UMTRI-90–24

INVESTIGATION OF DRIVER PREFERENCE FOR LOCATIONS OF PRIMARY CONTROLS AND ARMRESTS

PHASE III
REAL-WORLD VALIDATION OF SEATING BUCK RESULTS

Lawrence W. Schneider
Miriam A. Manary

University of Michigan
Transportation Research Institute
2901 Baxter Road
Ann Arbor, Michigan 48109–2150

Submitted to:

Chrysler Motors Corporation
12000 Chrysler Drive
Highland Park, Michigan 48288–1118

April 1990

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UMTRI-90-24		

4. Title and Subtitle	5. Report Date
INVESTIGATION OF DRIVER PREFERENCE FOR LOCATIONS OF PRIMARY CONTROLS AND ARMRESTS. PHASE III: REAL-WORLD VALIDATION OF SEATING BUCK RESULTS	April 1990
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
L.W. Schneider and M.A. Manary	UMTRI-90-24
9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
University of Michigan Transportation Research Institute 2901 Baxter Road Ann Arbor, Michigan 48109-2150	11. Contract or Grant No. 389038
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	FINAL REPORT
Chrysler Motors Corporation 12000 Chrysler Drive Highland Park, Michigan 48288-1118	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Three vehicles representing G-, H-, and S-body types were modified to enable the primary driver controls and armrests to be located at the estimated "optimal" locations determined under static laboratory testing conditions and, where feasible, to be adjusted between optimal and production locations. Three sets of twenty drivers in four size (i.e., stature) groups test drove each vehicle with the control and armrest components located alternately in the two package configurations (i.e., production and optimal). Additionally, ten minivan drivers were tested in this manner to better evaluate the S-body optimal shift-knob height.

On each drive, subjects were asked to position the seat and seatback angle to their preferred locations and, upon return to the UMTRI parking lot, to provide subjective commentary (e.g., like/dislike and too close/too far) on the locations of the various components. The data were analyzed to determine if any dynamic driving factors would make the optimal locations unsuitable for in-vehicle use and to further evaluate these estimated optimal locations.

17. Key Words	18. Distribution Statement
Driver Controls Control Locations Driver Armrests	Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
None	None	178	

Reproduction of completed page authorized

ACKNOWLEDGEMENTS

The authors wish to acknowledge the many persons at Chrysler who assisted with the modifications to the test vehicles used in this study and who had input to the testing procedures. These include Al LaCroix (retired), Ray Towne, Paul Gritt, Brian Pechenuik, Scott Baker, Ken Socks, and others. The authors also wish to express appreciation to Ernest Lueder who designed and fabricated most of the components required to modify the vehicles, to Eric Olson and Scott Orr who conducted the data collection phase of the project, and to Leda Ricci for preparation of this document.

CONTENTS

ACKNOWLEDGEMENTS v

LIST OF TABLES ix

LIST OF FIGURES xi

SUMMARY 1

I. INTRODUCTION AND OBJECTIVES 3

II. PROCEDURES 5

A. Vehicles and Vehicle Modifications 5
B. Test Procedures and Protocol 9

III. RESULTS 15

A. Subjective Ratings for Pedal/Steering Wheel Locations, Steering Wheel-to-Pedal Distance, and Accelerator-Brake Lift-Off Distance 15
B. Subjective Ratings for Armrest Heights 22
C. Subjective Ratings for Shift-Knob Height 25
D. Seat Position Results 27
E. Brake Responsiveness 31
F. Subject Comments Re: Other Ergonomic Factors 31

IV. DISCUSSION AND CONCLUSIONS 33

A. Wheel-Pedal Relationship in G- and H-Body Vehicles 34
B. Accelerator-Brake Lift-Off 35
C. Armrest Heights 35
D. Shift-Knob Heights 36
E. Preferred Seat Positioning 37

APPENDIX A: Data Collection Forms 39

APPENDIX B: Tabulation of Subjective Ratings for Control/Armrest Locations 53

APPENDIX C: Bar Graphs of Overall and Individual Subjective Ratings for Pedal and Steering Wheel Locations 71

APPENDIX D: Bar Graphs of Overall and Individual Subjective Ratings for Door and Console Armrest Heights 89

APPENDIX E: Bar Graphs of Overall and Individual Subjective Ratings for Shift-Knob Heights 107

APPENDIX F: Comparisons of Driver Selected Seat Position, Seatback Angles, and Chin-to-Wheel Distances in Optimal- and Production-Package Configurations 113

APPENDIX G: Subject Comments with Regard to Brake System Responsiveness in Optimal and Production Packages 125

APPENDIX H: Subject Comments with Regard to Other Interior Design Features 131

LIST OF TABLES

	Page
1. Optimal Versus Production Control Locations	6
2. Changes in Production Control/Armrest Locations Used to Implement Optimal Package Configurations	6
3. Subject Groups and Sample Size for Study Population	12
4. Overall Mean Subjective Ratings for Optimal and Production Control/ Armrest Location	18
5. Frequency of Strong Subjective Response Re Pedals and Steering Wheel Locations in Optimal and Production Configurations	19
6. Frequency of Strong Subjective Responses to Armrest Heights in Optimal and Production Configurations	23
7. Frequency of Strong Subjective Responses to Shift-Knob Heights in Optimal and Production Configurations	26
8. Summary of Preferred Seat Adjustments	27
9. Summary of Preferred Seat to Controls Positioning	29

LIST OF FIGURES

Page

1. Modified pedals in G- and H-body vehicles showing added aluminum brackets for attaching more rearward brake and clutch pedals and modified accelerator linkage with receptacle for interchanging accelerator pedals with different shaft lengths. 7

2. Raised shift knob in Minivan 8

3. Console and door armrests in G-body and H-body vehicles showing removable pad in place to achieve optimal armrest heights 10

4. Seat track and seat back angle read-out scales 11

5. Bar graphs comparing overall subjective ratings of like/dislike for production and optimal control/armrest locations 16

6. Bar graphs comparing overall subjective ratings for location of production and optimal controls and armrests 17

7. Comparisons of overall mean seat positions, seatback recline angles, and chin-to-wheel distance for optimal and production package configurations. . 28

8. Comparison of overall mean seat-to-wheel, seat-to-brake, and seat-to-AHP distance for optimal and production packages. 30

9. Minivan driver estimates for optimal shift-knob heights 37

SUMMARY

In two previous studies (Schneider et al. 1987, 1988), a computer-controlled laboratory seating buck with adjustable positions for the steering wheel, pedals, shift knob, and armrests was used to experimentally determine preferred and acceptable locations for these controls and armrests in G-, H-, and S-body roadable vehicles. One-hundred subjects spanning the stature range from 5th percentile female to 95th percentile male were tested in each vehicle package configuration, and the results were used to estimate improved control and armrest locations that would "satisfy" a maximum percentage of the driving population.

In the present study, modifications were made to G-, H-, and S-body vehicles that enabled the primary driver controls and armrests to be located at these "optimal" locations and, where feasible, to be adjusted between optimal and production locations. Twenty drivers in four size (i.e., stature) groups test drove each vehicle with the control and armrest components located alternately in the two package configurations (i.e., production and optimal). On each drive, subjects were asked to position the seat and seatback angle to their preferred locations and, upon return to the UMTRI parking lot, to provide subjective commentary (e.g., like/dislike and too close/too far) on the locations of the various components.

While the subjective responses to the optimal and production pedal-to-wheel relationships do not show a strong or consistent preference for either package configuration for the pedals and steering wheel, it is most significant to the purpose of the study that there were no "dynamic" (i.e., during driving) factors that overruled the results from the laboratory seating buck tests. With regard to accelerator-to-brake lift-off distance, only two people out of sixty indicated that the brakes seemed less responsive in the optimal configuration with a smaller accelerator-to-brake lift-off distance.

Subjective responses to the optimal and production armrest heights suggest, in general, that the optimal height is somewhere between the two and that the optimal armrest may be one that is adjustable in height for different types of driving. Results for the Minivan shift knob location suggest that the optimal height determined in the seating buck study is too high by about two inches.

I. INTRODUCTION AND OBJECTIVES

In two previous studies (Schneider et al. 1987, 1988), a computer-controlled laboratory seating buck with adjustable primary control and armrest locations was used to determine preferred and acceptable locations for the steering wheel, pedals, shift knob, and armrests in G-, H-, and S-body vehicles. One-hundred subjects[1] spanning the stature range from 5th percentile female to 95th percentile male were tested for each vehicle package configuration, and the results were used to estimate optimal control locations that would "satisfy" a maximum percentage of the driving population.

The results of these laboratory studies suggest the following changes in current package dimensions:

1. reduction of the steering wheel-to-pedal horizontal distance in the G- and H-body vehicles;
2. reduction of the accelerator-to-brake pedal lift-off distance in all vehicles;
3. raising of the door and center armrest heights in all vehicles for highway driving;
4. raising of the shift-knob height in the S-body vehicle.

Before implementing these changes in future production vehicles, it was desired to experimentally validate these "optimal" control locations by implementing them in actual vehicles and having drivers evaluate and compare them to the production dimensions under actual driving conditions. In the current study, it was primarily desired to determine if there were any dynamic (i.e., during actual driving) factors, such as undesirable changes in subjective feel of braking, that would conflict with or modify the laboratory findings for optimal control and armrest locations determined in the static seating buck tests.

---

[1]The rights, welfare, and informed consent of the volunteer subjects who participated in this study were observed under guidelines established by the U.S. Department of Health and Human Services on Protection of Human Subjects, and accomplished under medical research design protocol standards approved by the Committee to Review Grants for Clinical Research and Investigation Involving Human Beings, Medical School, The University of Michigan.

II. PROCEDURES

A. VEHICLES AND VEHICLE MODIFICATIONS

In order to accomplish the validation of control/armrest locations, 1989 G-, H-, and S-body vehicles equipped with manual transmissions were obtained from Chrysler Motors Corporation and modified to achieve the optimal control and armrest locations. Tables 1 and 2 summarize the current and desired (i.e., optimal) positions and the changes in pedal, shift knob, and armrest locations that were implemented in the three vehicles.

Figure 1 illustrates the pedal modifications made to the G- and H-body vehicles to allow switching between optimal and production[2] steering wheel-to-pedal distances. Aluminum brackets were attached to the clutch and brake pedal linkages to enable a second brake or clutch pedal to be placed over the production pedal, thereby achieving the more rearward (i.e., closer to steering wheel) pedal locations called for in the optimal control locations. While the manner in which this was accomplished resulted in some change in the effective pedal-to-pivot point distances (i.e., increased the effective pivot arm for the optimal location), which in turn resulted in some change in required pedal force (i.e., less force required in the optimal pedal configuration), this difference was judged by the investigators to be unnoticeable and insignificant. Furthermore, since the required pedal force was reduced for the optimal locations, it was felt that the changes made would result in a less desirable (i.e., less responsive) pedal feel which would tend to enhance the probability of finding a problem with the optimal pedal locations. In designing the adapting brackets, care was taken to ensure that the brackets did not interfere with the driver's foot during pedal actuation in either the optimal or production configurations.

In the S-body vehicle, it was desired to increase the steering wheel-to-brake pedal distance by about one inch (see Table 2). This was done by adjusting the steering wheel mounting bracket to allow the steering column to be tilted rearward enough to accomplish the desired one inch of rearward movement of the center of the steering wheel. Changes in the steering wheel tilt and height resulting from this modification were minimal.

In order to adjust the accelerator-to-brake lift-off distance and allow switching between production and optimal dimensions, the accelerator pedal linkage assembly in each

---

[2]The terms *production* and *design* are used interchangeably in this report to refer to current vehicle package geometry.

TABLE 1

OPTIMAL* VERSUS PRODUCTION CONTROL LOCATIONS

Control Variable	Optimal Coordinate	Production Coordinate	Optimal (mm)	Production (in)
G-Body				
Pedals (X)	506	527	21	0.8 forward
Steering Wheel (X)	1003	1067	64	2.5 forward
Shift Knob (X)	1032	1061	29	1.1 forward
Shift Knob (Y)	370	364	6	0.2 right
Shift Knob (Z)	490	525	35	1.4 below
Console Armrest (Z)	500	405	95	3.7 above
Door Armrest (Z)	530	480	50	2.0 above
H-Body				
Pedals (X)	514	527	13	0.5 forward
Steering Wheel (X)	987	1052	65	2.6 forward
Shift Knob (X)	1007	1074	67	2.6 forward
Shift Knob (Y)	370	350	20	0.8 right
Console Armrest (Z)	510	477	33	1.3 above
Door Armrest (Z)	549	507	42	1.7 above
S-Body				
Pedals (X)	518	545	27	1.1 forward
Steering Wheel (X)	976	977	1	0.0 forward
Shift Knob (X)	1016	1067	51	2.0 forward
Shift Knob (Y)	381	390	9	0.4 left
Shift Knob (Z)	719	560	159	6.3 above
Console Armrest (Z)	715	510	5	0.2 above
Door Armrest (Z)	749	715	34	1.3 above

*From laboratory seat buck studies (Schneider et al. 1987, 1988).

TABLE 2

CHANGES IN PRODUCTION CONTROL/ARMREST LOCATIONS USED TO IMPLEMENT OPTIMAL PACKAGE CONFIGURATIONS

Control Variable	G-Body (in)	H-Body (in)	S-Body (in)
Brake/Clutch Pedal	1.7 back	2.1 back	No change
Accelerator Pedal	2.5 back	2.6 back	1.1 back
Steering Wheel	No change	No change	1.1 back
Shift Knob (X)	1.1 back	0.6 down	0.9 forward
Shift Knob (Z)	1.4 down	No change	6.3 up
Door Armrest Height	2.0 up	1.7 up	1.3 up
Console Armrest Height	3.7 up	1.3 up	0.0 no change

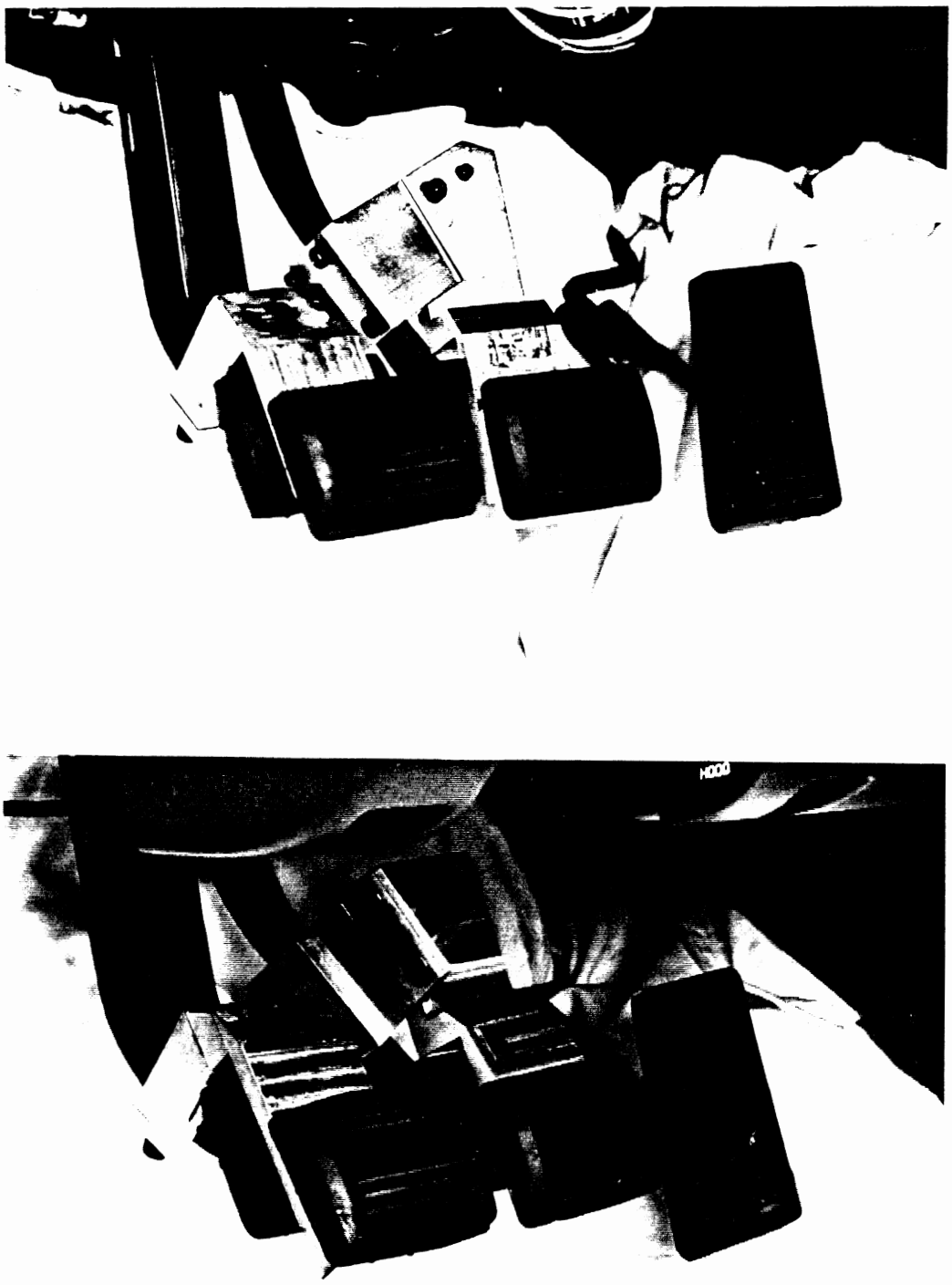


FIGURE 1. Modified pedals in G- and H-body vehicles showing added aluminum brackets for attaching more rearward brake and clutch pedals and modified accelerator linkage with receptacle for interchanging accelerator pedals with different shaft lengths.

vehicle was replaced with a modified linkage assembly. The new linkage allowed quick removal of the accelerator pedal and connecting shaft and replacement with a pedal having a longer shaft to position the pedal more rearward (i.e., closer to brake pedal) to reduce accelerator-to-brake lift-off.

In all three vehicles, the production shift-linkage assembly was modified to include the 1990 shift knob and shift pattern that includes a three-plane shifter rather than the lift-ring mechanism. In the H-body vehicle, the optimal shift knob location was very close to the production location and therefore no changes were made. In the G-body, the shift knob was moved 1.1 in. rearward and 1.4 in. down but it was not possible to accomplish this in a manner that allowed changing between production and optimal shift knob locations during testing. In the S-body, the shift knob was moved up 6.0 in. and forward 0.9 in. and remained in this location for the duration of the testing. In order to accomplish this change, it was necessary to install a specially-made set of shift linkage cables. The raised shift knob linkage in the Minivan is illustrated in Figure 2.

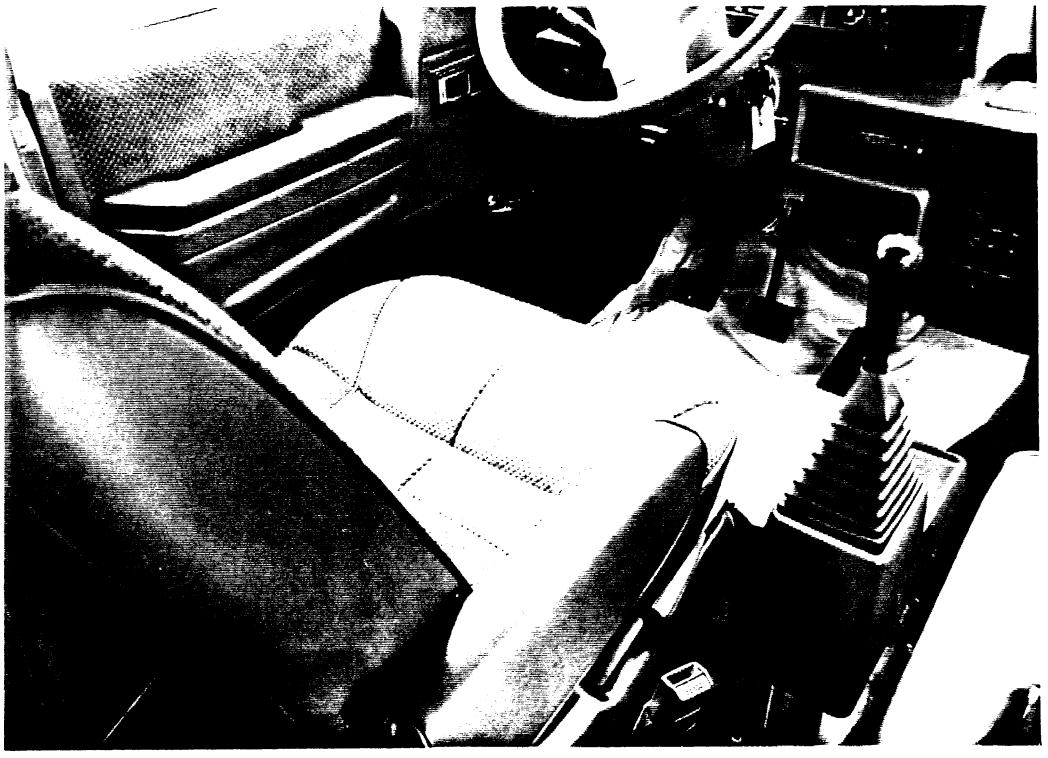


FIGURE 2. Raised shift knob in Minivan.

To accomplish the optimal armrest locations (i.e., heights), additional armrests and console lids were obtained from Chrysler and modified to install on top of the production

armrests as illustrated in Figure 3. These armrests were easily removed or installed during vehicle testing.

As shown in Figure 4, the seat track and seat back recliner mechanisms were fitted with scales to provide for manual readout of seat position and seat back angle after each drive. In addition, the seat tracks were lengthened to allow an additional two detents of travel rearward of the production limits in each vehicle. A readout scale was also provided on the tilt steering wheel column of each vehicle but the wheel was maintained at the design position throughout the testing.

Upon completion of subject testing, the vehicles were calibrated at Chrysler using SAE J826 H-point procedures and the locations of the pedals and steering wheels in the optimal and production package configurations were measured. It should be noted that the H-point calibrations were done with the seats in the rear-most detent of the extended seat track rather than in the design seat position.

B. TEST PROCEDURES AND PROTOCOL

To assess and compare the production and optimal control and armrest locations it was not considered necessary or feasible under the scope of the study to use a sample population of drivers that fully represented the distribution of the U.S. driver population by stature. Instead, a sample of twenty drivers of manual transmission vehicles spanning the range of U.S. adult statures from short to tall was used to test the different package conditions in each vehicle. Table 3 summarizes the four stature groups and sample sizes for each vehicle. In addition, ten drivers of manual transmission vehicles were recruited to test drive the Minivan (S-body) vehicle and assess the location of the optimal shift knob position, for a total sample population for this validation study of seventy subjects—three groups of twenty subjects for each of the test vehicles and one group of ten Minivan drivers for additional testing in the S-body vehicle.

After completing the subject screening and qualification process in which the subject completed a medical questionnaire, reviewed and signed a consent form, and was measured for several anthropometric variables, each subject was assigned to one of the vehicles (G, H, or S) and instructed to drive a specified route involving about thirty-five minutes of both city and highway driving (see map in Appendix A). Each subject drove his assigned vehicle twice—once with the controls and armrests in the design or production positions and once with the controls/armrests in the estimated optimal positions (except for the shift knob which remained in the optimal location for all drivers) based on the laboratory seating buck results. The order of testing in the optimal and production configurations was randomly varied between subjects to remove all bias due to order of testing.

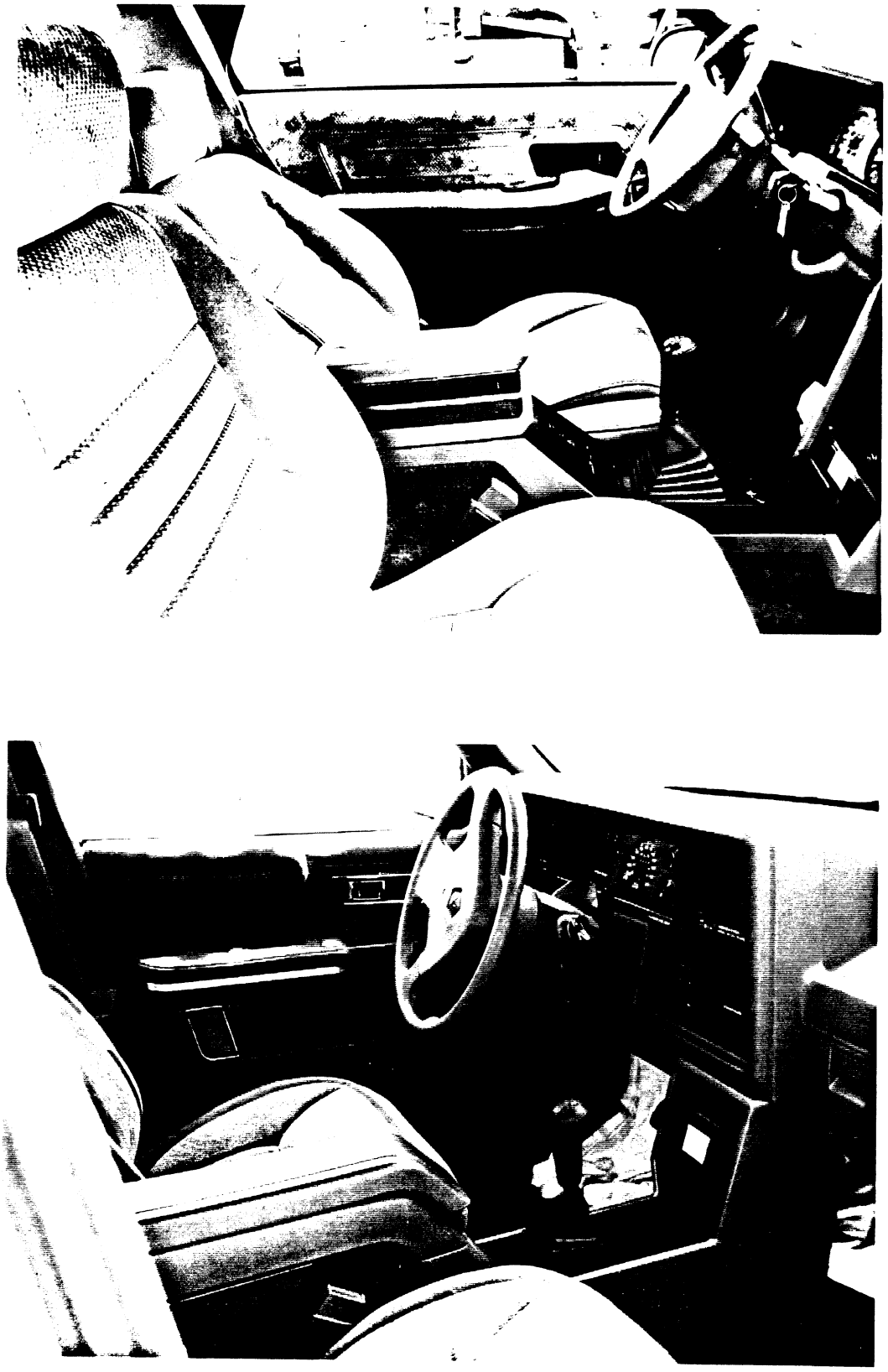


FIGURE 3. Console and door armrests in G-body (upper) and H-body (lower) vehicles showing removable pad in place to achieve optimal armrest heights.

