Entry/Exit problems could have resulted in higher scores than totaling the scores for shoulder belt comfort simply because three more questions (and, hence, three more numbers) were involved, not necessarily because the problems identified for Entry/Exit were more frequent or severe than for Comfort and Convenience.

Using the aspect of the Shoulder Belt Comfort, we can illustrate how the severity-based rating is derived. As noted, three questions were included in the examination of this aspect. All three were coded using the 1 to 7 interval scale. Assume that, when evaluating the belt system of a specific vehicle, the driver gave scores of 5, 2, and 6. This driver's score for this aspect for this car would be $(\frac{1+0+2}{3}) = 1$. That is, the first question receives a score of (5-4) = 1; the second question is given a zero (any score less than 4 is "no problem," or 0); and the third question is scored (6-4) = 2. Since there are three questions involved in scoring this aspect, the sum is divided by 3. Because the severity-based index for each aspect is the average of these numbers, higher numbers represent more severe problems. For example, if the driver rated the vehicle 5, 6, and 7 on the three aspects, rather than 5, 2, and 6, the severity-based index would have been $2 = (\frac{1+2+3}{3})$ rather than 1.

(2) The result of the first step was a set of nine severity-based problem aspect ratings for each vehicle/driver combination. In the second step for computing the composite index, the average for each vehicle/driver combination across all aspects was calculated. The nine aspect ratings were summed and divided by 9 to compute a composite rating.

(3) The second step resulted in a set of composite ratings with a possible range of 0 (no problems) to 2.5 (the most severe problem for every aspect.[1] The final step in computing the composite index was to index the composite rating to a 0 to 100 scale. Using this scale, "0" means no problems, and "100" indicates severe problems in every aspect. Continuing with the Shoulder Belt Comfort aspect rating as an example, the first rating of "1" becomes 40.0 ($\frac{1 \times 100}{2.5}$), and the second rating of "2" is 80.0 ($\frac{2 \times 100}{2.5}$).

[1]The upper bound of 2.5 for the composite rating takes into account that the worst case rating for two aspects is one and that the other aspects include binary (zero or one) components.