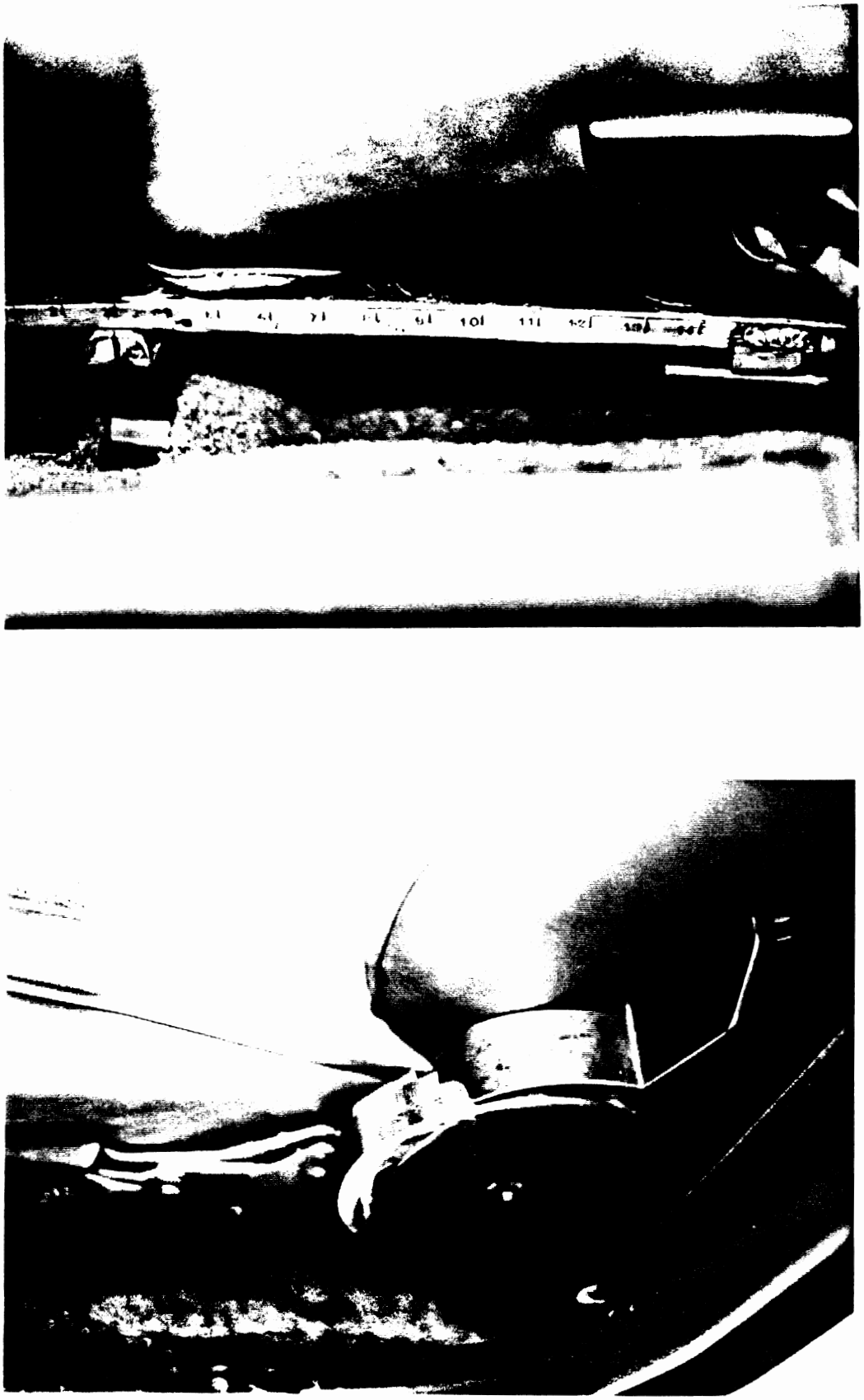


FIGURE 4. Seat track and seat back angle read-out scales.

TABLE 3

SUBJECT GROUPS AND SAMPLE SIZE FOR STUDY POPULATION

Vehicle	Group No.	N	Gender	Stature Range
G-Body	1G	5	F	59"–62.5"
	2G	5	M or F	62.5"–66.5"
	3G	5	M or F	66.5"–70.5"
	4G	5	M	70.5"–74"
H-Body	1H	5	F	59"–62.5"
	2H	5	M or F	62.5"–66.5"
	3H	5	M or F	66.5"–70.5"
	4H	5	M	70.5"–74"
S-Body	1S	5	F	59"–62.5"
	2S	5	M or F	62.5"–66.5"
	3S	5	M or F	66.5"–70.5"
	4S	5	M	70.5"–74"
S-Body current drivers		10	No Requirements	No Requirements
TOTAL		70		

Appendix A shows samples of the data collection forms used for each subject and illustrates the measurement data and subject responses obtained from each test drive. Prior to the first drive, the subject was instructed as to the specific items which he/she would be asked to comment on (e.g., pedal location, pedal-to-wheel distance) upon returning from the drive. A listing of these items was posted to the right of the instrument panel for reference during the drive. This list included the following:

- Steering wheel-to-pedal distance
- Pedal location
- Steering wheel location
- Brake/accelerator lift-off
- Door armrest height—city
- Door armrest height—highway
- Center/console armrest height—city
- Center/console armrest height—highway
- Shift knob height

Each subject was instructed and encouraged to make as many adjustments in the seat position and seatback angle during their drive as they considered necessary and to return with the seat in his/her preferred locations. As indicated on the data sheet, each subject rated the location of each component under study (e.g., steering wheel, pedals, etc.) on a scale of one to ten for both acceptability (i.e., like or dislike) and position (e.g., near or far). In addition to these specific items, subjects were asked for their comments on other

ergonomic features of their assigned vehicle—both likes and dislikes—as indicated on the last page of the data collection forms.

III. RESULTS

Tables B1 through B9 of Appendix B tabulate and summarize the results from the three vehicles for the four subject groups and for all subjects combined. Tables B1, B2, and B3 contain the mean anthropometric results for stature, sitting height, knee height, and buttock-knee length in metric and English units. Tables B4, B5, and B6 summarize the mean seat position results and seatback recliner angles as well as the measured distance from the driver's chin to the center of the steering wheel. In these tables, the values used for seat position are based on the package X-coordinate value for the design H-point which is assumed to be in the next to last detent of the production seat track (i.e., 4th to last detent of the extended tracks). The seatback angle is based on the J826 H-point drops conducted by Chrysler staff with the seat in the rearmost detent of the extended seat track.

The remaining tables in Appendix B contain the mean values of subject preference ratings for optimal and production (or design) conditions. The bar graphs in Appendices C, D, and E provide more graphical descriptions of these results and compare the group-mean and overall-mean responses for the two test conditions. For each control location rating, there are two bar graphs—one indicating the rating for *like* and *dislike* and the other indicating the rating for relative position such as *too far/too close* or *too high/too low*. For armrest height, there are also separate sets of data and bar graphs for *city* and *highway driving*. Figures 5 and 6 on the following pages summarize the overall response ratings to these different package conditions for preference (i.e., *like/dislike*) and location (e.g., *far/close*), respectively. Table 4 shows the overall mean subjective ratings used to generate Figures 5 and 6.

A. SUBJECTIVE RATINGS FOR PEDAL/STEERING WHEEL LOCATIONS, STEERING WHEEL-TO-PEDAL DISTANCE, AND ACCELERATOR-BRAKE LIFT-OFF DISTANCE

A quick inspection of Figures 5 and 6 indicates that, with regard to the overall mean subjective ratings for pedal and steering wheel locations, steering wheel-to-pedal distances, and accelerator-brake lift-off distances, neither configuration was strongly favored or disfavored over the other, and neither was considered greatly different with regard to closeness and farness of the pedals to the driver or to each other. While an inspection of the responses for the individual subjects from the figures in Appendix C does show some distinct preferences for the optimal or production distances, there are no apparent correlations of the

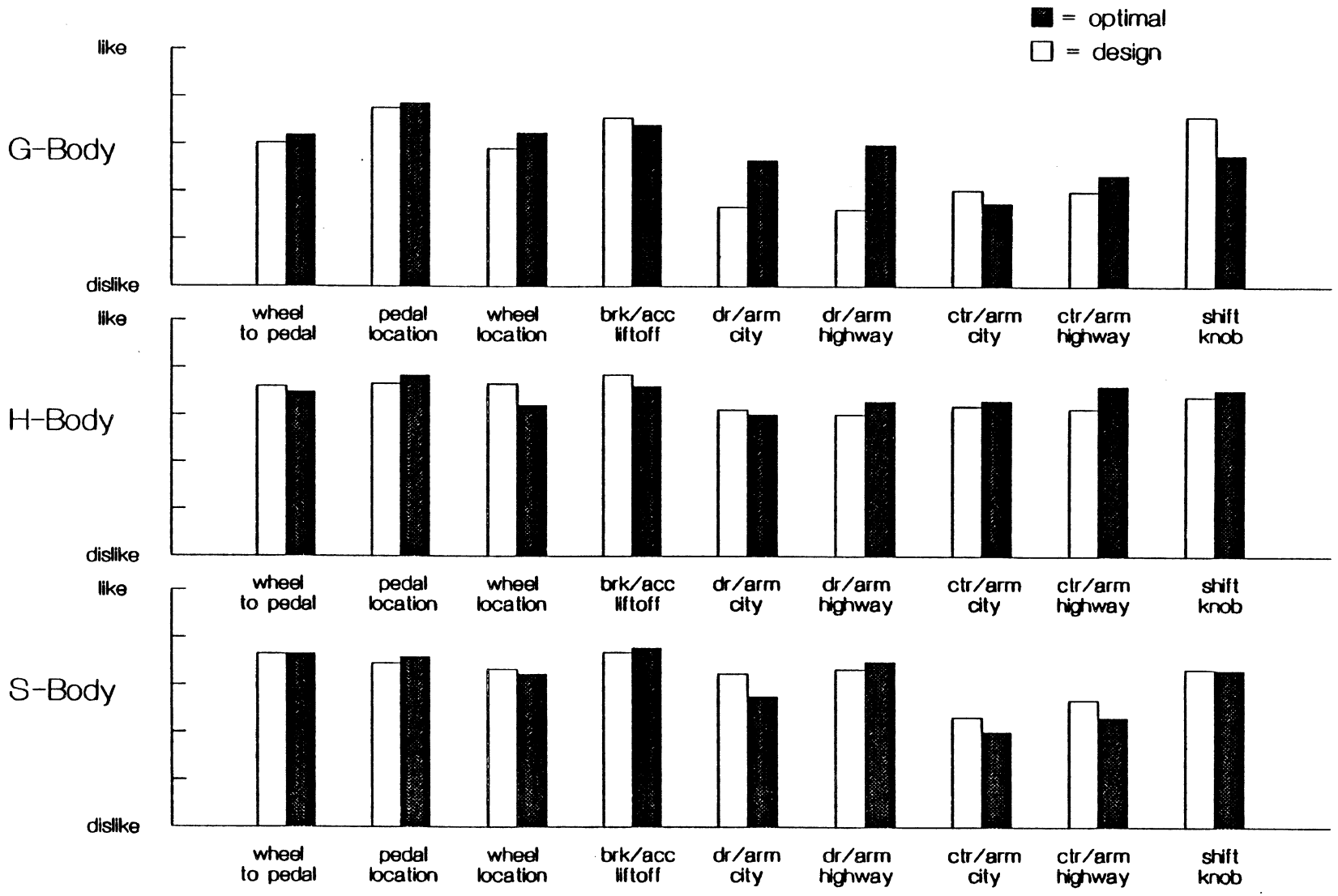


FIGURE 5. Bar graphs comparing overall subjective ratings of like/dislike for production and optimal control/armrest locations.

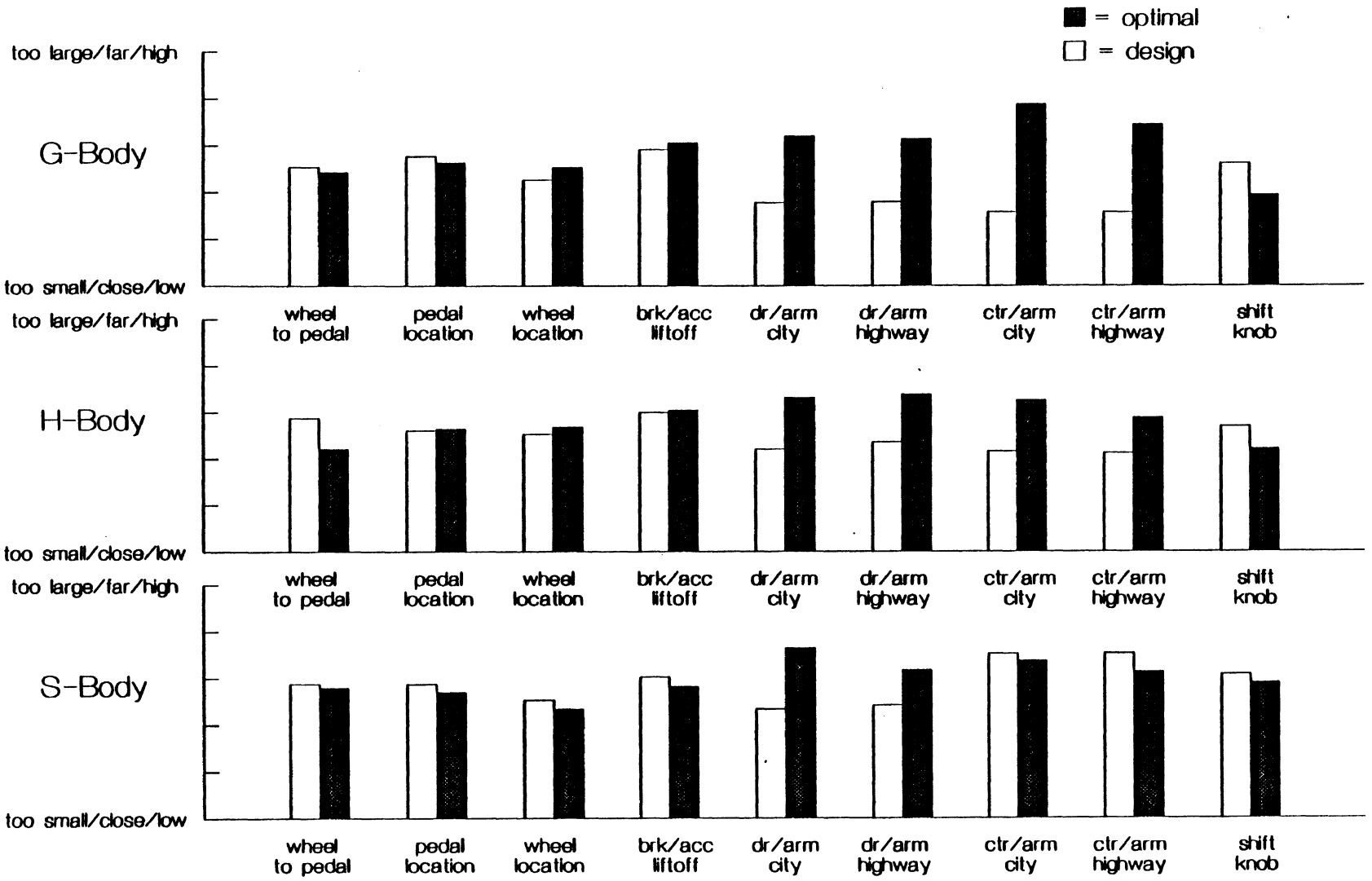


FIGURE 6. Bar graphs comparing overall subjective ratings for location of production and optimal controls and armrests.

TABLE 4

OVERALL MEAN SUBJECTIVE RATINGS FOR OPTIMAL AND PRODUCTION CONTROL/ARMREST LOCATION

Vehicle Body Type	Wheel to Pedal		Pedal Location		Wheel Location		Brake/Accel Lift-Off		Dr/Arm City		Dr/Arm Highway		Ctr/Arm City		Ctr/Arm Highway		Shift Knob	
	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.
Like/Dislike*																		
G-Body	6.0	6.4	7.5	7.7	5.8	6.5	7.1	6.9	3.4	5.3	3.2	5.9	4.1	3.5	4.0	4.7	7.2	5.5
H-Body	7.2	7.0	7.3	7.7	7.3	6.4	7.7	7.2	6.2	6.0	6.0	6.6	6.4	6.6	6.3	7.2	6.8	7.1
S-Body	7.3	7.3	6.9	7.2	6.7	6.4	7.4	7.6	6.5	5.5	6.6	6.9	4.6	4.0	5.3	4.6	6.7	6.6
Large, Far, High/ Small, Close, Low**																		
G-Body	5.1	4.9	5.5	5.3	4.5	5.1	5.8	6.1	3.6	6.4	3.6	6.3	3.2	7.8	3.2	6.9	5.2	3.9
H-Body	5.8	4.4	5.2	5.3	5.1	5.4	6.0	6.1	4.4	6.6	4.7	6.8	4.3	6.5	4.2	5.8	5.4	4.4
S-Body	5.8	5.6	5.7	5.4	5.1	4.7	6.1	5.6	4.7	7.3	4.8	6.3	7.1	6.7	7.1	6.3	6.2	5.8

*A rating of 1 is the strongest *dislike* and a rating of 10 is the strongest *like*.

**A rating of 1 is the strongest *too small, close, or low* and a rating of 10 is the strongest *too large, far, or high*. A rating of 5.5 is therefore *just right*.

ratings for *like/dislike*, *near/far*, or *small/large* ratings with respect to subject size. Also, in response to the question of brake responsiveness, only one in sixty subjects (Subject 20305 in G-body) reported a distinctly less desirable brake responsiveness with the smaller lift-off distance of the optimal package configuration.

In an attempt to further define and quantify these subjective ratings, the results were examined by counting only those subjects who *strongly liked* (a rating of 8, 9, or 10) or *strongly disliked* (rating of 1, 2, or 3) a control position or control-control relationship, or strongly felt it was *too close* or *too small* (1, 2, or 3) or *too far* or *too large* (8, 9, 10). The results of this counting analysis are tabulated in Table 5 for the three vehicles and for the ten S-body drivers for the Minivan. The numbers in this table indicate the following.

TABLE 5

FREQUENCY OF STRONG SUBJECTIVE RESPONSE RE PEDALS AND STEERING WHEEL LOCATIONS IN OPTIMAL AND PRODUCTION CONFIGURATIONS

Locations	N	Strongly Like		Strongly Dislike		Too Close/ Too Small		Too Far/ Too Large	
		Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Large
G-Body									
Pedals	20	14	13	3	3	1	0	6	3
Pedal-St. Wheel Dist.	20	8	5	2	1	4	2	1	1
Life-Off	20	9	11	4	3	0	0	4	3
H-Body									
Pedals	20	16	11	3	1	2	3	2	0
Steering Wheel	20	8	13	3	3	1	2	1	1
Pedal-St. Wheel Dist.	20	11	11	4	1	6	0	0	1
Lift-Off	20	11	14	1	0	0	0	3	2
S-Body									
Pedals	20	10	8	0	1	0	1	1	3
Steering Wheel	20	9	10	4	4	2	2	0	1
Pedal-St. Wheel Dist.	20	11	13	1	1	1	0	1	3
Lift-Off	20	12	12	0	1	0	0	0	3
S-Body Minivan Drivers									
Pedals	10	5	1	1	1	0	2	1	1
Steering Wheel	10	5	5	1	2	1	1	0	1
Pedal-St. Wheel Dist.	10	7	4	1	2	0	3	0	0
Lift-Off	10	6	2	1	4	0	0	0	5

*NOTE: Strong response is a rating of 1, 2, 3 or 8, 9, 10 on a scale of 1 to 10.

A.1 G-Body Vehicle (N=20)

- *Pedals.* More than half of the subjects strongly liked the pedal locations in both production and optimal configurations (like to dislike=14 to 3 and 13 to 3 for optimal and production, respectively) and one or fewer subjects thought the pedals were too close or too far in either package.
- *Steering Wheel.* About one-third of the subjects strongly liked the steering wheel location in each configuration but more (5 to 2) strongly disliked the production steering wheel location than strongly disliked the optimal steering wheel locations. However, four subjects thought it was too close in the optimal position and none thought it was too close in the production position. Interestingly, five people also thought the wheel was too far in the optimal package than in the production package and none thought it was too far in the production.
- *Steering Wheel-to-Pedal Distance.* More people strongly liked the steering wheel-to-pedal distance in the optimal package than in the production package (8 to 5) and only one or two strongly disliked this distance in either package. But, more drivers also thought this distance was too small in the optimal (4 to 2).
- *Accelerator-to-Brake Lift-Off Distance.* About one-half of the subjects (9 and 11) strongly liked the lift-off distance in both vehicles. No subjects strongly thought this distance was too small in either package but a few (4 and 3) thought it was too large in both.

A.2 H-Body Vehicle (N=20)

- *Pedals.* Over three-fourths of the subjects (16) strongly liked the optimal pedal location and about one-half (11) strongly liked the production pedal locations. Relatively few (2 or 3) thought they were too close or too far in either.
- *Steering Wheel.* More people strongly liked the production steering wheel location than the optimal steering wheel location (13 to 8) and relatively few (3 and 3) strongly disliked the wheel location in either package. Only one or two subjects thought it was too close or too far in either case.
- *Steering Wheel-to-Pedal Distance.* Just over half of the subjects strongly liked the pedal-to-wheel distance in both packages but four strongly disliked this distance in the optimal and only one strongly disliked it in the production, with six persons thinking that this distance was too small in the optimal and one thinking it was too large in the production.
- *Accelerator-to-Brake Lift-Off Distance.* More people strongly liked the lift-off distance in the production package than in the optimal (14 to 11) but in each case this number was more than half of the subjects. Only one subject strongly disliked this distance in the optimal and none strongly disliked it in the production. However, three and two persons

thought this distance was too large in the optimal and production packages, respectively, but none thought it was too small.

A.3 S-Body Vehicle (N=20)

- *Pedals, Steering Wheel, and Steering Wheel-to-Pedal Distance.* Approximately half of the subjects strongly liked the locations of the pedals and steering wheel and the distance between them in both the production and optimal packages. (Note: The only difference was the location of the accelerator pedal). Very few (0 to 3) subjects thought that they were too far or too close to either the pedal or steering wheel in either configuration. The greatest expression of dislike (4 in each case) was for the steering wheel location, with two people saying it was too close. (Note that the steering wheel was moved approximately 2-inches rearward of the normal production location.)
- *Accelerator-to-Brake Lift-Off Distance.* Results for the lift-off distance were essentially the same in both production and optimal packages with twelve subjects expressing a strong approval in each case and only one subject expressing strong disapproval for the production package.

A.4 S-Body Vehicle (Minivan Drivers) (N=10)

- *Pedals.* There was greater approval for the pedal locations in the test vehicle with the optimal pedal configuration (i.e., accelerator pedal moved rearward 1.1 inches) with five of ten subjects expressing strong approval in the optimal and only one of ten expressing strong approval in their own vehicle with the production pedal locations. However, only one subject in each case expressed strong disapproval for the pedal location.
- *Steering Wheel.* An equal number of people (5 of 10) expressed strong approval for the steering wheel location for both conditions even though the steering wheel was further rearward in the test vehicle. Only one to two subjects expressed strong disapproval in either case.
- *Steering Wheel-to-Pedal Distance.* Steering wheel-to-pedal distance was strongly approved by more subjects in the test vehicle (7 versus 4), with three people saying the distance was too small in their own vehicle. However, only one and two people, respectively, for optimal and production, strongly disapproved of this relationship.
- *Accelerator-to-Brake Lift-Off Distance.* The lift-off distance was strongly approved of by more people in the test vehicle (6 versus 2) with four subjects expressing strong disapproval and five subjects saying that this distance was too large in their own vehicle.

B. SUBJECTIVE RATINGS FOR ARMREST HEIGHTS

Looking again at Figures 5 and 6 and Table 4 for the overall subjective ratings of armrest heights, it is seen that there are some distinct differences between optimal and production heights. In particular, in the G-body vehicle, the optimal door armrest height is more strongly *liked* than the production height for both city and highway driving (Figure 5). While the overall ratings for like/dislike of the G-body console armrest are similar for optimal and production, both the door and console optimal armrest heights were considered somewhat high for both city and highway driving while the production door and console armrest heights were considered to be low (Figure 6).

For the H-body vehicle, subjects generally liked both the production and optimal armrest heights equally and quite strongly. Again, however, there was a tendency to rate the optimal armrests as being too high for both highway and city driving.

For the S-body vehicle, the overall ratings for like/dislike were again similar for production and optimal but were generally higher (greater approval) for the door armrest than the center (seat) armrest. From Figure 6, it is seen that drivers again experienced the optimal door armrest height as somewhat high, particularly for city driving, and found the center or seat armrest somewhat high for both city and highway driving.

A further analysis of the ratings for armrest heights is presented in Table 6 which summarizes the subjective responses by counting and tabulating only the *strong* responses of 1, 2, or 3 or 8, 9, and 10. Examination of the numbers in this table indicates the following.

B.1 G-Body (N=20)

- A general preference for the optimal height on the door for both city and highway driving with the preference being slightly greater for highway driving.
- An indication that the door armrest is somewhat low in the production and slightly high in the optimal.
- A general dislike for the console armrest height in both configurations with the optimal being disliked more than the production for city driving and the production being disliked more than the optimal heights for highway driving.
- An indication that the optimal height is too high for both city and highway driving and the production is too low for both.

TABLE 6

FREQUENCY OF STRONG SUBJECTIVE RESPONSES TO ARMREST HEIGHTS IN OPTIMAL AND PRODUCTION CONFIGURATIONS

Vehicle Body Type	N	Strongly Like		Strongly Dislike		Too Low		Too High	
		Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.
G-Body									
Door Armrest:									
City	20	6	2	5	12	1	11	6	1
Highway	20	8	1	4	11	1	9	4	1
Console:									
City	20	4	3	11	11	1	10	12	0
Highway	20	5	2	7	11	1	12	8	0
H-Body									
Door Armrest:									
City	20	9	8	6	5	0	5	6	0
Highway	20	9	8	5	6	0	4	8	1
Console:									
City	20	9	10	4	4	0	4	6	0
Highway	20	12	9	2	4	1	5	1	0
S-Body									
Door Armrest:									
City	20	9	12	9	5	0	4	10	1
Highway	20	11	10	2	3	0	5	5	2
Seat/Center:									
City	20	5	6	12	10	3	0	9	8
Highway	20	6	8	8	7	3	0	7	7
S-Body Minivan Drivers									
Door Armrest:									
City	10	1	6	4	1	0	1	6	0
Highway	10	3	5	4	1	1	1	4	0
Seat/Center:									
City	10	2	4	1	2	1	0	0	1
Highway	10	3	4	1	0	1	1	0	0

B.2 H-Body (N=20)

- Approximately equal satisfaction with the door armrest height in both optimal and production for city driving but slightly greater approval of the optimal for highway driving.
- An indication that the door armrest height is somewhat high in the optimal condition for both city and highway driving.

- Slightly greater approval of the production console armrest height for city driving and slightly greater approval for the optimal console height for highway driving.
- An indication that the optimal console armrest height is too high for city driving.

B.3 S-Body (N=20)

- Greater approval for the production door armrest height than optimal height during city driving (12 production to 9 optimal liked) but nearly equal overall approval for both during highway driving (11 and 10 liked).
- Subjects either strongly liked or strongly disliked the door armrest heights in either condition, particularly in city driving (see bar graphs in Appendix D).
- An equal number of subjects (9) strongly approved and strongly disapproved of the optimal height under city driving conditions.
- A greater number of subjects (12) strongly approved of the production door armrest height than disapproved (5) during city driving.
- More subjects (9) strongly disapproved of the optimal door armrest height in city driving than disapproved of the production height (5).
- More subjects (12) strongly approved of production door armrest height in city driving than approved of the optimal height (9).
- About half of the subjects strongly approved of both armrest heights during highway driving and only a couple disapproved of each.
- Approximately one fourth of the subjects (4 and 5) thought that the production door armrest height was too low in either city or highway driving. None thought the optimal height was too low.
- Half (10) of the subjects thought the optimal door armrest height was too high during city driving and five thought it was too high for highway driving.
- More people strongly disliked the center/seat armrest height for city driving (10 and 12) than strongly liked it (5 and 6), with most of these indicating that it was too high (9 and 8).[3]
- Nearly an equal number strongly liked or strongly disliked the center/seat armrest height for highway driving (about 7) and those who disliked it generally thought it was too high.[2]

---

[3]The seat/center armrest height was the same for optimal and production packages as was the shift-knob height.

B.4 S-Body (Minivan Drivers) (N=10)[4]

- More Minivan drivers strongly disliked the optimal door armrest height than strongly liked it (4 versus 1) for city driving.
- More Minivan drivers strongly liked the production armrest height than disliked it (6 versus 1) for city driving.
- Approximately half of the drivers thought the door armrest was too high in the optimal position for both city and highway driving.
- Half of the subjects strongly liked the production door armrest height during highway driving and only one strongly disliked it.
- Only a few subjects had strong opinions of the center armrest height but there were more strong preferences for it than against it (4 for production and 2 or 3 for optimal).

C. SUBJECTIVE RATINGS FOR SHIFT-KNOB HEIGHT

Since the shift-knob height was fixed in the three test vehicles, differences in preference and perception of the shift-knob height between optimal and production packages are generally due to differences in console or center armrest heights. In the S-body test vehicle, the center armrest was also the same in both production and optimal packages. However, for the ten additional Minivan drivers who drove their own vehicles for the production vehicle drive, there was a difference in the location of the shift knob between optimal and production packages.

With these factors in mind, the subjective response ratings of Figures 5 and 6 and Table 4 for shift-knob height, indicate that the shift-knob heights generally received high approval in all vehicles and for both production and optimal configurations (ratings of about 6.9 on like/dislike scale), although the production height was more strongly liked in the G-body than the optimal height. For the G- and H-body vehicles, drivers generally thought that the shift knob was about right (not too high or too low) in both packages but the tendency was for the optimal shift-knob height to be considered on the low side (obviously due to the higher armrest). In the S-body test vehicle, the shift knob was generally considered to be on the high side.

Table 7 summarizes the *strong* subjective response results for shift-knob height using the counting procedure for strong responses described previously and suggests the following.

---

[4]While the armrest heights should be about the same for the production and optimal drivers, the shift-knob heights were different with the shift knob raised approximately 6 inches in the optimal drive.

TABLE 7

FREQUENCY OF STRONG SUBJECTIVE RESPONSES TO SHIFT-KNOB HEIGHTS IN OPTIMAL AND PRODUCTION CONFIGURATION

Vehicle Body Type	N	Strongly Like		Strongly Dislike		Too Low		Too High	
		Opt.	Prod.	Opt.	Prod.	Opt.	Prod.	Opt.	Prod.
G-Body	20	5	11	5	1	10	1	0	1
H-Body	20	10	9	2	3	4	1	1	1
S-Body	20	7	8	1	1	0	0	2	4
S-Body (Minivan Drivers)	10	4	3	4	0	0	2	3	0

C.1 G-Body (N=20)

- An equal number of subjects expressed a strong dislike (5) or like (5) for the optimal height, but over half of the subjects (11) expressed a strong like for the production height while only one (1) subject expressed a strong dislike for the production height.
- Half the subjects (10) thought that the optimal height was too low (relative to the higher armrest in the optimal condition).

C.2 H-Body (N=20)

- Half the subjects strongly liked both the optimal and production shift-knob heights and only a couple (2 and 3) strongly disliked both.
- Four subjects thought the optimal shift-knob height was too low (again relative to the higher armrest height).

C.3 S-Body (N=20)

- More subjects strongly liked the shift-knob height than disliked it (7 versus 1) although a few subjects (2 to 4) thought it was too high.

C.4 S-Body (Minivan Drivers) (N=10)

- An equal number (4) of the drivers strongly liked or strongly disliked the optimal shift-knob height.
- Three subjects strongly liked the production height while none strongly disliked it.
- Two subjects thought the production shift-knob height was too low while three subjects thought the optimal shift-knob height was too high.

D. SEAT POSITION RESULTS

As indicated in the procedures, information on driver preferred seat position and seatback recline angle was recorded immediately upon return from each test drive and the results for optimal and production packages can be compared. Appendix F shows the results graphically for each subject in each vehicle where the seat position, seatback recline angle, and measured chin-to-wheel (center) distance for the production and optimal drivers are indicated by an * and solid dot (•), respectively. The overall results are summarized in Table 8 and Figure 7. It should be noted that the seat position used in these results is based on the package design coordinates for the design H-point (second to last detent of production vehicle seat track) and not on the actual H-point calibration data.

TABLE 8

SUMMARY OF PREFERRED SEAT ADJUSTMENTS

Distances	Configuration	Car Type		
		G-Body	H-Body	S-Body
Seat Position (mm)	Production	1376	1364	1287
	Optimal	1396	1387	1297
Recliner Angle (deg)	Production	26.8	23.2	21.5
	Optimal	26.2	22.6	20.6
Chin-to-Wheel (mm)	Production	380	377	416
	Optimal	397	394	417

As might be expected from the more rearward locations of the pedals in the G- and H-body vehicles, there was a general tendency for subjects to sit more rearward in the optimal package and there does not appear to be any evidence that this decision to sit more rearward is related to size of the driver. Overall, there was a shift in the mean seat position of about one detent (approximately 20 mm) in these vehicles while the pedals were shifted rearward more than two detents (i.e., about 50 mm or more).

Accompanying this more rearward seat position was a slight decrease in the overall mean for seatback recline angle (i.e., a slight tendency to sit more upright in the optimal package), although it should be noted that most subjects sat as fully upright as the seat would allow in both production and optimal configurations. For the H-body, in particular, the data suggest that subjects generally want to sit fairly upright but are more willing to recline, or perhaps are forced to recline more, in the production package, perhaps out of a need to get further from the steering wheel while still reaching the pedals comfortably.

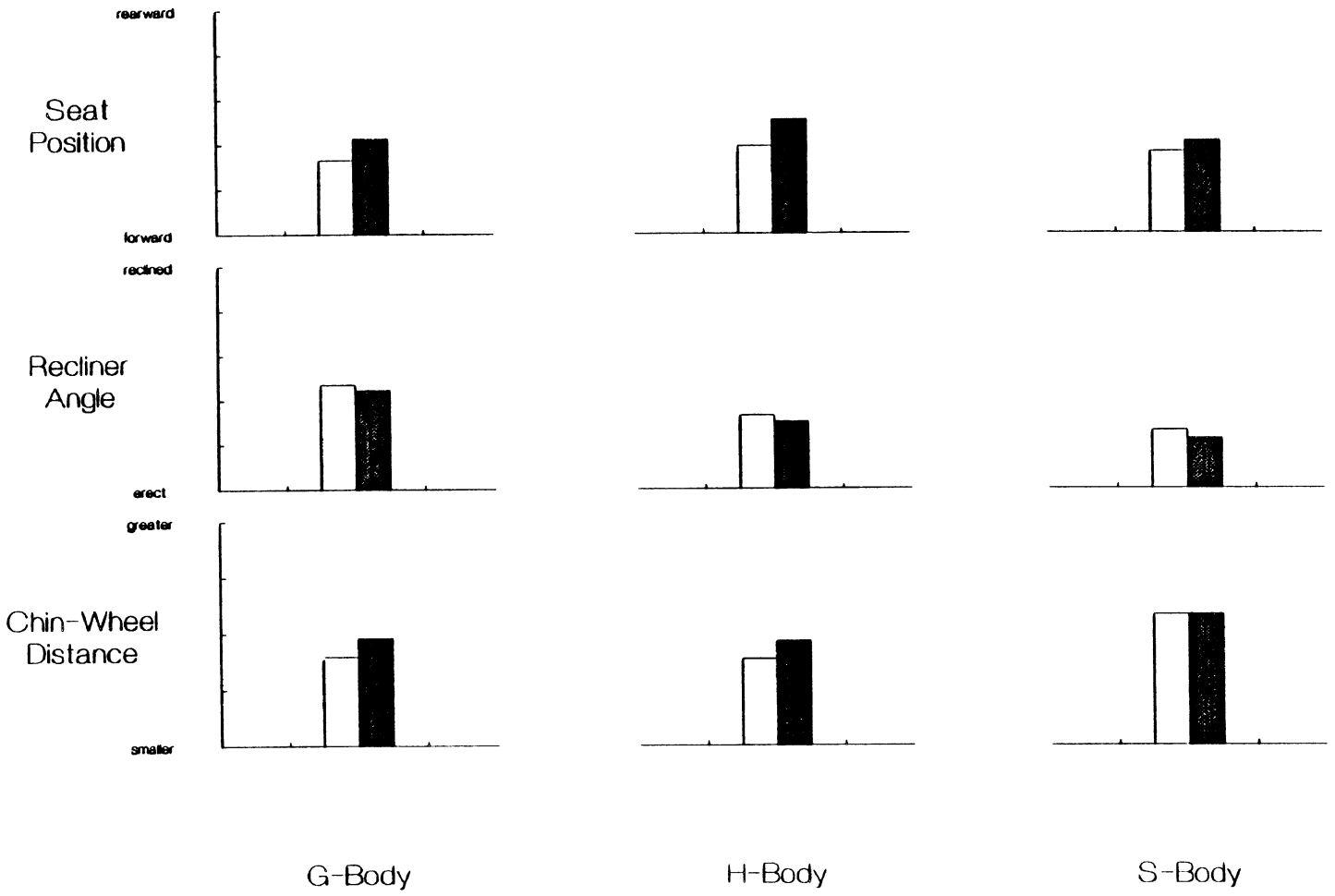


FIGURE 7. Comparisons of overall mean seat positions, seatback recline angles, and chin-to-wheel distance for optimal and production package configurations.

In the S-body vehicle, where only the accelerator pedal was moved rearward for the optimal package, the results for seat position and seatback angle are similar to that found for the other two vehicles, although the shift in overall mean seat position is only 10 mm. Again, most subjects positioned the seatback in the full upright position for both drives.

The net result of chin-to-wheel distance for the G- and H-body vehicles due to the more rearward seat position and more inclined seatback angle of the optimal package was a slightly increased chin-to-wheel distance, the effect of the rearward shift apparently being greater than the seatback angle shift with regard to head position. In both the G- and H-body vehicles, the overall mean chin-to-wheel distance increased by 17 mm. In the S-body vehicle the chin-to-wheel distances were essentially the same in the two packages.

Figure 8 and Table 9 present and compare the overall mean seat-to-steering wheel, seat-to-brake pedal, and seat-to-AHP distances for the production and optimal package configurations. The results indicate that, overall, drivers selected shorter seat-to-pedal distances in the optimal package configuration and a larger seat-to-wheel distance. The changes are seen to be greatest for the G- and H-body vehicles where the pedal movements were greatest. In fact, in the S-body, where the accelerator pedal was moved rearward 1.1 inches and the brake and clutch were not moved at all, drivers tended to move the seat rearward, thereby increasing their distance from the steering wheel. While this resulted in an increased distance from the brake/clutch pedals, the distance to the accelerator pedal was generally decreased. It will also be noted that the amount of rearward seat movement (overall mean) is less than the amount of pedal rearward movement (brake/clutch or accelerator) in each case. Similarly, the amount of increased distance from the steering wheel is generally less than the amount of rearward pedal movement and the chin-to-wheel distance is less than the rearward seat movement since there was a slight tendency to sit more upright in the optimal package configuration.

TABLE 9

SUMMARY OF PREFERRED SEAT-TO-CONTROLS POSITIONING

Distances	Configuration	Car Type		
		G-Body	H-Body	S-Body
Seat-to-Wheel (mm)	Production	290	294	343
	Optimal	310	317	353
Seat-to-Brake (mm)	Production	838	814	809
	Optimal	815	784	819
Seat-to-AHP (mm)	Production	845	755	678
	Optimal	801	712	660

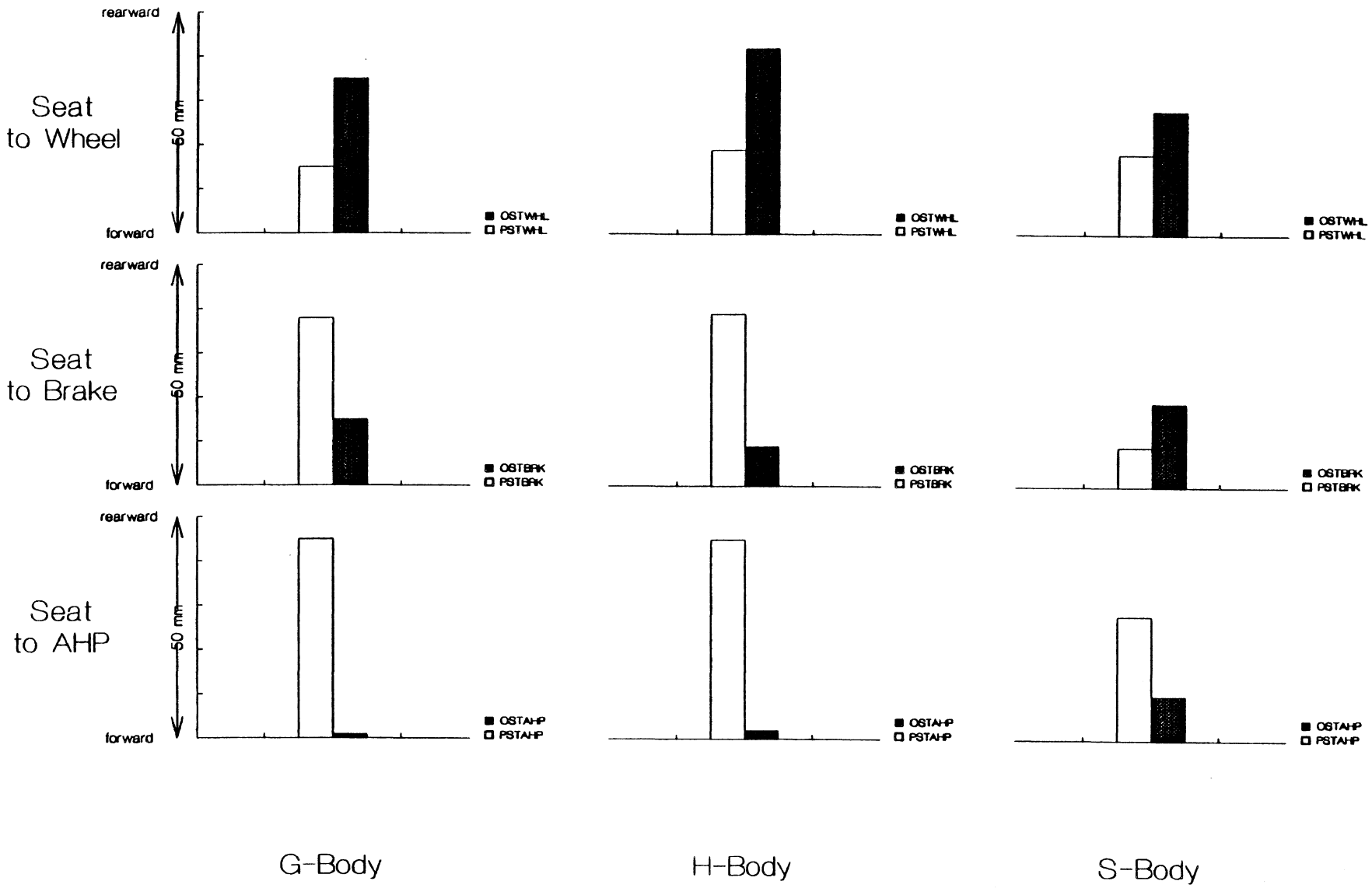


FIGURE 8. Comparison of overall mean seat-to-wheel, seat-to-brake, and seat-to-AHP distance for optimal and production packages.

E. BRAKE RESPONSIVENESS

In the process of planning the test procedures, a concern was expressed by some Chrysler personnel that a reduction in the accelerator-to-brake lift-off distance would result in a perception of poorer brake responsiveness or performance. This concern appears to have arisen from previous reduction of the lift-off distance where the brake was moved forward to be closer to the accelerator pedal. The result of this modification was an increase in the "warranty" claims when, in fact, no changes had been made to the actual brake system.

As a result of these concerns, subjects were asked to comment on their perception of the brake responsiveness in the two package configurations with production and optimal lift-off distances. In order to minimize the attention being given to the issue of brake responsiveness, subjects were also asked to comment on their perception of the clutch and shift linkage performance.

The tables in Appendix G summarize the subject comments with regard to the responsiveness of the brake system in the two packages and for the three vehicles. Allowing for the fact that there was some difference in the required pedal actuation force in the two cases (i.e., less force required in the optimal package where effective pivot-arm distance was slightly larger), the results do not support a concern for reduced brake responsiveness with decrease lift-off distance achieved by moving the accelerator pedal rearward as was done in this study. In general, subjects considered the brakes to operate just as effectively in both packages. While some subjects did express a preference of the production brake responsiveness, others thought that the optimal brake system was slightly better. Of the sixty subjects tested in the three vehicles, only the response of two subjects (G20305 and S20215) could be considered to represent a definite negative comment regarding the responsiveness of the brake in the optimal package.

F. SUBJECT COMMENTS RE: OTHER ERGONOMIC FACTORS

Before exiting the test vehicle after the second drive, each subject was asked to give his comments and impressions regarding a number of other ergonomic factors about the vehicle. As indicated on the final data collection forms in Appendix A, the subject was first asked about any strong likes or dislikes he may have experienced during his relatively brief encounters with the vehicles. Next the subject was questioned with regard to:

Personal space/headroom
Visibility/mirrors
Dash layout, visibility/readability, usability
Wheel shape
Door controls, window crank
Seats: Comfort, design

The results of these questions have been compiled and tabulated and are presented in Appendix H as additional input to Chrysler without further comment at this time.

DISCUSSION AND CONCLUSIONS

While it had been hoped that this validation study might clearly and definitively either support or refute the findings and conclusions of the seating buck studies with regard to the estimated optimal locations for the pedals, steering wheel, shift knob, and armrests, the results are not that clearcut and simple. While, on the one hand, it can be said that the results of the seating buck study remain valid in that no dominant "dynamic" factors were found that would clearly and consistently overrule the findings of the seating buck studies, the results of the present study do suggest that the position changes suggested by the seating buck results may be extreme in some cases and should be modified.

In making any such modifications, however, it should also be recognized that, in the absence of any clear overriding dynamic factors, the results of the seating buck studies might be considered more objective and reliable than the more subjective results of the current study and, in many cases, demonstrate their own validity through statistical consistency across subject-size groups or consistent patterns with subject size. For example, the observations from the present study that there was no relationship between preferences for production and optimal pedal-to-steering-wheel locations and driver size casts suspicions upon the reliability of the subjective response data collected in this study.

While the approach taken in the seating buck studies (i.e., positioning rather than rating of positions) is likely to be the more reliable of the two, it, unfortunately, cannot be easily carried out within the vehicle and under dynamic conditions. It is a quite different thing to ask a driver to tell you what he/she thinks about a control location than to ask him to position that control to where he/she would prefer it to be.

While the subjects drove each vehicle a little over thirty minutes with each package configuration, the results of this study suggest that this may be an insufficient amount of exposure to be able to distinguish differences and determine likes and dislikes in a meaningful way. Also, while the constraints of this study did not allow each control/armrest to be changed and evaluated independently, the fact that several package dimensions were changed at the same time when going from production to optimal (i.e., armrest heights, pedal-to-steering wheel distance, accelerator-to-brake lift-off distance) may have made it more difficult for subjects to offer preferences and opinions about the locations of the individual components.

Beyond what has been learned in the present study regarding the validity of the seating-buck-based optimal locations, the results of the present study also indicate that:

(a) drivers have a fairly wide tolerance for the packaging of driver controls, perhaps derived from the necessity to accommodate to a wide range of vehicle geometries in today's fleet,

(b) drivers often have difficulty distinguishing and expressing a clear and quantitative preference between control locations that differ quite substantially (e.g., optimal and production pedal locations varied by about 2 inches but drivers did not, in many cases and overall, distinguish strongly between them).

and

(c) We still have much to learn about the factors that influence driver preferences for the locations of the primary controls and his/her preferred position (i.e., seat adjustment) with respect to these controls.

With these perspectives in mind, the following conclusions have been derived at this time from the results of this study.

A. WHEEL-PEDAL RELATIONSHIP IN G- AND H-BODY VEHICLES

Since there is no strong evidence against the optimal pedal locations (relative to the steering wheel) in the G- and H-body vehicles, it is suggested that the shorter steering wheel-to-pedal distances recommended from the seating buck results are generally valid. However, due to the lack of strong evidence in favor of the optimal over the production locations, it is suggested that the degree of change might be reduced somewhat. Clearly, there is no strong evidence from the present study that would suggest that the optimal locations are worse than the current production locations.

Additionally, one might consider that the fact that drivers tend to sit further from the steering wheel in the optimal wheel-pedal package to have a positive safety effect, not only with regard to reducing the likelihood of contacting the steering wheel in a frontal collision for belt restrained occupants but also, and perhaps more importantly, in future Chrysler vehicles with regard to increasing the distance from the airbag module to the driver should the airbag deploy in an accident.

It should also be kept in mind that the manner in which the optimal pedal-wheel relationships were established by moving the pedals rearward rather than moving the steering wheel forward could have an effect on the results which was not appreciated in the seating buck studies. We know relatively little, for example, about the influence of the header and windshield on driver perception of the seating package and on driver preference for seat position.

B. ACCELERATOR-BRAKE LIFT-OFF

Again, there was no strong evidence that the smaller optimal lift-off distance was preferred strongly over the larger production distance or visa versa. Additionally, and perhaps more importantly, there was no evidence that the optimal lift-off distances created any increase in "warranty" due to a perception of poor braking. This, it is felt, is due to the fact that the smaller lift-off was created simultaneously with a reduction in the overall wheel-to-pedal distance. If, in previous Chrysler efforts to reduce lift-off, this was achieved by moving the brake pedal forward, thereby increasing the distance from the steering wheel to the brake and thus the distance from the driver to the brake pedal, this could reduce the feeling of brake responsiveness and explain the increased warranty problem.

In light of these findings and observations, it is suggested that the results of the seating buck study with regard to a reduction in accelerator-to-brake lift-off being an improvement are generally valid, but it is recommended that any such changes in future vehicles be accompanied by a simultaneous reduction in wheel-pedal distance so as not to increase the distance of the driver from the pedals.

C. ARMREST HEIGHTS

It will be recalled that the results from the two seating buck studies showed different results for optimal armrest heights. In the first study where highway-type driving was emphasized, the higher optimal armrest heights used in this validation study were determined. In the second study, where the emphasis was on the driver controls, the optimal armrest heights were not so different from the current production heights.

As one might have concluded from these conflicting seating buck study results, the findings of the present study suggest that the optimal armrest height may generally lie somewhere between the optimal and production heights, or that alternatively, the armrest be made adjustable or removable (as in the case of the S-body seat armrest).

In the G-body, the present study confirms that the production door armrest is too low and generally unusable by most drivers (perhaps also due to its inward slope—see comments in Appendix H) and that the optimal armrest height is slightly on the high side. It is recommended that the door armrest be positioned close to, but slightly below, the optimal armrest height and that the slope of the armrest be reduced, at least in the region where most elbows would be placed (see seating buck reports for X-coordinates of elbow locations).

Similar results were found for the console armrest in the G-body. The production console height is far too low but the optimal was too high. It is recommended that a first attempt at a new optimal console height would lie midway between the two.

For the H-body vehicle, the door armrest findings are similar and it is again recommended that a new optimal door armrest height would reduce the height change recommended from the seating buck results (1.7 inch up) by about 0.5 to 0.7 inch . Similarly, the optimal console armrest height adjustment recommended from the seating buck study (1.3 inches up) might also be reduced somewhat based on the results of the present study, although it should be noted that, for highway driving, only one of twenty subjects had a strong opinion that it was too high.

In the S-body vehicle, the results of the present study again suggest a compromise between the production and optimal door armrest heights. The results also suggest that the flip-down seat armrest is too high for both city and highway driving (although the results of the first armrest study suggested that it was about right) and that consideration be given to lowering this armrest somewhat.

D. SHIFT-KNOB HEIGHTS

For the G-body, the shift-knob location was not adjusted between optimal and production packages but the console armrest was. The results suggest that, for the production console armrest height (which is too low), the shift-knob height is about right and that, for the optimal console armrest height, the shift knob is too low. Since the shift knob was moved down 1.4 inches based on the results of the seating buck studies, it is recommended that it be adjusted back up toward its original production height in any future modifications to raise the console armrest height.

In the H-body also, the shift-knob location was not adjusted between drives and remained at the original production location which was close to the optimal height determined in the seating buck study. The results of the present study do not provide any strong evidence for changing this height, although there is some indication that it is too low if the console armrest is moved up from the production height.

In the S-body vehicle, the shift-knob location was fixed at the optimal height for both production and optimal drives for the 20 non-Minivan drivers, so it was not possible to get input from this population regarding preference for the optimal or production heights. Since the seat armrest was also the same for both drives there were no differences between the two. In general, however, there was greater acceptance for this optimal shift-knob height than there was strong non-acceptance, although some drivers thought it was too high.

Of the ten Minivan drivers who also drove their own vehicle for the production-package drive, there was also fairly good acceptance for the higher optimal armrest although there was also some strong dislike for it. In an attempt to determine a new optimal shift-knob height for the Minivan, these subjects were asked to estimate how much below the optimal shift-knob height they would like it to be. The results are illustrated in Figure 9 and

suggest that the new optimal height lies about 3.5 inches above the current production height.

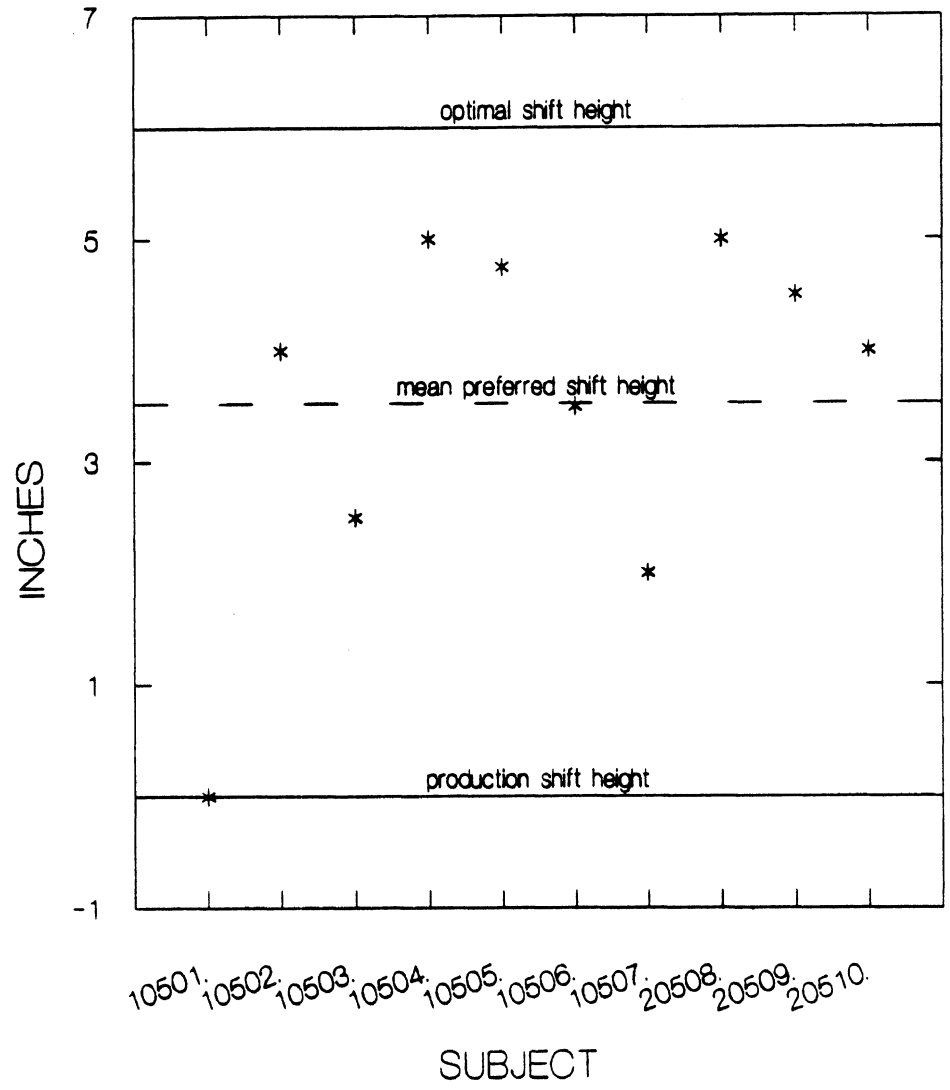


FIGURE 9. Minivan driver estimates for optimal shift-knob heights.

E. PREFERRED SEAT POSITIONING

The results of this study indicate that, when the pedals were moved rearward, the distribution of driver seat positions also moved rearward but less than the amount of pedal movement. The seat recline angle decreased very slightly. Two interpretations of this shift are possible.

One is that subjects would have preferred to sit closer to the pedals than was permitted in the production-package configuration, where moving closer to the pedals would have meant moving too close to the wheel and moving further from the wheel would have

meant moving too far from the pedals. However, the fact that subjects did not sit closer to the pedals (i.e., did not stay in the same seat position as they selected with production-pedal positions) may suggest that their desire to sit closer to the pedals was satisfied in the optimal package configurations so that they were no longer willing to sit as close to the steering wheel as they had in the production package.

The other interpretation is that subjects were caused to move rearward to keep from getting too close to the pedals in the optimal position but limited their rearward movement (to be less than the rearward movement of the pedals) to prevent getting too far from the steering wheel. If this is the case, the results indicate that subjects were willing to sit somewhat closer to the pedals and further from the steering wheel. Again, the fact that they did not move rearward equivalent to the amount of rearward pedal movement suggests that they did not want to move too much further from the steering wheel.

APPENDIX A

DATA COLLECTION FORMS

SUBJECT CONSENT FORM

THE UNIVERSITY OF MICHIGAN
TRANSPORTATION RESEARCH INSTITUTE

DRIVER CONTROL POSITION STUDY

I understand that the purpose of this study is to determine the preferred positions of various components within the drivers' seating space (e.g., pedals, steering wheel, shift knob, and armrests). I will be asked to drive a vehicle over a specified route and to give my opinion with regard to the locations of armrests, pedals, steering wheel, and shift knob. The results of this study shall be used to improve the positioning of driver controls for increased comfort and control.

I understand that my participation in this study is voluntary and is conditional to a review of my responses to a health questionnaire and my physical qualifications with regard to experimental design criteria. I understand that I will be paid for my participation at a rate of $10/hr., and that I may discontinue my involvement at any time without prejudice or change in my rate of pay.

The Transportation Research Institute is a research organization and as such my records and personal information may be reviewed by research staff. I acknowledge, however, that all data and results will remain confidential and will be used in scientific publications and presentations only in a coded form not identifying me. I also give my consent to use photographs taken during the testing sessions in publications, reports, and presentations as long as I am not identified by name in these photographs.

I agree to the conditions set forth above and have had an opportunity to discuss my concerns regarding my participation in the proposed study.

NAME (please print): _____

Signature: _____

Signature of Witness: _____

Date: _____

Phone Numbers of Investigators: 936-1103 (work), 996-3861 (home)

Instructions for Chrysler Control Position Study

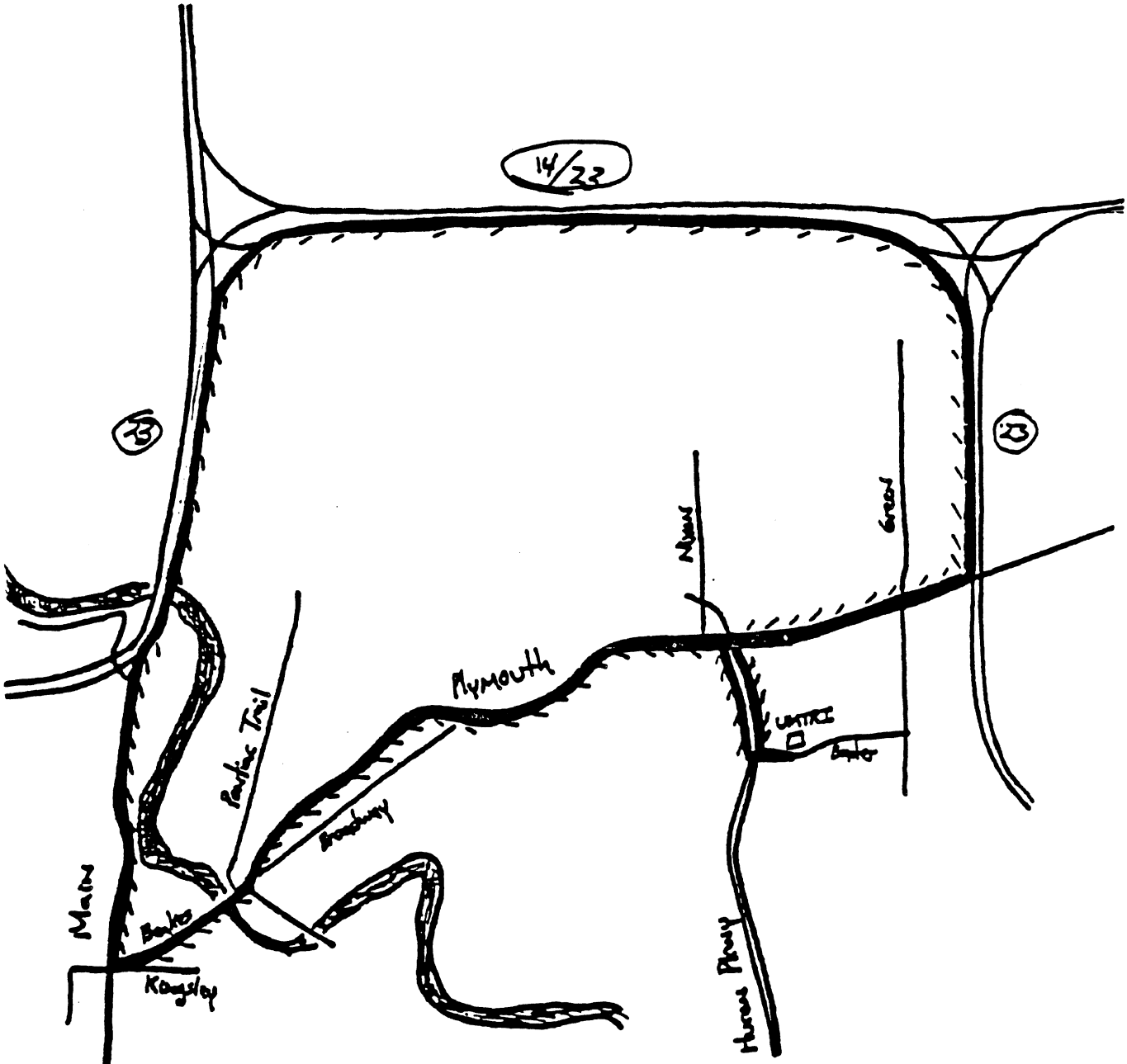
Welcome to UMTRI. Today you are participating in a study exploring the positioning of various automobile controls. During the test session you will take two drives over a specified route that includes both city and highway driving conditions.

While in the car, take time to adjust the seat position (forward or backward) and the seat recliner to the settings best suited for your driving comfort. Do not assume that your initial seat adjustments are the best for you. Experiment during your drive.

Please don't rush through your test drives; take time to get comfortable in the car and decide what you like and what you dislike about each one. Make sure you evaluate the configuration under both city and highway conditions. When you return from each drive, you will be asked to evaluate the positions of various controls in the vehicle (i.e., pedals, steering wheel, shift knob, etc.). Upon completion of both drives you will be asked to compare both configurations.

Turn over this sheet and look at the map outlining your drive. The investigator can answer any questions you may have about the route or the experiment. Drive carefully, wear your seat belt and obey all traffic laws. Thanks for participating.

UMTRI Bio-Sciences
2901 Baxter Rd.
763-3582



north on **Huron Parkway** until **Plymouth** (1st light)
turn left (west) onto **Plymouth Rd.**
follow **Plymouth** until the **Broadway** intersection (3rd light)
Plymouth becomes **Broadway**
other side of bridge **Broadway** becomes **Beakes**, then **Kingsley**
turn right (north) onto **N. Main St.** (1st <u>stop light</u> after bridge)
keep right on **N. Main**, following it onto **M-14 East/US-23 North**
follow **M-14 East** (<u>not US-23 North</u>) until the intersection of **M-14 East** and **US-23 South**
take **US-23 South** to **Plymouth Rd.**
turn right (west) on **Plymouth Rd.** to **Huron Parkway** (2nd light)
turn right (south) onto **Huron Parkway** and return to UMTRI

Vehicle Testing Data Collection Sheet

Subject#_____ Date_____ Time_____ Test Order OP PO Vehicle Type: G H S

Drive One: Seat Detent_____ Seat Recliner_____ Photo_____ Chin to Wheel_____mm

Comment_____

Steering Wheel to Pedal Distance

dislike like too small too large

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

Pedal Location

dislike like too close too far

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

Steering Wheel Location

dislike like too close too far

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

Brake to Accelerator Liftoff

dislike like too small too large

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

Door Armrest Height City Driving

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

Highway Driving

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

Console Armrest Height

City Driving

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

_____

Highway Driving

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

_____

Shift Knob Height

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

_____

Drive One

Comments, if any, on:

Feel of shift knob:

Responsiveness of brake:

Responsiveness of clutch:

Overall Comments, Drive One:

_____

_____

_____

_____

Vehicle Testing Data Collection Sheet

Subject#_____ Date_____ Time_____ Test Order OP PO Vehicle Type: G H S

Drive Two: Seat Detent_____ Seat Recliner_____ Photo_____ Chin to Wheel_____mm

Comment_____

Steering Wheel to Pedal Distance

dislike 1---2---3---4---5---6---7---8---9---10 like

too small 1---2---3---4---5---6---7---8---9---10 too large

Comments:_____

_____

Pedal Location

dislike 1---2---3---4---5---6---7---8---9---10 like

too close 1---2---3---4---5---6---7---8---9---10 too far

Comments:_____

_____

Steering Wheel Location

dislike 1---2---3---4---5---6---7---8---9---10 like

too close 1---2---3---4---5---6---7---8---9---10 too far

Comments:_____

_____

Brake to Accelerator Liftoff

dislike 1---2---3---4---5---6---7---8---9---10 like

too small 1---2---3---4---5---6---7---8---9---10 too large

Comments:_____

_____

Door Armrest Height

City Driving

dislike 1---2---3---4---5---6---7---8---9---10 like

too low 1---2---3---4---5---6---7---8---9---10 too high

Comments:_____

_____

Highway Driving

dislike 1---2---3---4---5---6---7---8---9---10 like

too low 1---2---3---4---5---6---7---8---9---10 too high

Comments:_____

_____

Console Armrest Height

City Driving

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

_____

Highway Driving

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

_____

Shift Knob Height

dislike like too low too high

1---2---3---4---5---6---7---8---9---10 1---2---3---4---5---6---7---8---9---10

Comments:_____

_____

Drive Two

Comments, if any, on:

Feel of shift knob:

Responsiveness of brake:

Responsiveness of clutch:

Overall Comments, Drive Two:

_____

_____

_____

_____

You have just driven a car in two different control configurations. Overall, which did you prefer?

For highway driving: Drive One Drive Two Neither

For city driving: Drive One Drive Two Neither

Any strong likes or dislikes: _____

_____

_____

_____

Personal space/headroom: _____

_____

_____

_____

Visability/Mirrors: _____

_____

_____

_____

Dash: layout, visability/readability, usability: _____

_____

_____

_____

Wheel shape: _____

_____

_____

_____

Door controls: window, latch: _____

_____

_____

_____

Seats: comfort, design _____

_____

_____

Subject Data Collection Sheet

Chrysler Driver Control Position Study

Ergonomic Questionaire
(Minivan Drivers)

Subject #:_____ Date:_____ Time:_____

Any strong likes or dislikes: _____

_____

_____

_____

Personal space/headroom: _____

_____

_____

_____

Visability/Mirrors:_____

_____

_____

_____

Dash: layout, visability/readability, usability:_____

_____

_____

_____

Wheel shape: _____

_____

_____

_____

Door controls: window, latch: _____

_____

_____

_____

Seats: comfort, design _____

_____

_____

_____

The shift knob of the test vehicle you drove is six inches higher than the shift knob in your vehicle. Please indicate, on the scale to the right by marking an X, your best estimate for an optimal shift knob height in this vehicle.

The shape of the shift knob in the test vehicle differed from that in your vehicle. Which style of shift knob did you prefer?

_____

_____

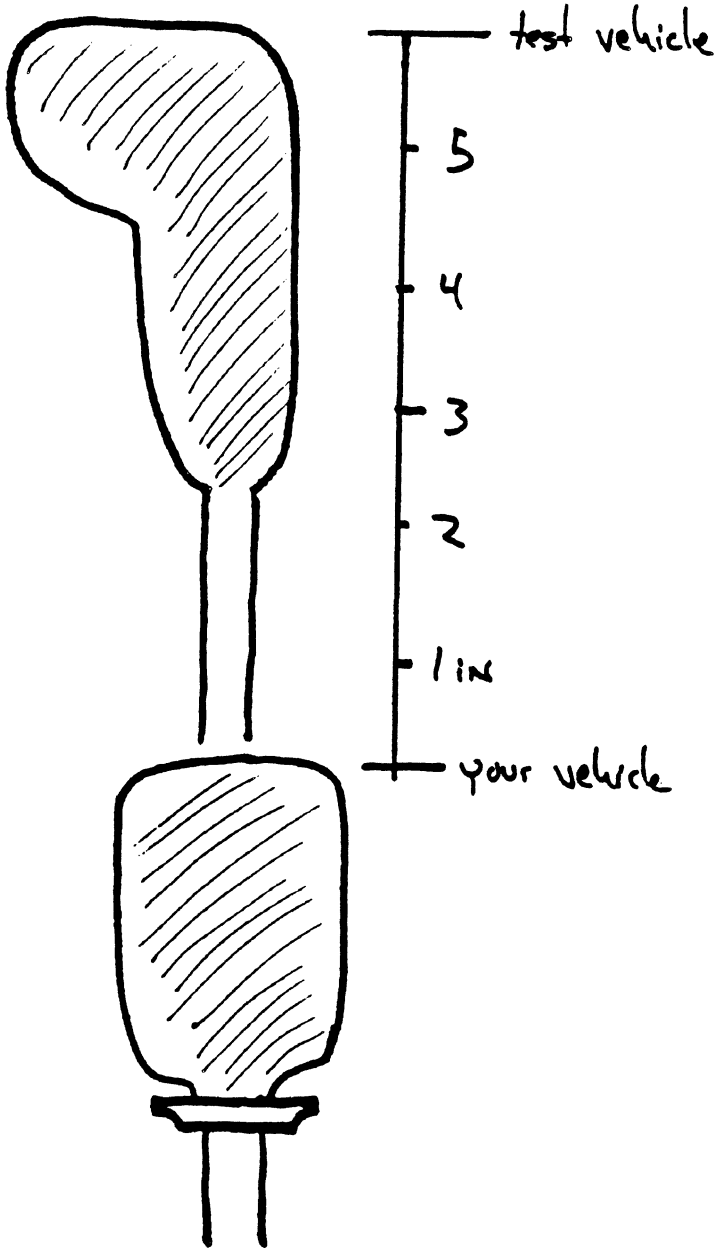
_____

The manner in which you engaged reverse in the two vehicles differed: "crash through" in the test vehicle versus a mechanical "pull-up" release on your vehicle. Which do you prefer?

_____

_____

_____



APPENDIX B

TABULATION OF SUBJECTIVE RATINGS FOR CONTROL/ARMREST LOCATIONS

Table B-1
G-body Sample Population Anthropometric Data

Group #	Stature (mm) (in)		Sitting Height (mm) (in)		Knee Height (mm) (in)		Buttock to Knee Length (mm) (in)	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	1562 61.5	20 0.8	850 33.4	23 0.9	474 18.7	13 0.5	517 20.4	17 0.7
2	1661 65.4	30 1.2	869 34.2	6 0.2	507 20.0	19 0.8	568 22.3	10 0.4
3	1720 67.7	38 1.5	903 35.5	26 1.0	530 20.9	20 0.8	595 23.4	12 0.5
4	1826 71.9	28 1.1	970 38.2	13 0.5	565 22.2	9 0.4	597 23.5	17 0.7
all	1692 66.6	102 4.0	899 35.4	51 2.0	519 20.4	37 1.5	569 22.4	36 1.4

Table B-2
H-body Sample Population Anthropometric Data

Group #	Stature (mm) (in)		Sitting Height (mm) (in)		Knee Height (mm) (in)		Buttock to Knee Length (mm) (in)	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	1538 60.5	17 0.7	832 32.7	16 0.6	471 18.6	12 0.5	516 20.3	33 1.3
2	1650 65.0	16 0.6	868 34.2	18 0.7	502 19.8	8 0.3	567 22.3	25 1.0
3	1739 68.5	25 1.0	910 35.8	19 0.8	534 21.0	8 0.3	587 23.1	25 1.0
4	1846 72.7	36 1.4	940 37.0	18 0.7	568 22.4	16 0.6	637 25.1	18 0.7
all	1693 66.7	119 4.7	887 34.9	45 1.8	519 20.4	38 1.5	577 22.7	50 2.0

Table B-3
S-body Sample Population Anthropometric Data

Group #	Stature (mm) (in)		Sitting Height (mm) (in)		Knee Height (mm) (in)		Buttock to Knee Length (mm) (in)	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	1548	16	835	22	472	5	532	17
	61.0	0.6	32.9	0.9	18.6	0.2	20.9	0.7
2	1660	27	856	27	523	12	613	35
	65.3	1.1	33.7	1.1	20.6	0.5	24.1	1.4
3	1725	22	893	24	534	10	599	18
	67.9	0.9	35.1	1.0	21.0	0.4	23.6	0.7
4	1824	24	941	17	564	11	624	23
	71.8	1.0	37.0	0.7	22.2	0.4	24.6	0.9
all	1689	105	881	46	523	35	592	43
	66.5	4.1	34.7	1.8	20.6	1.4	23.3	1.7

Table B-4
G-body Driver Preferred Position Results

Group #	Control Configuration	Seat Position (X in mm)		Seat Back Recliner Angle (degrees)		Chin to Wheel Distance (mm)	
		mean	s.d.	mean	s.d.	mean	s.d.
1	production	1286	36	28.4	4.1	310	37
	optimal	1310	42	27.1	2.4	324	55
2	production	1366	26	26.1	1.7	351	46
	optimal	1386	17	25.6	0.6	378	49
3	production	1418	11	25.3	0.9	409	33
	optimal	1438	30	25.3	0.0	428	42
4	production	1434	17	27.3	2.9	448	18
	optimal	1450	14	26.9	2.1	457	11
all	production	1376	63	26.8	2.7	380	63
	optimal	1396	62	26.2	1.7	397	65

Table B-5
H-body Driver Preferred Position Results

Group #	Control Configuration	Seat Position (X in mm)		Seat Back Recliner Angle (degrees)		Chin to Wheel Distance (mm)	
		mean	s.d.	mean	s.d.	mean	s.d.
1	production	1289	17	23.3	2.5	309	29
	optimal	1313	18	23.9	2.1	320	23
2	production	1341	26	23.1	3.3	347	41
	optimal	1373	23	21.0	0.0	364	44
3	production	1397	27	22.8	2.7	397	41
	optimal	1417	30	22.7	2.3	418	30
4	production	1429	17	23.7	3.7	455	41
	optimal	1445	28	22.8	2.3	472	33
all	production	1364	59	23.2	2.8	377	66
	optimal	1387	56	22.6	2.1	394	66

Table B-6
S-body Driver Preferred Position Results

Group #	Control Configuration	Seat Position (X in mm)		Seat Back Recliner Angle (degrees)		Chin to Wheel Distance (mm)	
		mean	s.d.	mean	s.d.	mean	s.d.
1	production	1214	28	23.4	4.0	353	36
	optimal	1222	36	21.3	2.1	343	49
2	production	1294	20	23.0	4.9	420	29
	optimal	1306	23	20.5	2.5	408	27
3	production	1298	9	19.2	0.4	426	24
	optimal	1298	17	20.4	2.2	427	30
4	production	1342	41	20.4	2.5	465	31
	optimal	1362	18	20.4	1.5	489	10
all	production	1287	54	21.5	3.6	416	50
	optimal	1297	56	20.6	2.0	417	61

Table B-7
G-body Results of Driver Subjective Ratings

Group #	Control Configuration	Steering Wheel to Pedal Distance				Pedal Location				Steering Wheel Location			
		dislike/like		small/large		dislike/like		close/far		dislike/like		close/far	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	5.6	1.3	5.2	2.5	9.0	1.4	5.8	1.8	6.0	3.4	3.8	1.6
	optimal	4.8	2.9	5.8	2.2	7.6	3.6	5.4	0.5	5.2	2.3	3.8	1.1
2	production	6.4	2.1	4.4	1.3	8.4	1.9	5.4	0.9	6.2	2.8	5.4	1.1
	optimal	6.4	2.3	4.2	0.8	8.0	2.4	5.2	0.4	6.2	2.5	6.0	1.0
3	production	6.3	2.7	5.5	0.9	7.8	1.8	5.5	0.9	5.6	2.1	4.1	1.1
	optimal	7.2	1.9	5.0	1.6	8.6	1.3	5.0	1.2	7.6	1.8	5.2	1.3
4	production	5.8	1.6	5.2	1.1	4.8	3.3	5.4	1.1	5.4	3.4	4.8	1.5
	optimal	7.0	2.7	4.4	1.3	6.6	3.4	5.4	0.9	6.8	2.8	5.2	1.5
all	production	6.0	1.9	5.1	1.5	7.5	2.6	5.5	1.1	5.8	2.7	4.5	1.4
	optimal	6.4	2.5	4.9	1.6	7.7	2.7	5.3	0.8	6.5	2.4	5.1	1.4

Table B-7 (continued)
G-body Results of Driver Subjective Ratings

Group #	Control Configuration	Brake to Accelerator Liftoff				Door Armrest Height City Driving				Door Armrest Height Highway Driving			
		dislike/like		small/large		dislike/like		low/high		dislike/like		low/high	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	8.2	1.9	5.2	0.4	2.2	1.6	2.4	1.7	3.0	2.3	2.6	1.8
	optimal	6.6	2.7	5.8	1.3	6.2	3.0	6.8	1.8	6.6	2.9	6.4	1.7
2	production	8.4	1.5	5.2	0.4	4.0	3.2	2.8	1.6	3.2	2.8	3.0	1.9
	optimal	8.0	2.3	5.2	0.4	4.6	2.5	5.6	1.9	5.2	2.9	5.6	2.3
3	production	7.0	2.5	5.9	1.0	3.0	1.2	5.0	3.2	3.0	1.6	5.0	3.3
	optimal	7.6	2.8	6.2	1.3	6.0	3.2	6.8	1.9	6.6	3.2	7.0	1.9
4	production	4.8	2.0	7.0	1.9	4.2	2.3	4.0	1.9	4.0	1.0	3.8	0.5
	optimal	5.0	2.4	7.2	2.0	4.4	2.6	6.4	1.5	5.3	3.8	6.0	2.0
all	production	7.1	2.4	5.8	1.3	3.4	2.2	3.6	2.3	3.2	2.0	3.6	2.2
	optimal	6.8	2.6	6.1	1.5	5.3	2.7	6.4	1.7	5.9	3.0	6.3	1.9

Table B-7 (continued)
G-body Results of Driver Subjective Ratings

Group #	Control Configuration	Console Armrest Height City Driving				Console Armrest Height Highway Driving				Shift Knob Height			
		dislike/like		low/high		dislike/like		low/high		dislike/like		low/high	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	1.2	0.4	1.2	0.4	1.2	0.4	1.2	0.4	7.2	2.8	6.0	1.7
	optimal	3.0	3.1	8.4	2.6	4.6	3.8	8.0	2.4	6.0	1.4	4.5	1.0
2	production	4.4	3.2	4.2	1.9	4.2	2.2	4.6	1.7	7.0	2.4	5.2	1.1
	optimal	4.0	2.2	6.8	2.4	4.8	2.5	6.2	2.4	4.8	1.5	3.8	1.1
3	production	5.8	1.9	3.6	2.1	5.0	2.0	3.2	2.4	7.6	1.7	5.1	0.2
	optimal	4.0	4.1	8.6	1.9	4.6	3.8	8.0	1.9	7.0	3.5	4.1	2.1
4	production	4.8	3.4	3.6	1.7	6.0	2.9	3.6	1.7	6.8	2.8	4.6	0.9
	optimal	3.0	3.9	7.2	3.6	4.8	2.8	5.0	3.6	4.4	3.2	3.2	1.1
all	production	4.1	2.9	3.2	1.9	4.0	2.6	3.2	2.0	7.2	2.3	5.2	1.2
	optimal	3.5	3.2	7.8	2.6	4.7	3.0	6.9	2.7	5.5	2.7	3.9	1.4

Table B-8
H-body Results of Driver Subjective Ratings

Group #	Control Configuration	Steering Wheel to Pedal Distance				Pedal Location				Steering Wheel Location			
		dislike/like		small/large		dislike/like		close/far		dislike/like		close/far	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	6.4	3.3	6.8	2.0	8.2	2.4	5.8	0.8	6.4	2.9	3.3	1.5
	optimal	8.4	1.1	5.3	0.5	8.0	2.3	4.5	1.0	7.2	2.0	4.8	0.5
2	production	8.0	1.6	5.4	1.1	8.8	1.3	5.3	0.5	8.6	1.3	5.8	1.0
	optimal	7.8	2.9	4.3	1.0	9.2	0.8	5.0	0.0	5.8	2.7	7.0	1.4
3	production	7.8	1.1	5.4	0.4	5.0	1.6	5.1	1.6	7.8	2.2	5.2	0.8
	optimal	6.8	3.1	4.6	1.5	7.6	2.6	5.4	1.8	6.6	3.0	4.4	0.5
4	production	6.6	1.5	5.4	0.9	7.2	1.9	4.7	1.6	6.4	3.1	5.8	1.5
	optimal	4.8	2.3	3.7	1.6	5.8	3.0	6.0	1.9	6.0	2.3	5.2	1.3
all	production	7.2	2.0	5.8	1.3	7.3	2.3	5.2	1.2	7.3	2.5	5.1	1.5
	optimal	7.0	2.7	4.4	1.3	7.7	2.5	5.3	1.4	6.4	2.4	5.4	1.4

Table B-8 (continued)
H-body Results of Driver Subjective Ratings

Group #	Control Configuration	Brake to Accelerator Liftoff				Door Armrest Height City Driving				Door Armrest Height Highway Driving			
		dislike/like		small/large		dislike/like		low/high		dislike/like		low/high	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	8.0	2.3	6.0	1.4	5.8	3.4	3.8	2.2	4.2	2.9	4.5	3.1
	optimal	8.8	1.3	5.0	0.0	3.8	3.6	7.6	2.1	4.6	3.8	7.6	2.1
2	production	8.8	1.3	5.3	0.5	6.2	3.6	4.0	2.4	7.6	2.5	5.0	1.4
	optimal	7.2	2.3	5.5	1.0	6.4	1.8	6.0	1.0	6.8	2.3	7.0	2.0
3	production	6.6	2.7	6.2	1.3	5.6	1.9	5.0	1.9	5.6	2.9	4.3	2.0
	optimal	6.6	3.1	6.3	1.6	5.8	3.8	6.7	1.7	6.8	3.3	6.3	1.2
4	production	7.4	1.9	6.4	0.5	7.2	3.1	4.7	1.6	6.6	3.8	5.1	0.7
	optimal	6.2	3.6	7.2	1.6	8.0	3.5	6.2	1.6	8.0	3.4	6.1	1.7
all	production	7.7	2.1	6.0	1.0	6.2	2.9	4.4	1.9	6.0	3.1	4.7	1.8
	optimal	7.2	2.7	6.1	1.5	6.0	3.4	6.6	1.6	6.6	3.2	6.8	1.7

Table B-8 (continued)
H-body Results of Driver Subjective Ratings

Group #	Control Configuration	Console Armrest Height City Driving				Console Armrest Height Highway Driving				Shift Knob Height			
		dislike/like		low/high		dislike/like		low/high		dislike/like		low/high	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	4.0	3.1	3.2	2.2	4.6	3.5	3.3	2.2	6.0	2.3	5.4	1.1
	optimal	7.2	2.8	5.8	1.3	7.8	2.3	5.6	0.9	8.6	2.1	5.0	0.0
2	production	7.8	2.7	4.3	0.5	7.4	2.6	4.0	0.8	9.0	1.7	5.3	0.5
	optimal	8.0	1.2	6.5	1.7	8.0	1.2	5.8	1.5	9.0	1.7	4.8	0.5
3	production	6.6	3.4	4.9	1.5	7.2	3.4	5.2	1.4	6.2	3.5	5.9	1.7
	optimal	5.8	3.5	6.9	1.3	6.8	3.1	5.1	1.9	5.8	2.5	4.7	2.1
4	production	7.0	2.3	4.9	1.5	5.8	2.6	4.4	1.1	5.8	3.3	5.1	1.6
	optimal	5.2	3.3	6.9	2.1	6.2	3.6	6.6	2.0	4.8	3.2	3.4	1.5
all	production	6.4	3.0	4.3	1.6	6.3	3.0	4.2	1.6	6.8	2.9	5.4	1.2
	optimal	6.6	2.8	6.5	1.6	7.2	2.6	5.8	1.6	7.1	2.9	4.4	1.4

Table B-9
S-body Results of Driver Subjective Ratings

Group #	Control Configuration	Steering Wheel to Pedal Distance				Pedal Location				Steering Wheel Location			
		dislike/like		small/large		dislike/like		close/far		dislike/like		close/far	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	5.0	3.1	7.0	2.0	5.5	2.6	7.5	1.9	7.4	2.6	4.8	1.1
	optimal	6.6	1.7	6.0	2.0	6.4	1.8	5.3	1.3	6.2	3.0	4.3	1.5
2	production	8.8	0.8	5.6	0.5	8.8	1.3	5.8	0.4	7.8	2.8	5.2	0.8
	optimal	8.0	1.6	6.2	0.8	9.0	0.7	5.8	0.4	7.0	3.2	4.6	1.7
3	production	8.8	1.1	5.4	0.5	7.2	1.1	4.8	1.5	6.0	3.3	5.2	1.8
	optimal	8.2	1.9	5.4	1.1	6.4	1.7	5.6	1.8	6.8	3.1	4.6	1.1
4	production	6.6	1.5	5.0	1.2	5.8	2.0	5.2	1.6	5.4	2.7	5.0	0.7
	optimal	6.4	2.4	4.5	1.0	6.8	1.8	4.8	0.5	5.5	1.7	5.3	0.5
all	production	7.3	2.4	5.8	1.4	6.9	2.1	5.7	1.7	6.7	2.8	5.1	1.1
	optimal	7.3	1.9	5.6	1.4	7.2	1.8	5.4	1.1	6.4	2.7	4.7	1.2

Table B-9 (continued)
S-body Results of Driver Subjective Ratings

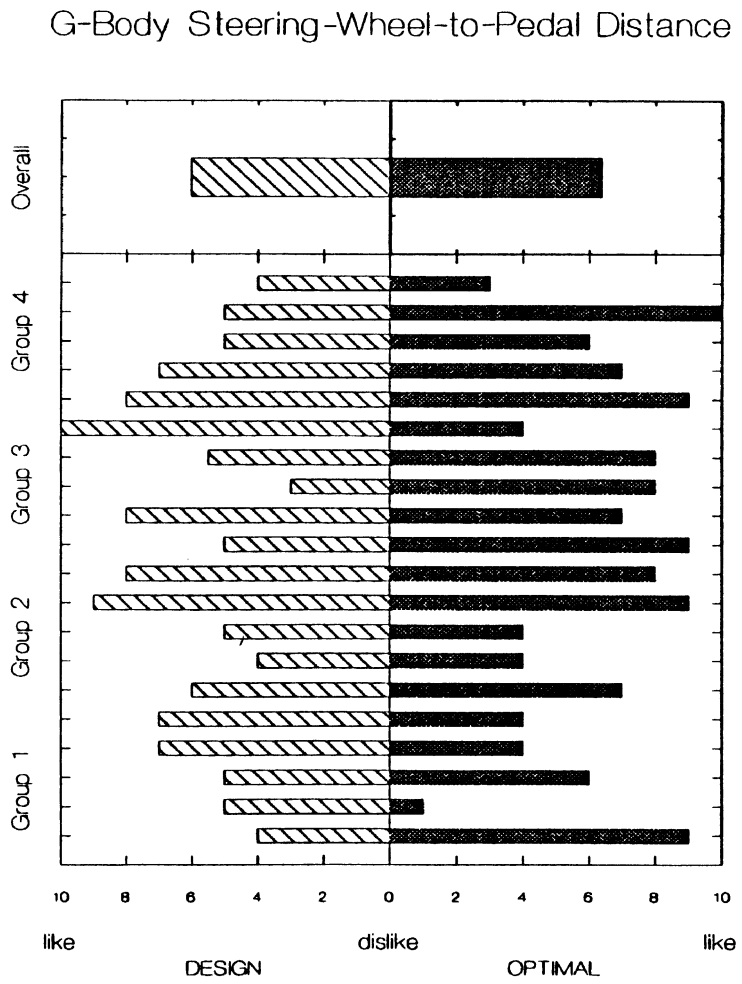
Group #	Control Configuration	Brake to Accelerator Liftoff				Door Armrest Height City Driving				Door Armrest Height Highway Driving			
		dislike/like		small/large		dislike/like		low/high		dislike/like		low/high	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	6.0	2.1	6.4	1.5	5.0	3.9	2.7	2.1	5.8	3.7	4.0	2.6
	optimal	7.0	2.5	5.5	1.0	6.4	4.1	6.8	2.5	8.0	2.5	5.8	1.5
2	production	9.2	0.8	5.8	0.4	7.0	3.7	5.0	2.5	7.0	3.7	5.4	2.7
	optimal	9.2	0.8	5.6	0.5	5.0	4.6	8.0	2.3	8.0	2.4	6.0	1.0
3	production	8.6	1.7	5.6	0.9	7.2	3.6	4.8	2.3	6.2	3.7	4.6	2.7
	optimal	7.8	2.2	5.8	0.8	6.8	3.6	7.0	2.1	6.8	4.1	6.6	2.3
4	production	5.6	1.5	6.4	1.1	6.6	3.0	5.4	0.9	7.8	1.9	5.3	0.5
	optimal	6.2	2.2	5.6	0.5	3.8	2.8	7.4	2.3	4.5	2.9	7.0	2.4
all	production	7.4	2.2	6.1	1.1	6.5	3.4	4.7	2.1	6.6	3.2	4.8	2.2
	optimal	7.6	2.2	5.6	0.7	5.5	3.7	7.3	2.2	6.9	3.1	6.3	1.8

Table B-9 (continued)
S-body Results of Driver Subjective Ratings

Group #	Control Configuration	Console Armrest Height City Driving				Console Armrest Height Highway Driving				Shift Knob Height			
		dislike/like		low/high		dislike/like		low/high		dislike/like		low/high	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
1	production	4.6	3.4	8.0	1.6	5.4	3.5	7.6	1.9	6.0	3.4	6.8	1.7
	optimal	2.8	2.9	7.0	3.2	3.8	2.7	5.5	2.1	6.0	2.0	5.5	1.0
2	production	5.4	4.2	6.0	1.9	6.8	3.4	6.2	1.8	7.6	1.9	6.0	1.4
	optimal	5.6	4.2	6.6	2.6	7.0	3.3	6.0	1.9	8.8	1.3	5.8	0.8
3	production	4.8	3.3	7.4	1.5	4.6	3.5	7.8	2.0	6.4	1.5	6.4	1.7
	optimal	4.8	3.1	6.8	2.6	4.6	3.3	6.8	2.6	6.2	2.8	6.0	1.4
4	production	3.7	2.7	6.8	1.8	4.4	2.8	6.5	1.7	6.6	2.1	5.6	0.9
	optimal	2.8	1.3	6.6	3.1	3.0	1.4	6.6	3.1	5.4	0.9	5.8	1.6
all	production	4.6	3.2	7.1	1.7	5.3	3.2	7.1	1.9	6.7	2.2	6.2	1.4
	optimal	4.0	3.1	6.7	2.6	4.6	3.0	6.3	2.3	6.6	2.2	5.8	1.2

APPENDIX C

BAR GRAPHS OF OVERALL AND INDIVIDUAL SUBJECTIVE RATINGS FOR PEDAL AND STEERING WHEEL LOCATIONS


G-Body Steering-Wheel-to-Pedal Distance
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

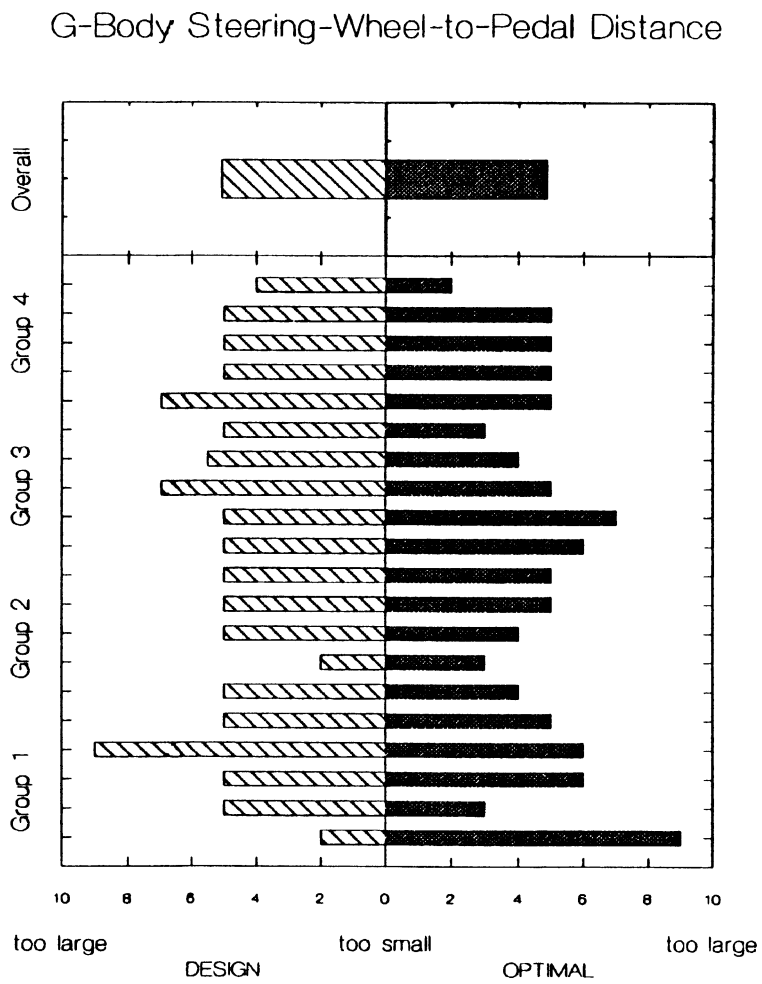
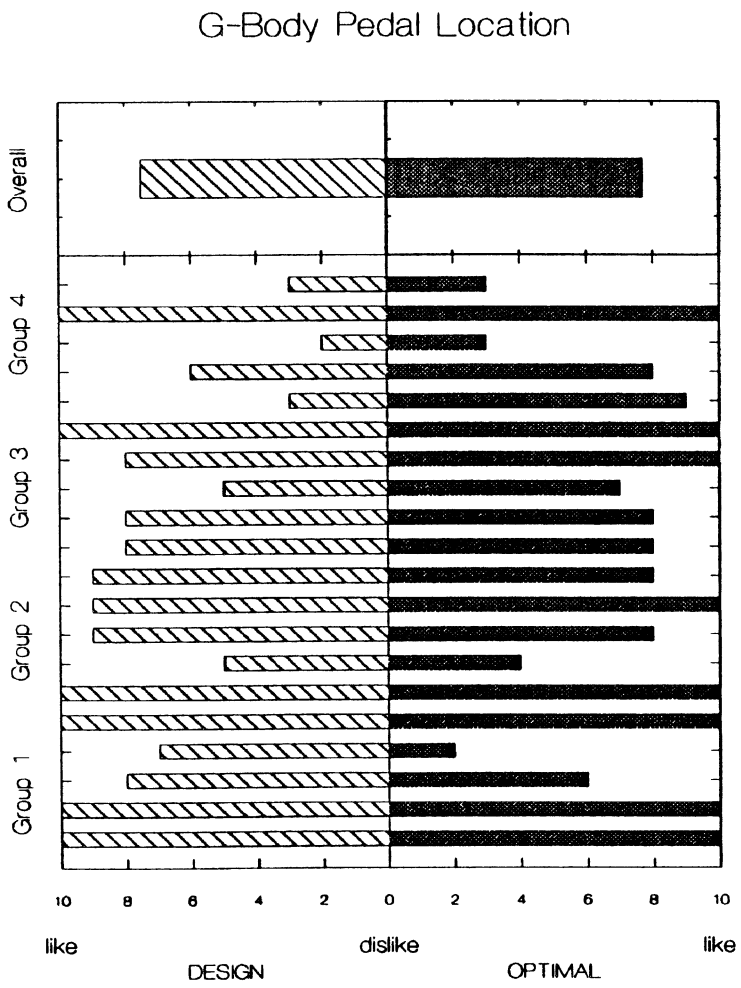

G-Body Steering-Wheel-to-Pedal Distance
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.1


G-Body Pedal Location
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

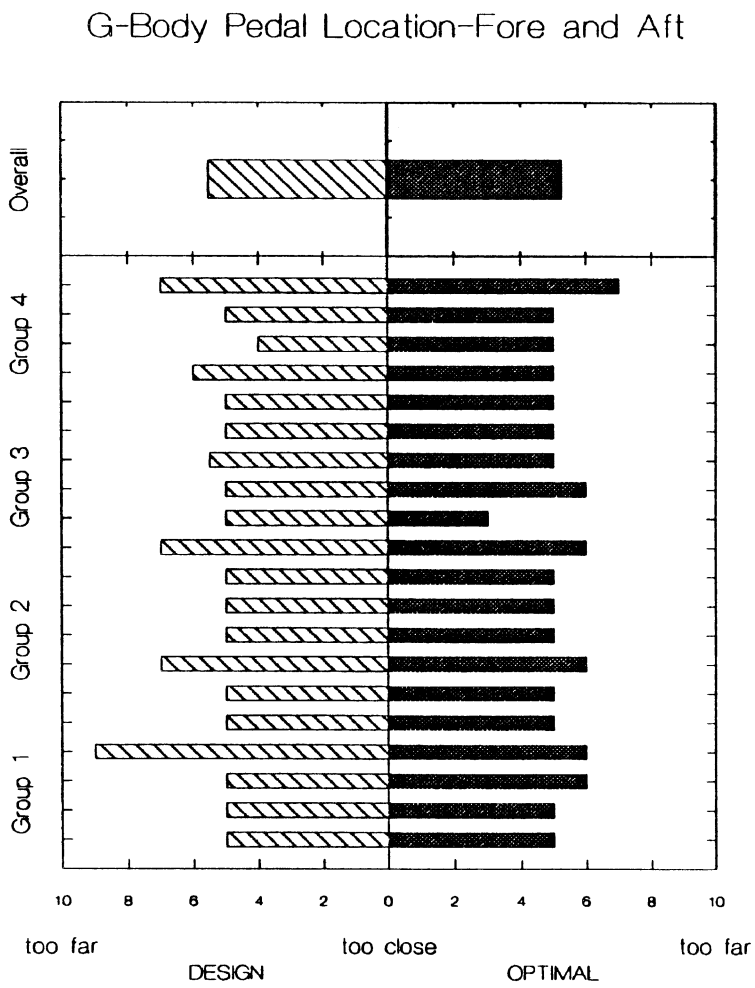
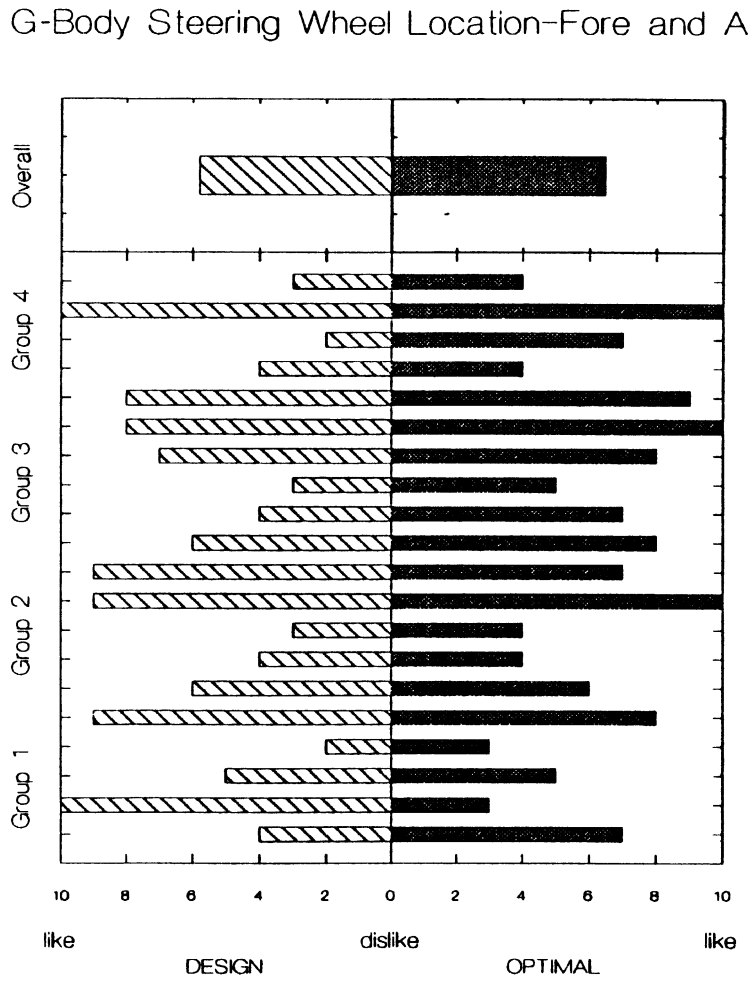

G-Body Pedal Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.2


G-Body Steering Wheel Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

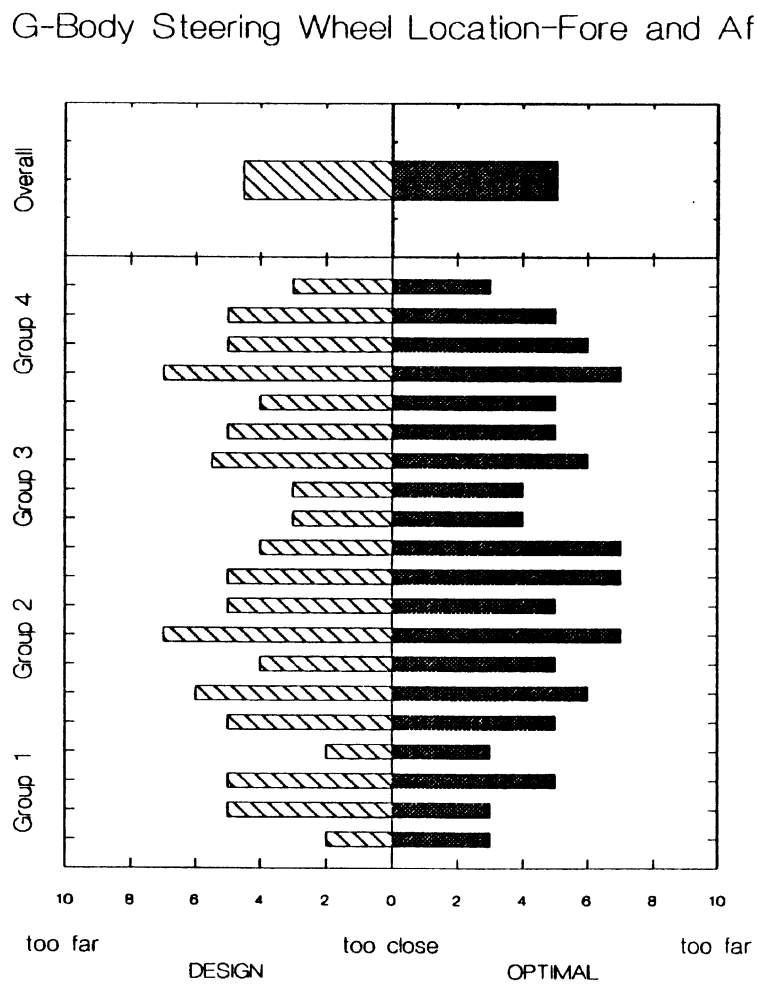

G-Body Steering Wheel Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.3

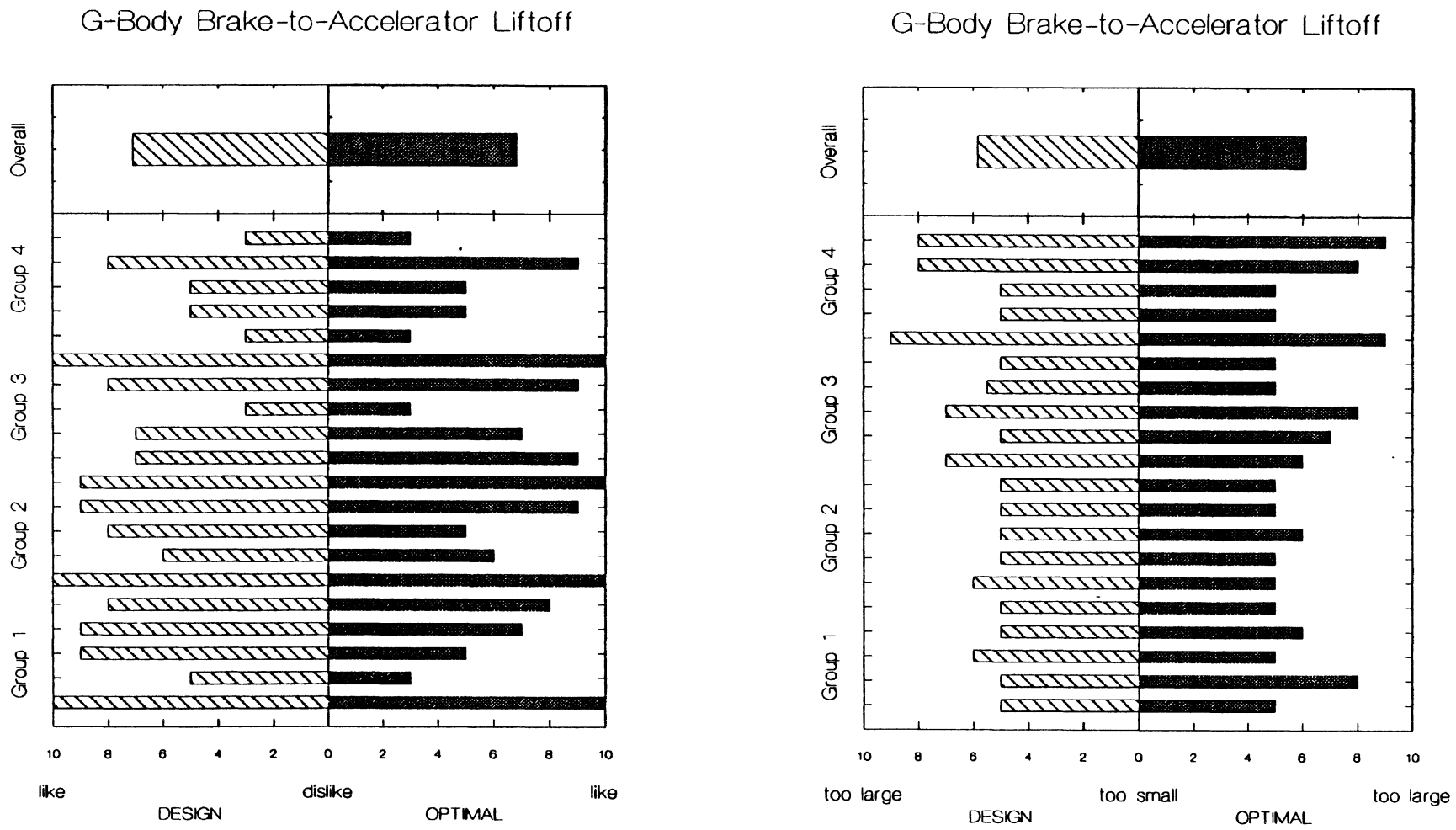

G-Body Brake-to-Accelerator Liftoff
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL
G-Body Brake-to-Accelerator Liftoff
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.4

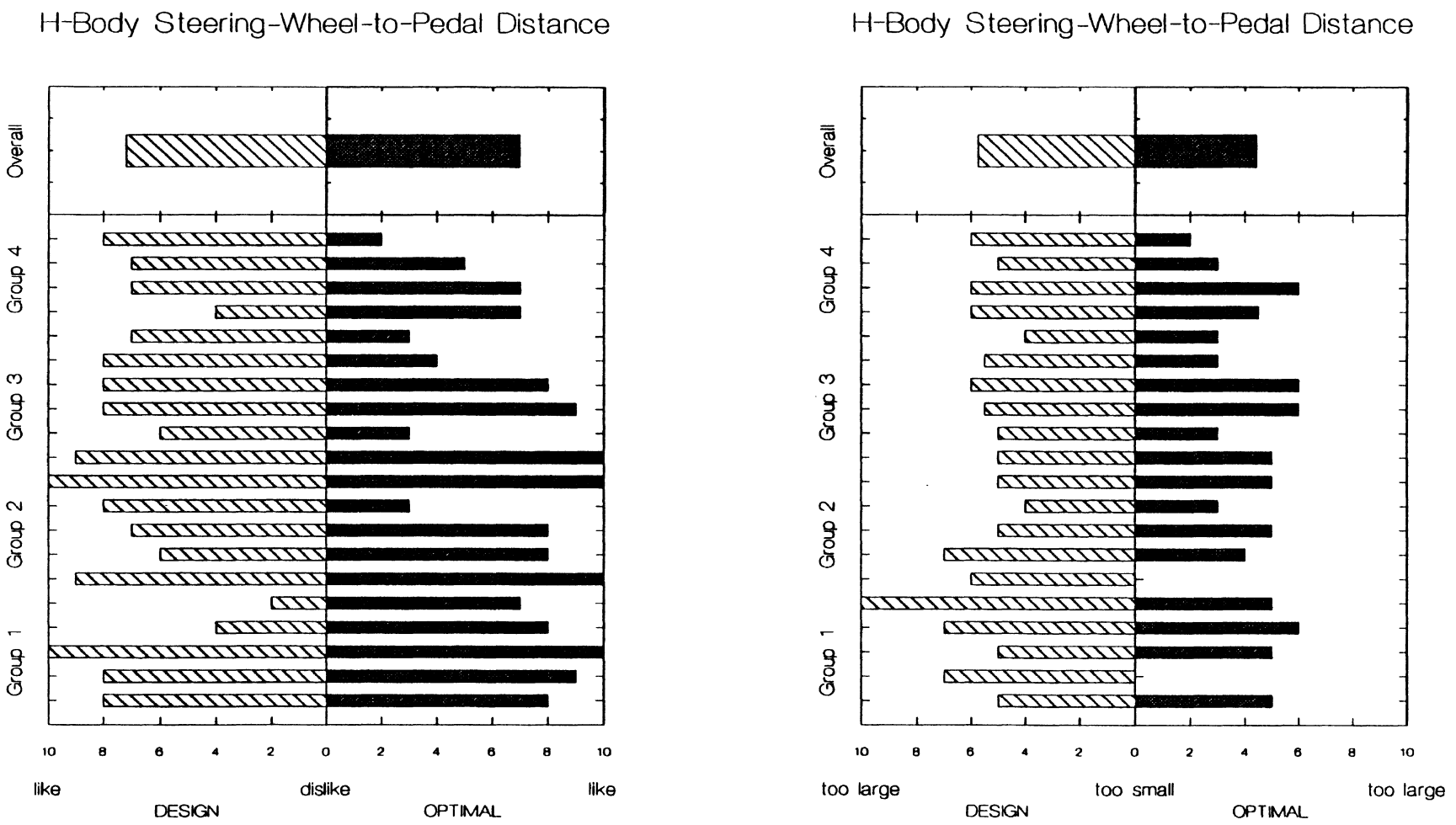
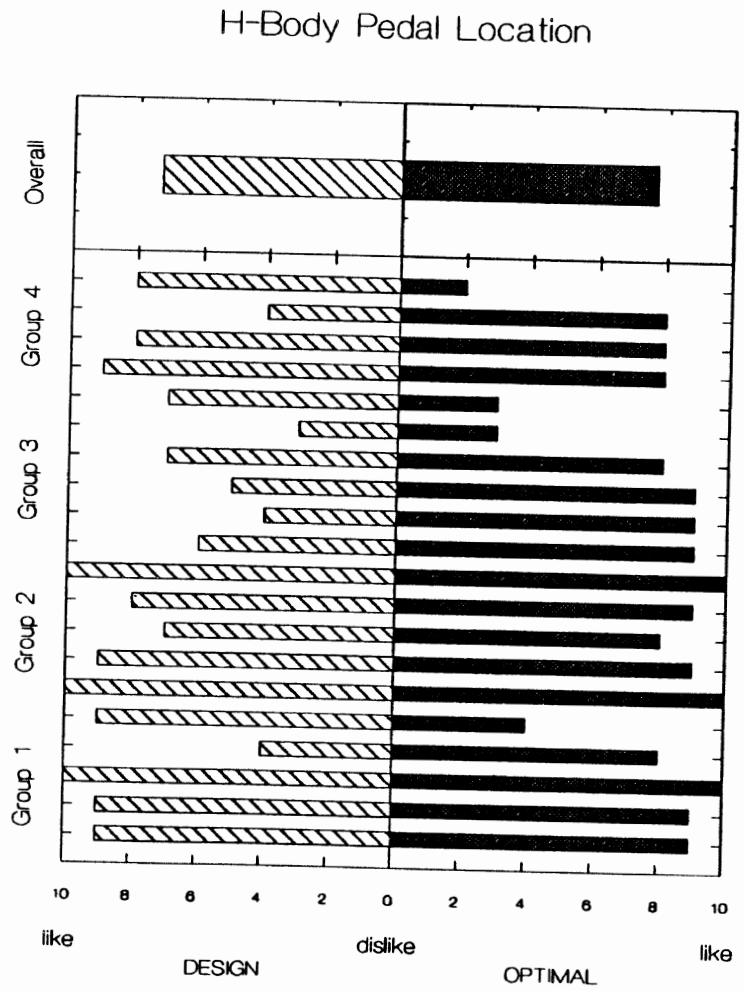

H-Body Steering-Wheel-to-Pedal Distance
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL
H-Body Steering-Wheel-to-Pedal Distance
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.5


H-Body Pedal Location
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

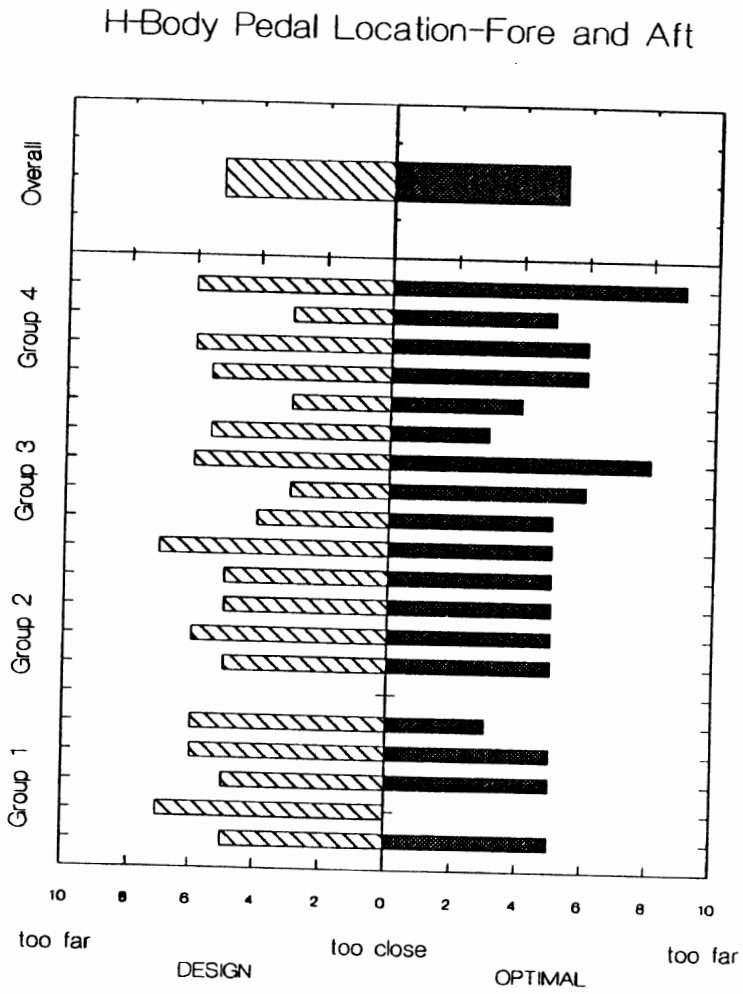
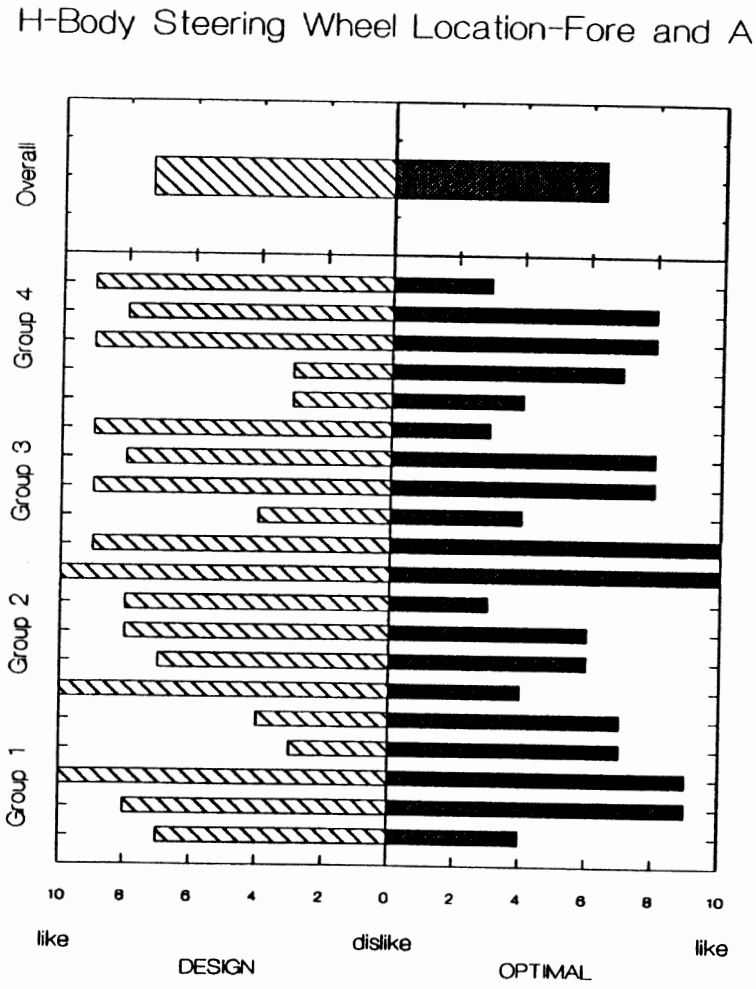

H-Body Pedal Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.6


H-Body Steering Wheel Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

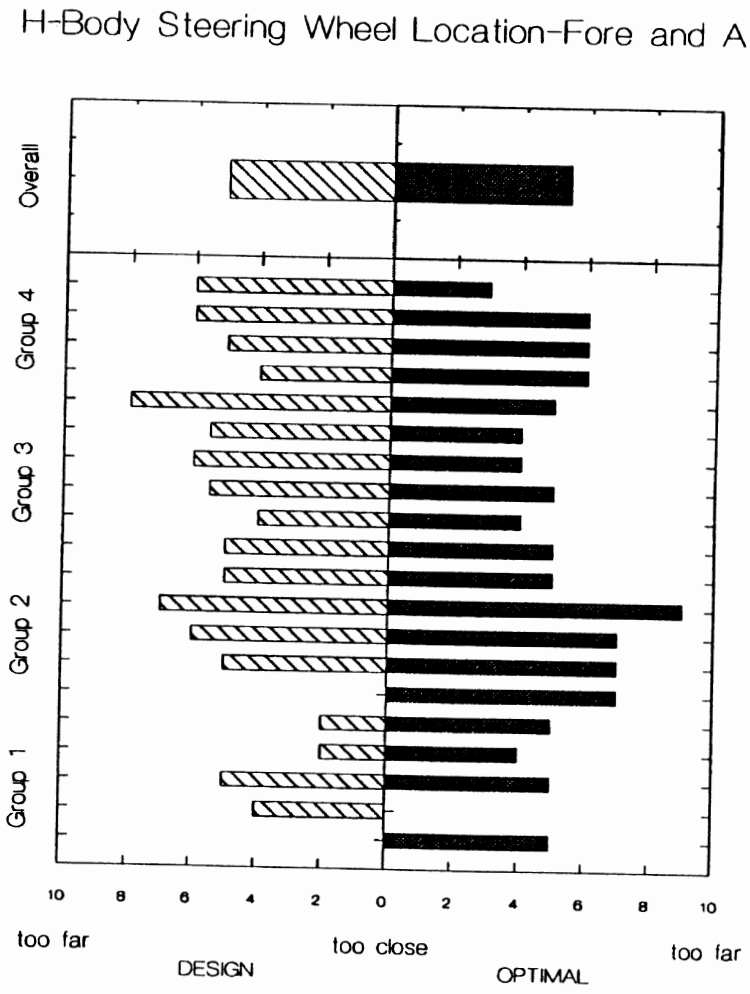
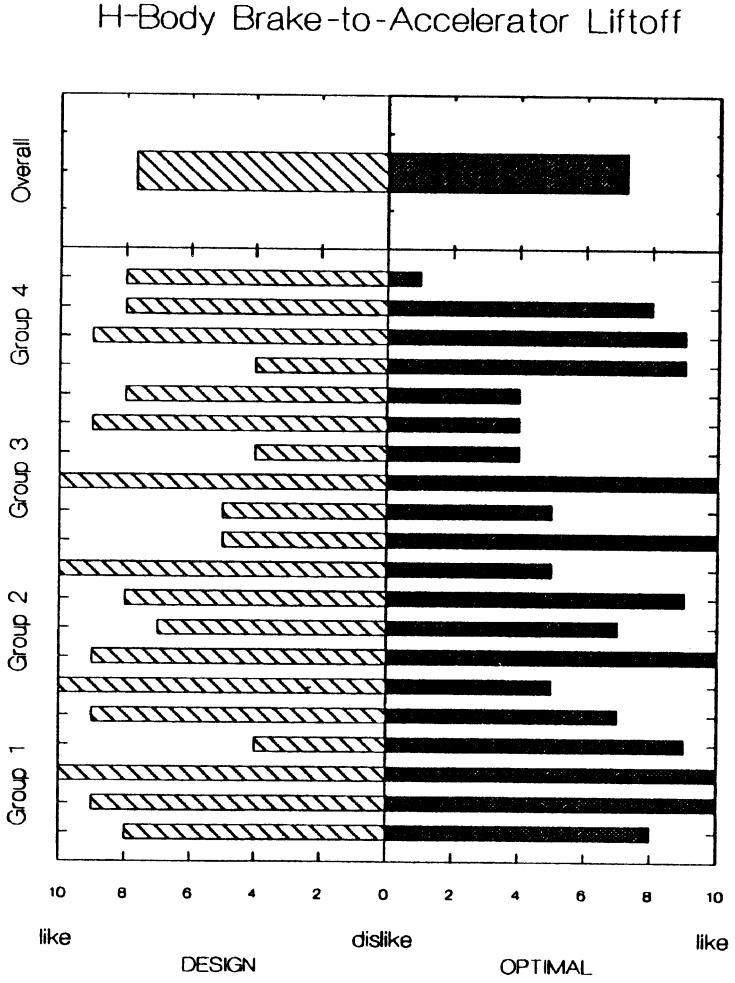

H-Body Steering Wheel Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.7


H-Body Brake-to-Accelerator Liftoff
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

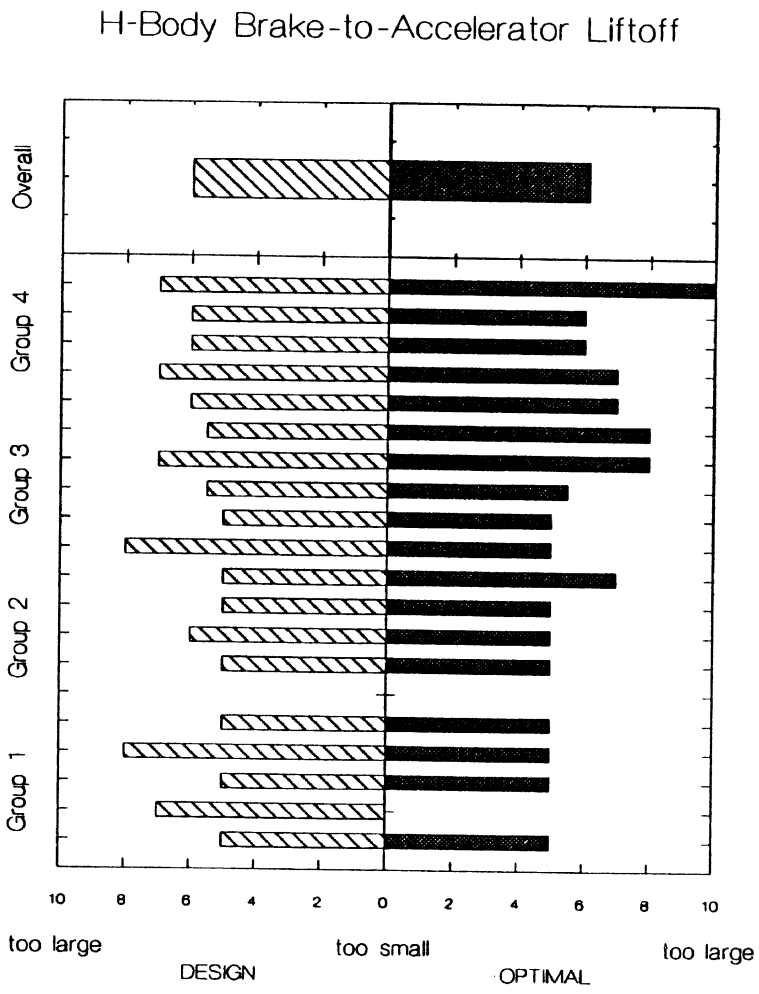
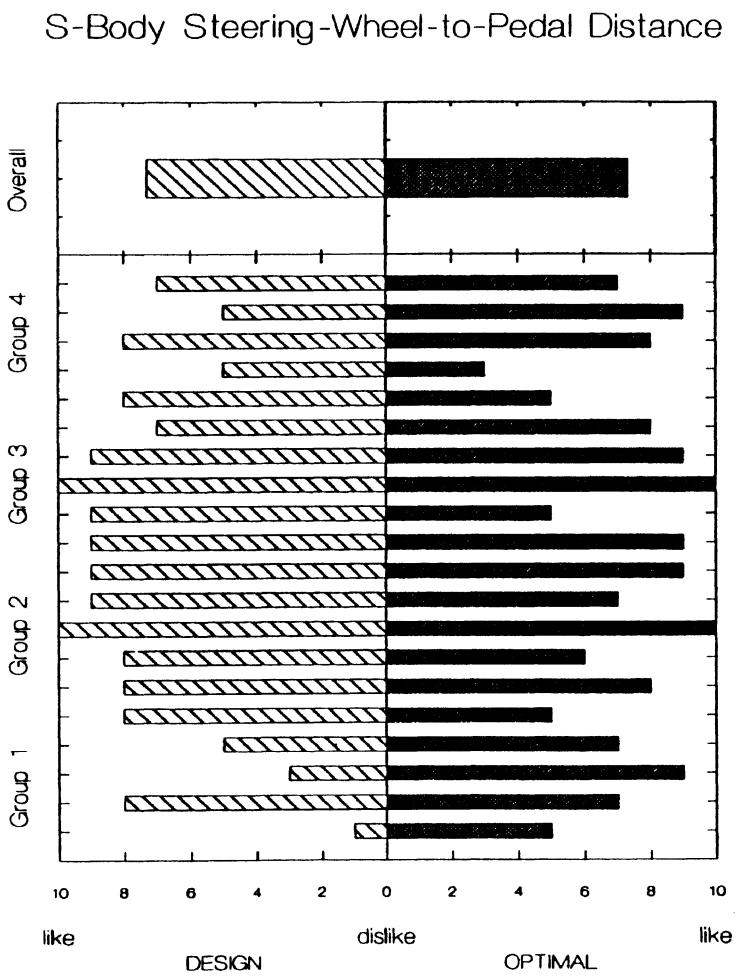

H-Body Brake-to-Accelerator Liftoff
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.8


S-Body Steering-Wheel-to-Pedal Distance
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

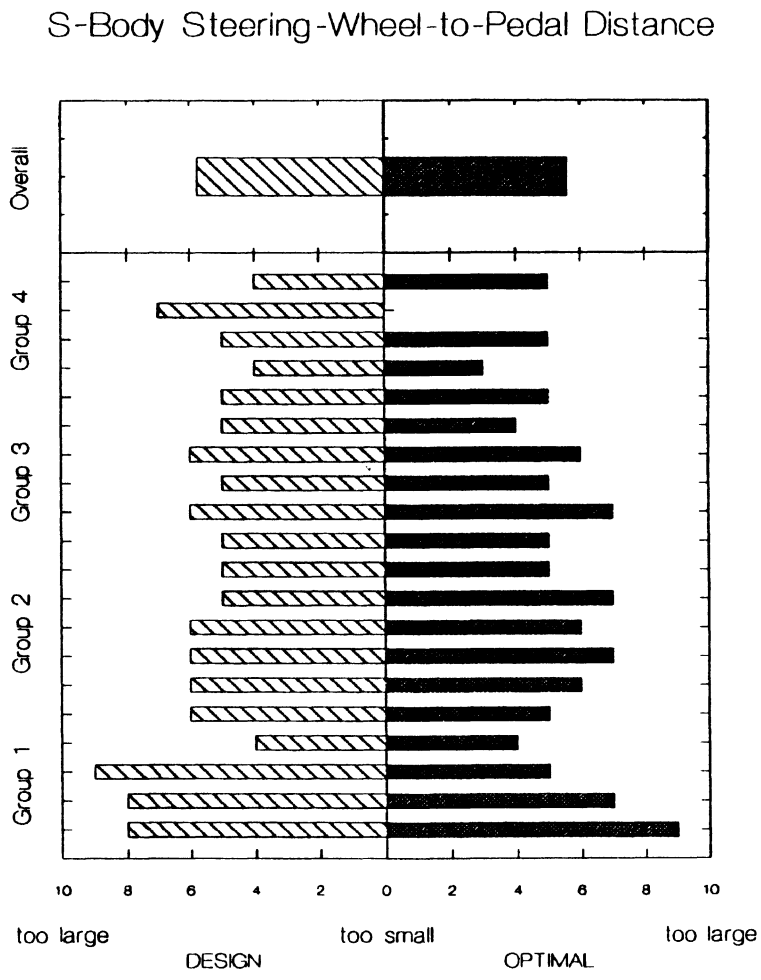
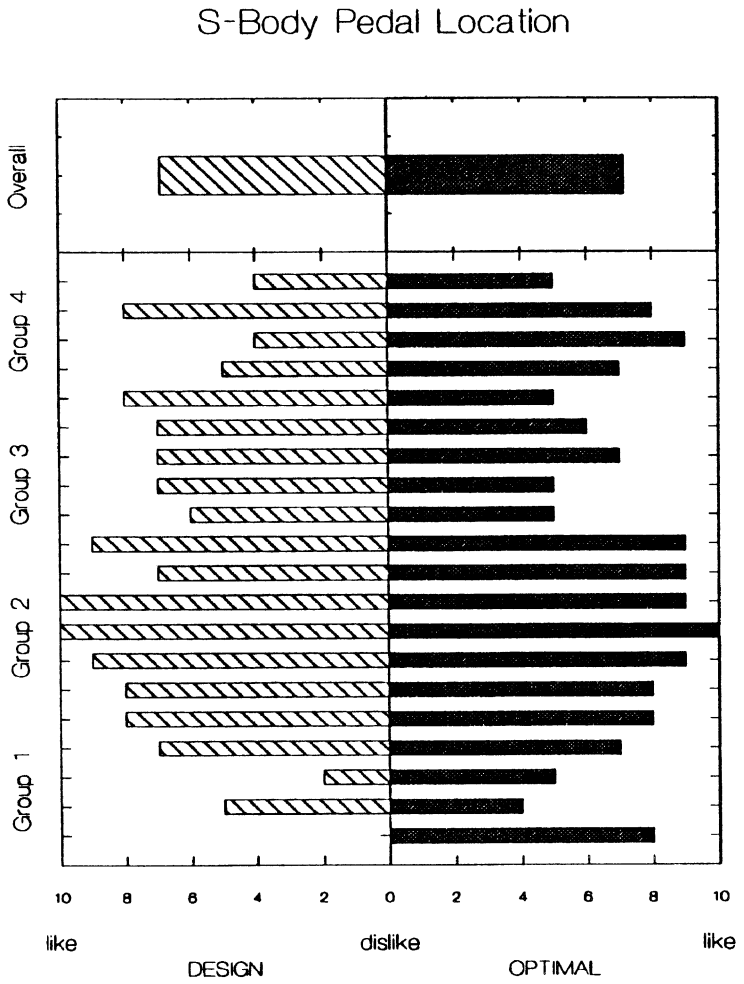

S-Body Steering-Wheel-to-Pedal Distance
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.9


S-Body Pedal Location
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

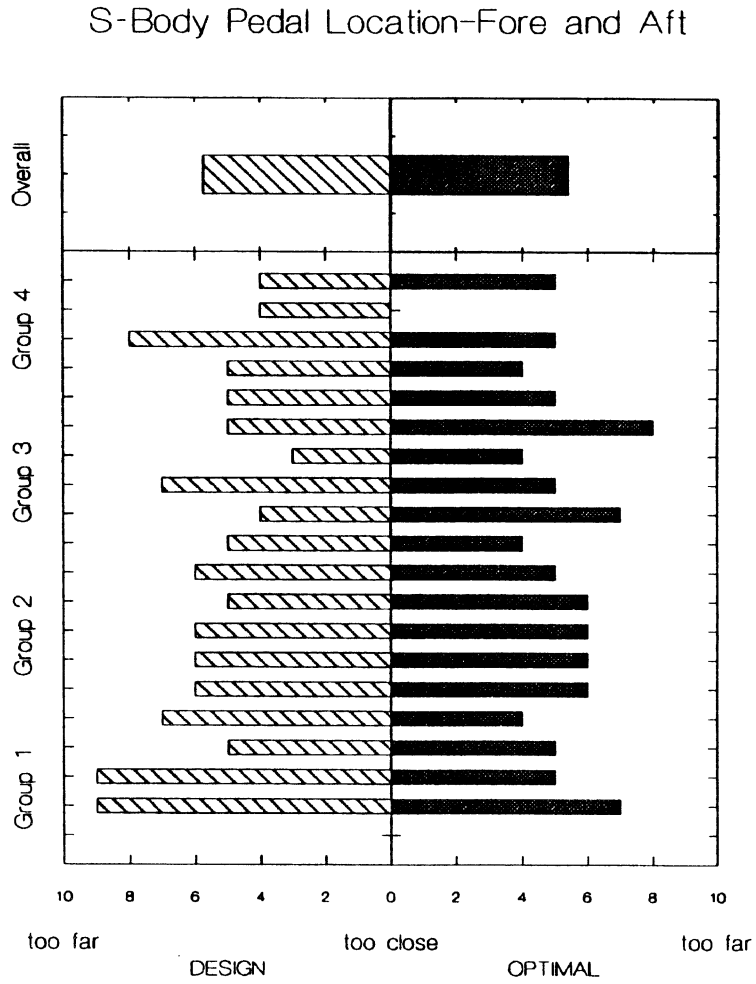
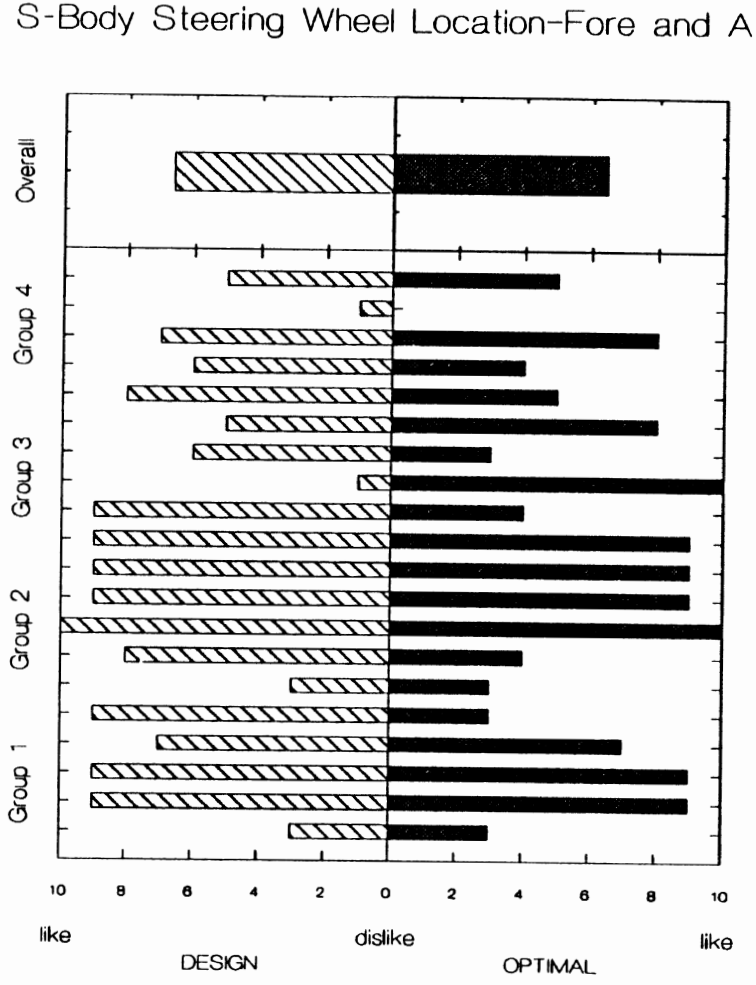

S-Body Pedal Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.10


S-Body Steering Wheel Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

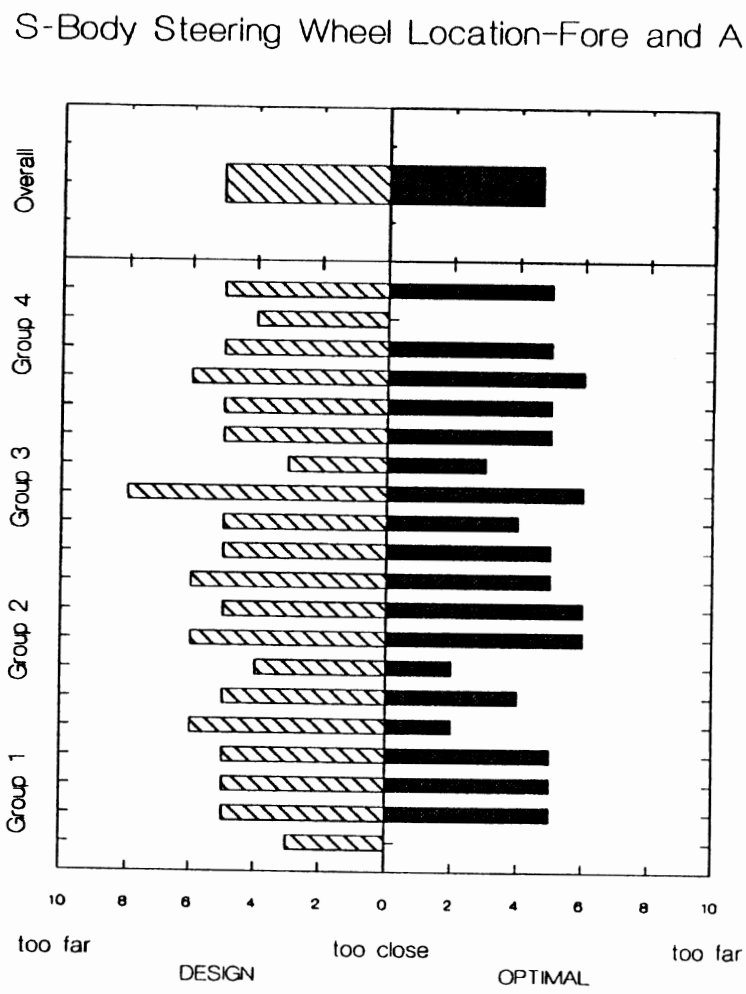

S-Body Steering Wheel Location-Fore and Aft
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.11

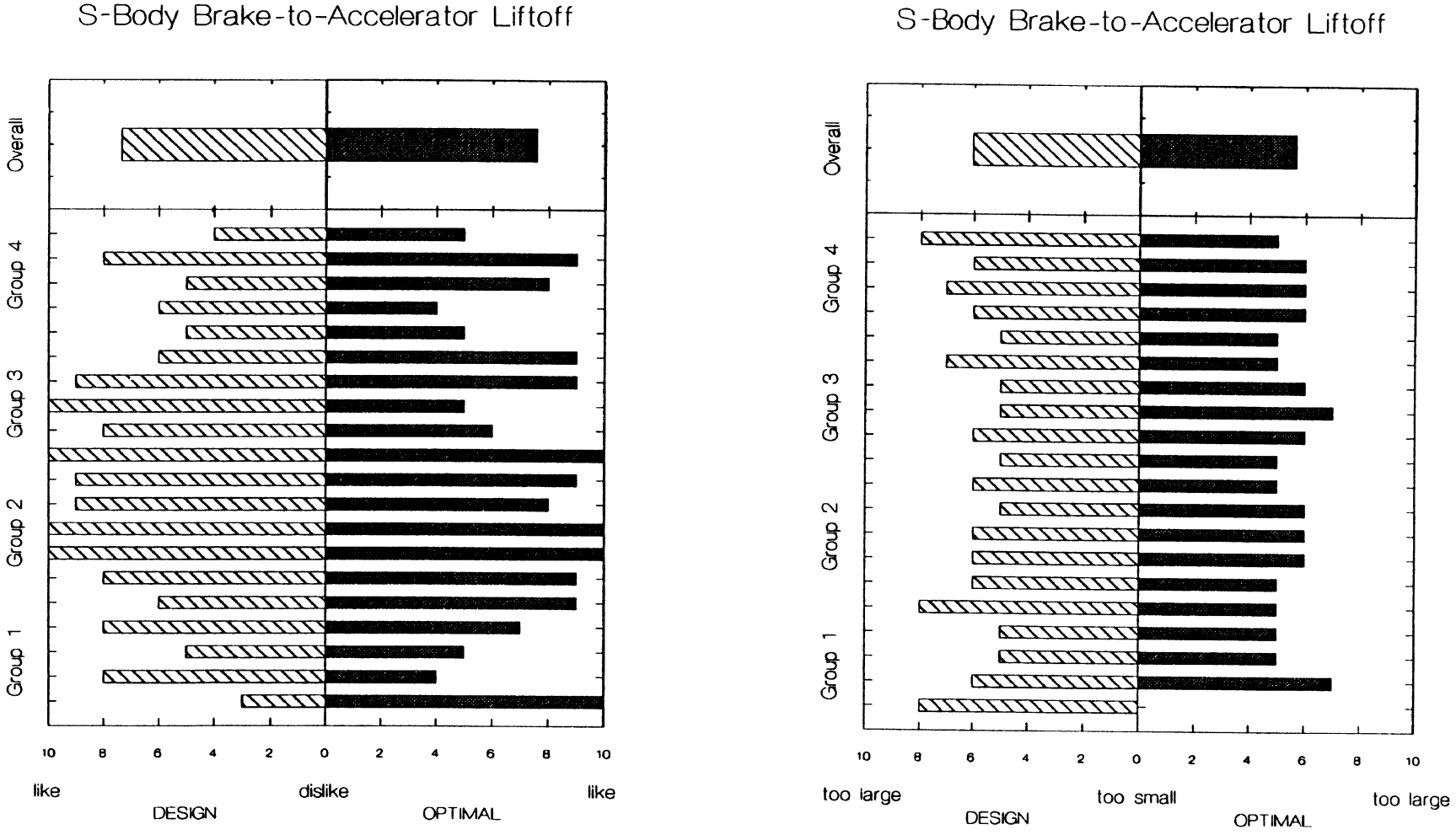
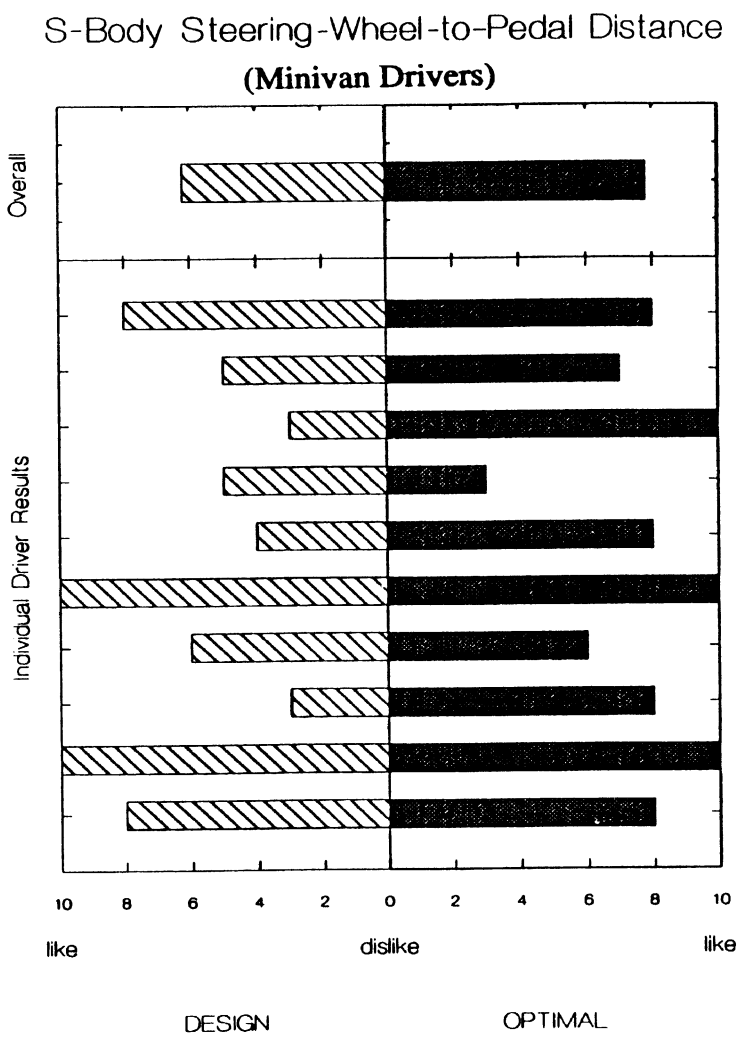

S-Body Brake-to-Accelerator Liftoff
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL
S-Body Brake-to-Accelerator Liftoff
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.12


S-Body Steering-Wheel-to-Pedal Distance
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

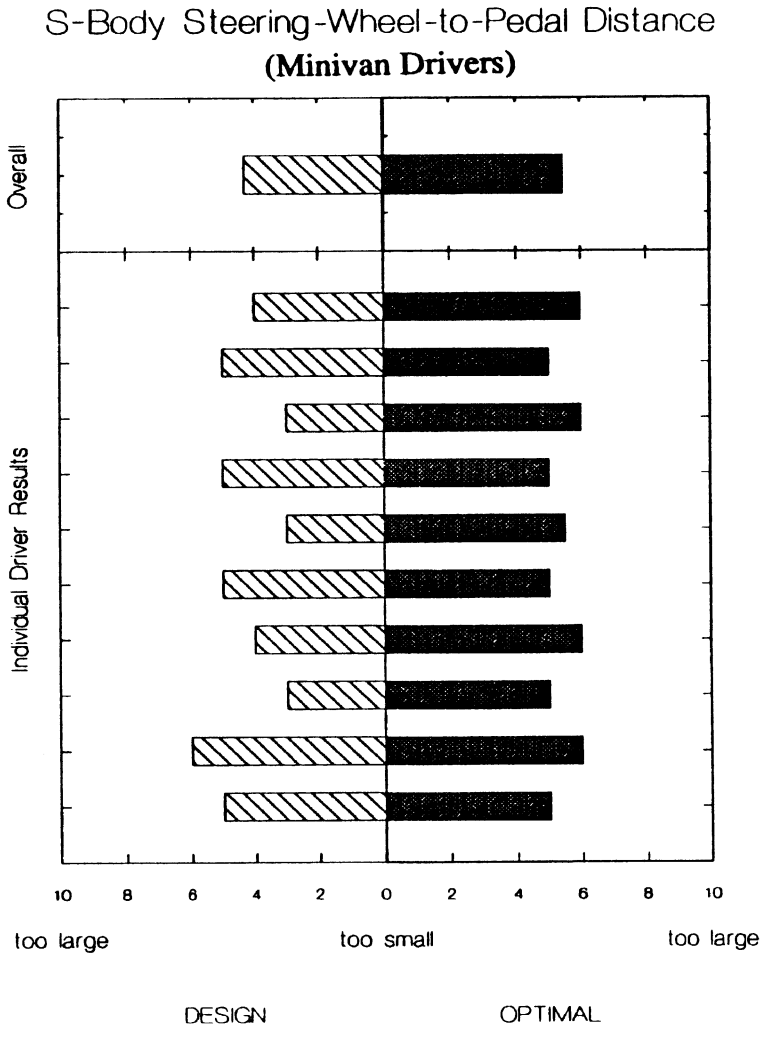
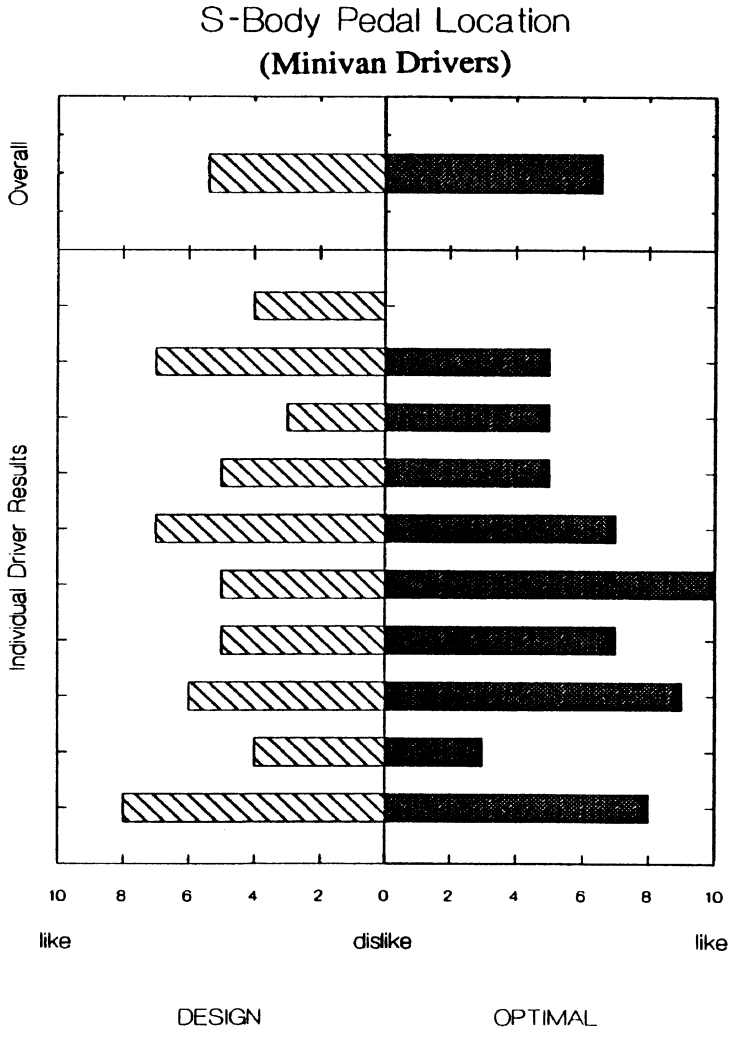

S-Body Steering-Wheel-to-Pedal Distance
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.13


S-Body Pedal Location
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

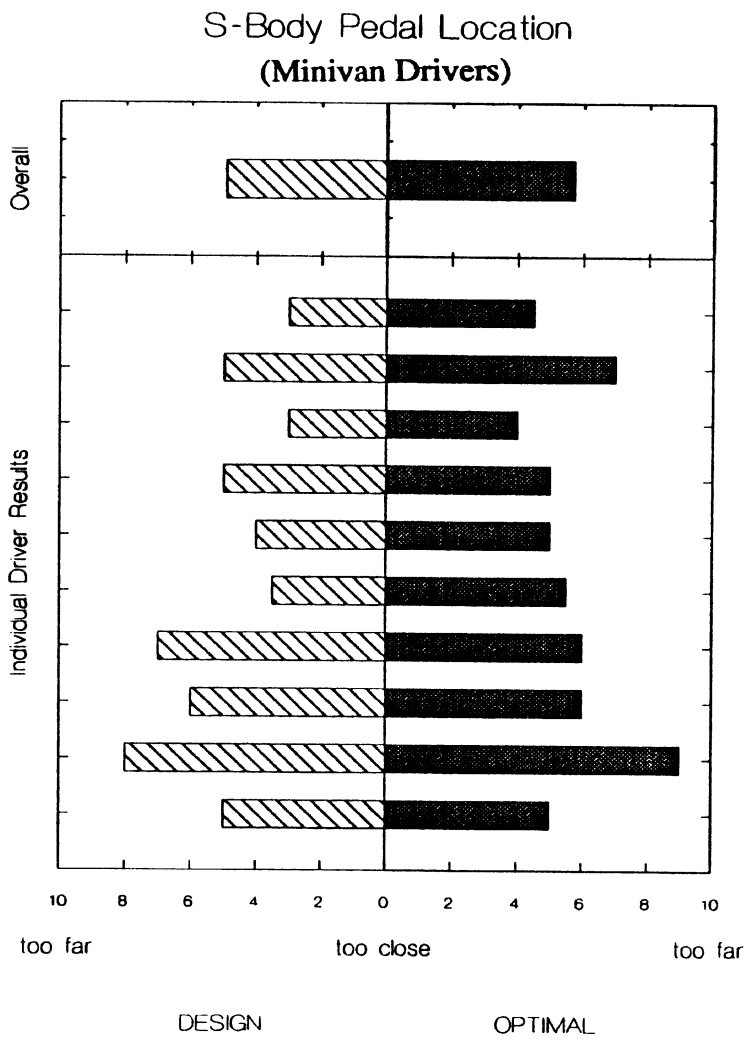
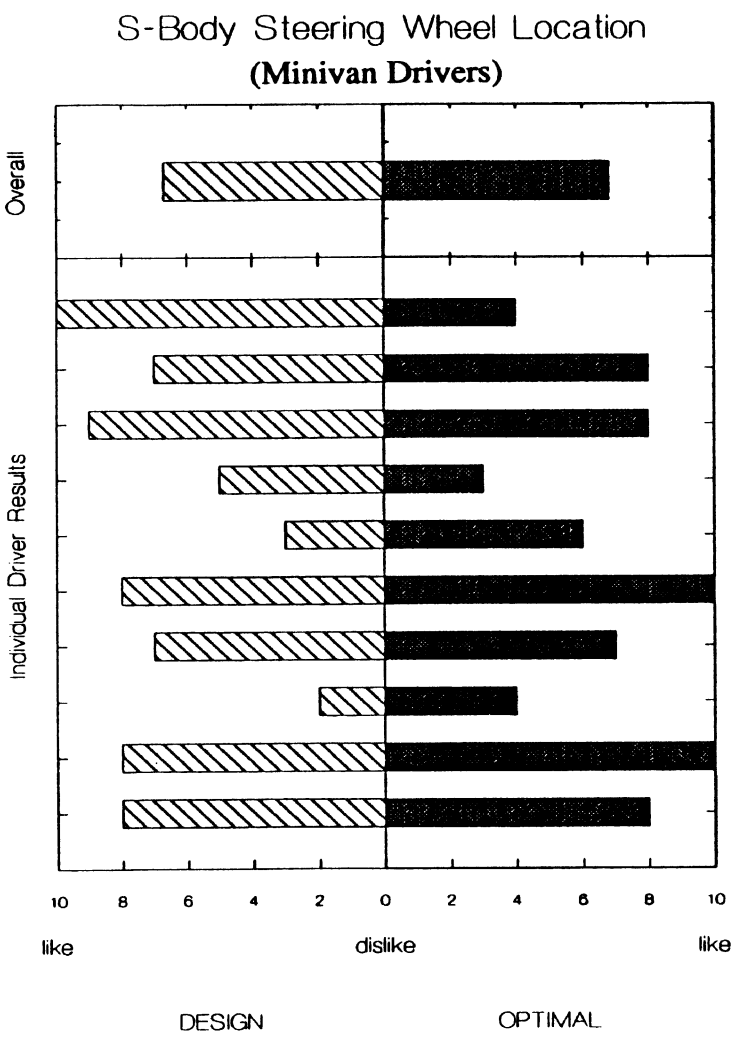

S-Body Pedal Location
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.14


S-Body Steering Wheel Location
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

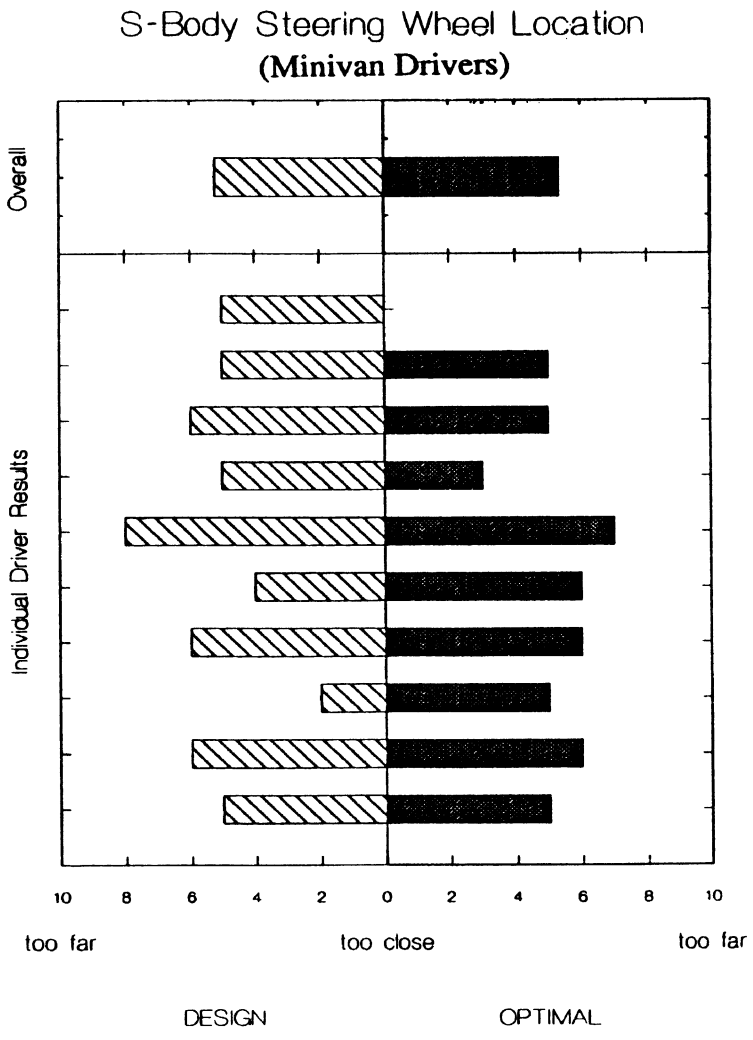
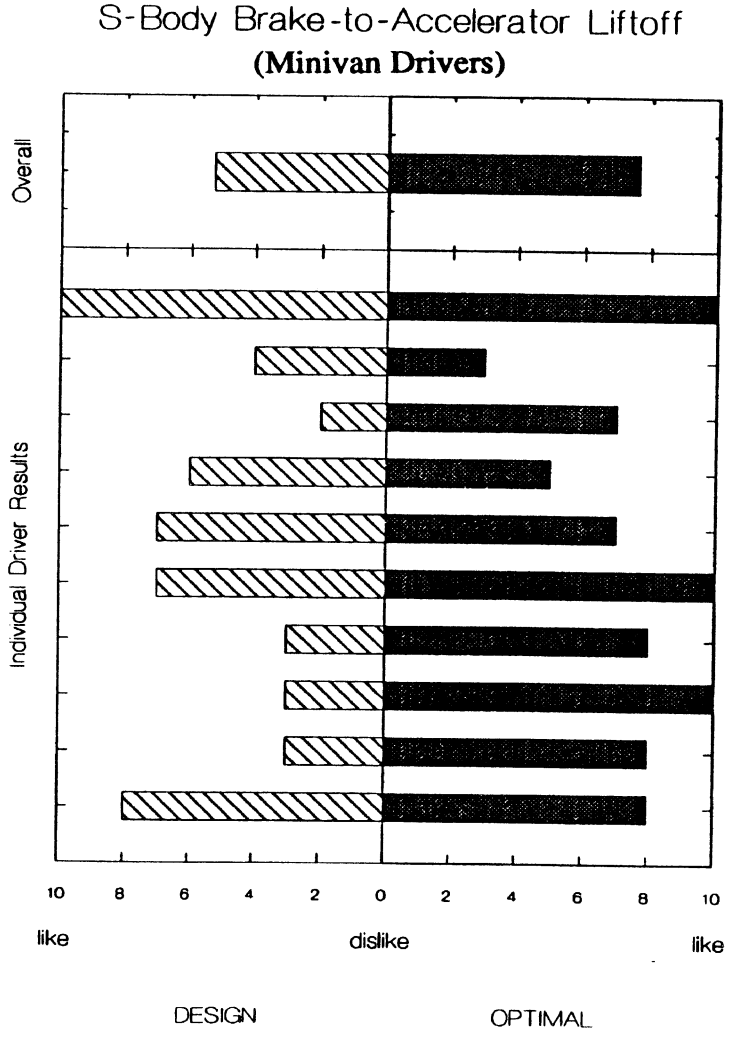

S-Body Steering Wheel Location
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too far
too close
too far
DESIGN
OPTIMAL

FIGURE C.15


S-Body Brake-to-Accelerator Liftoff
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

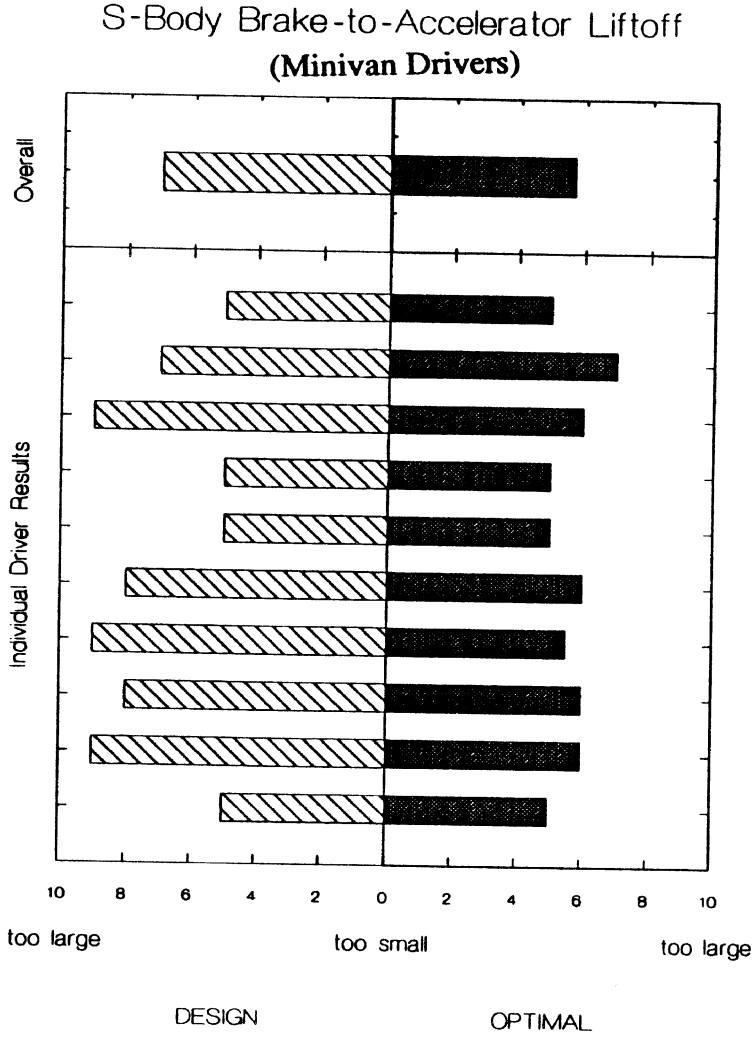
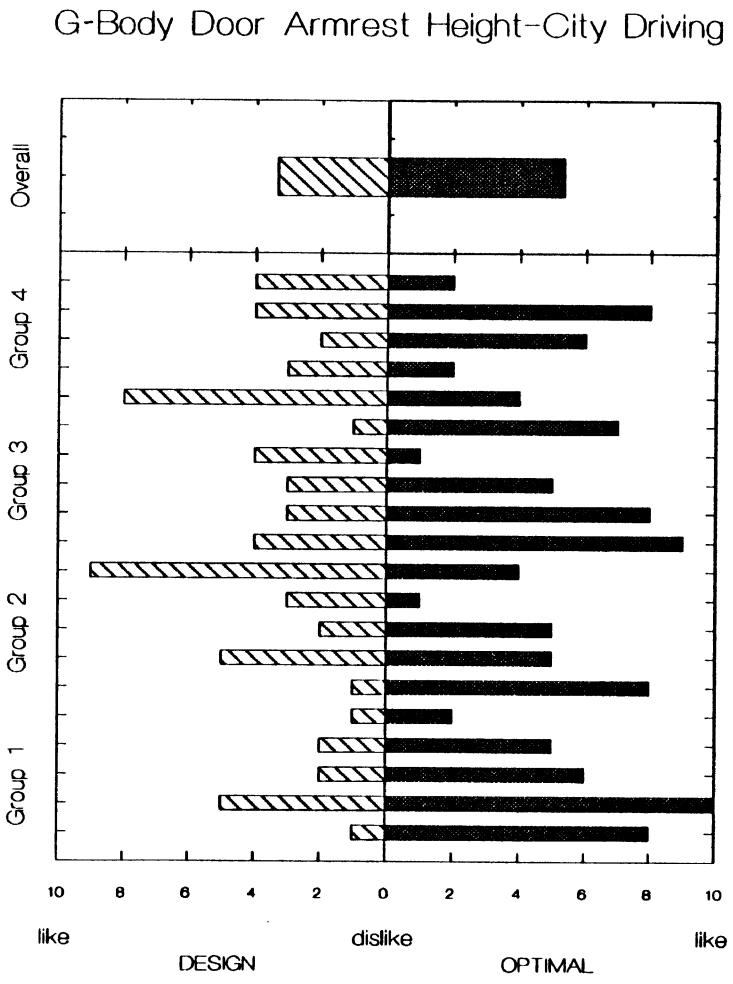

S-Body Brake-to-Accelerator Liftoff
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too large
too small
too large
DESIGN
OPTIMAL

FIGURE C.16

APPENDIX D

BAR GRAPHS OF OVERALL AND INDIVIDUAL SUBJECTIVE RATINGS FOR DOOR AND CONSOLE ARMREST HEIGHTS


G-Body Door Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

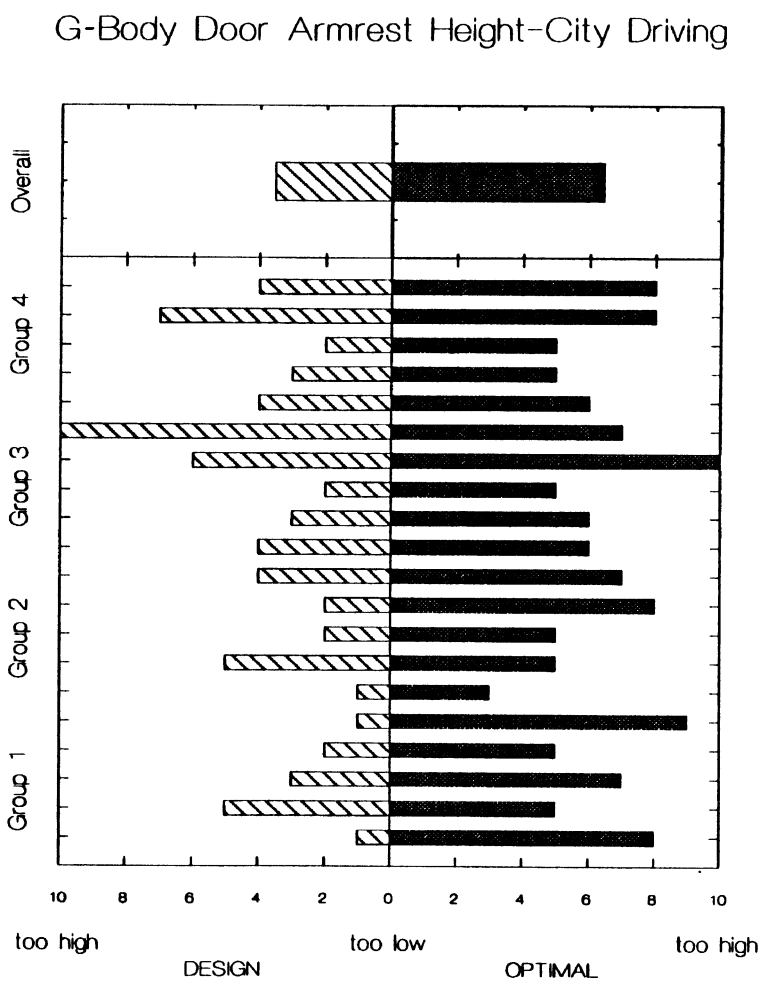
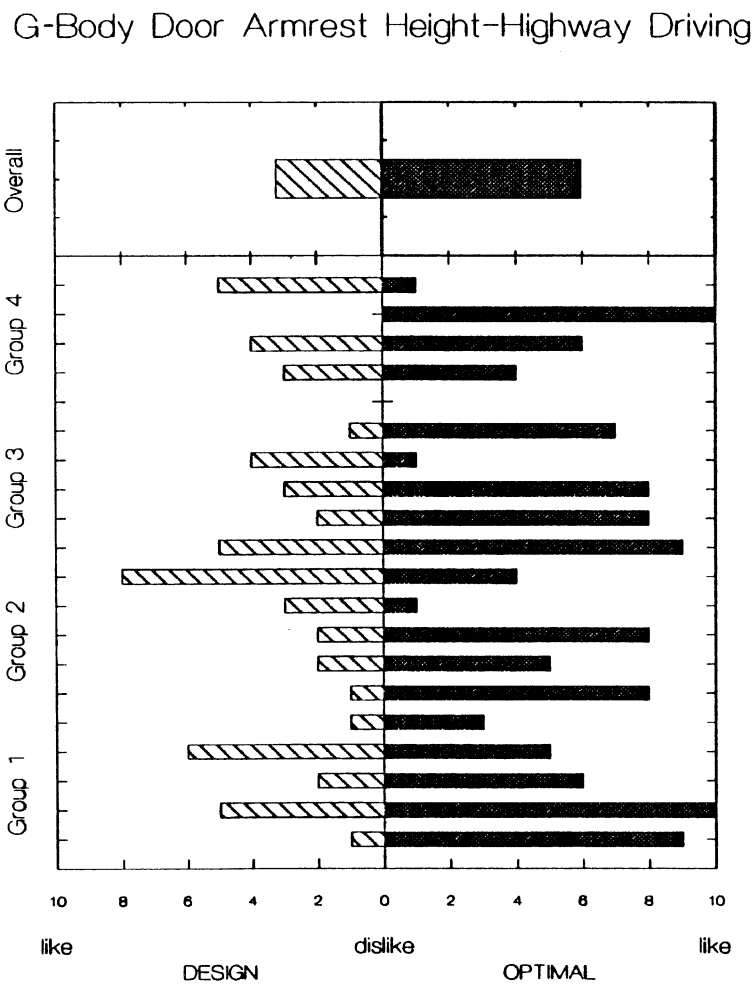

G-Body Door Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.1


G-Body Door Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

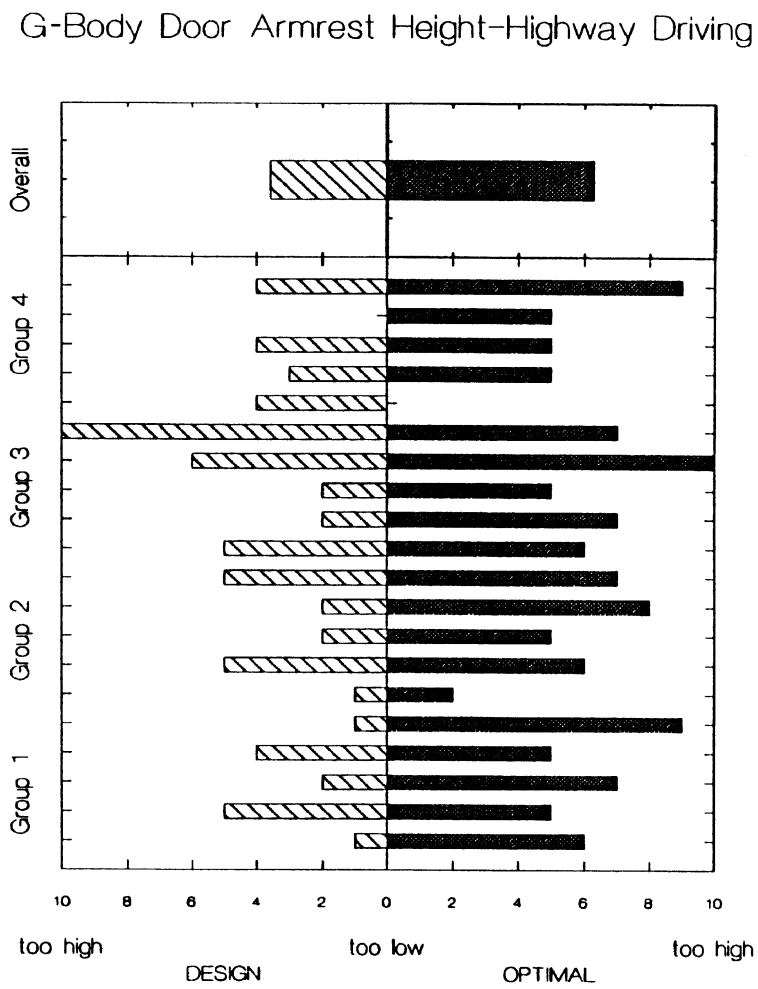

G-Body Door Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.2

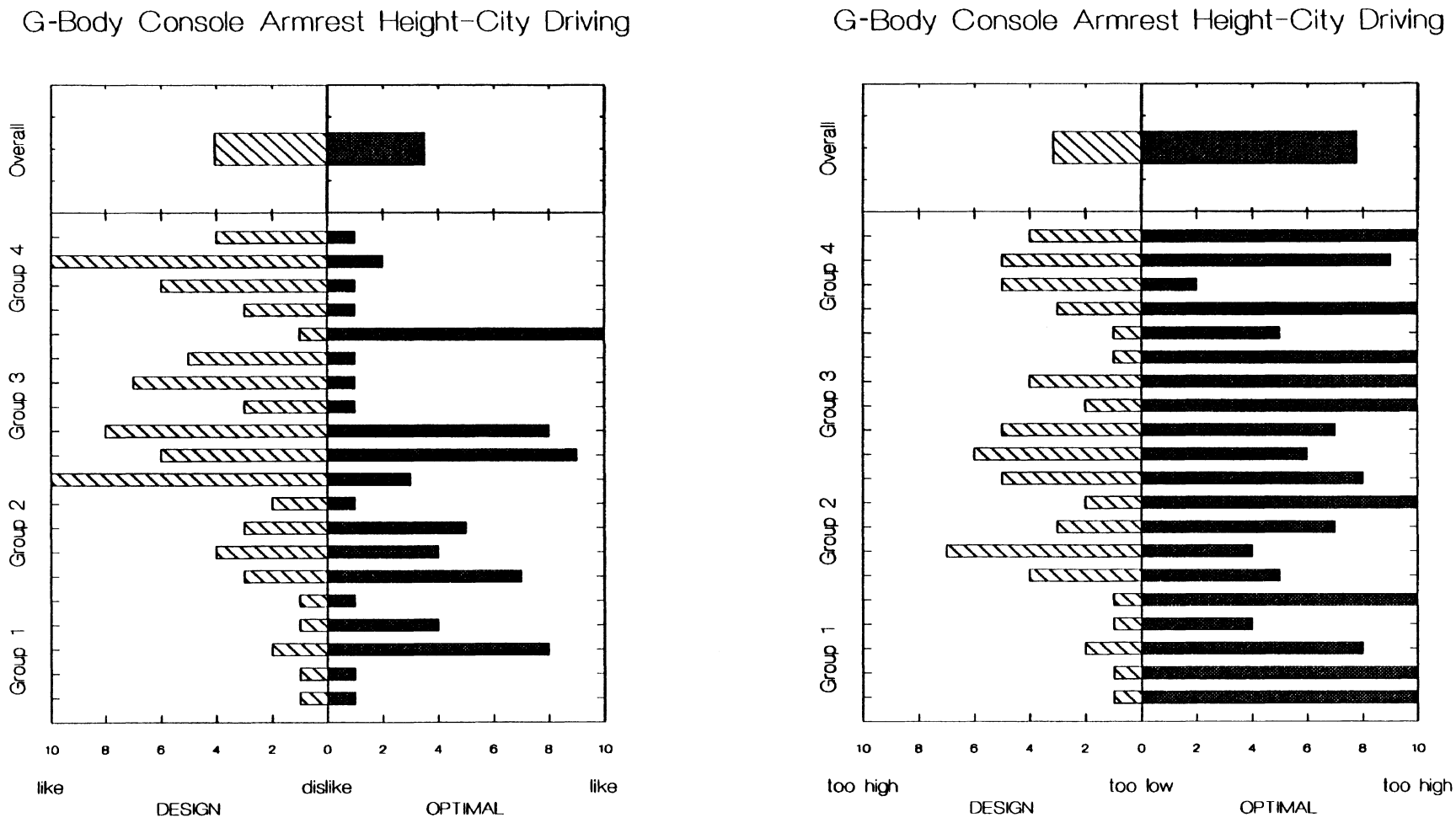
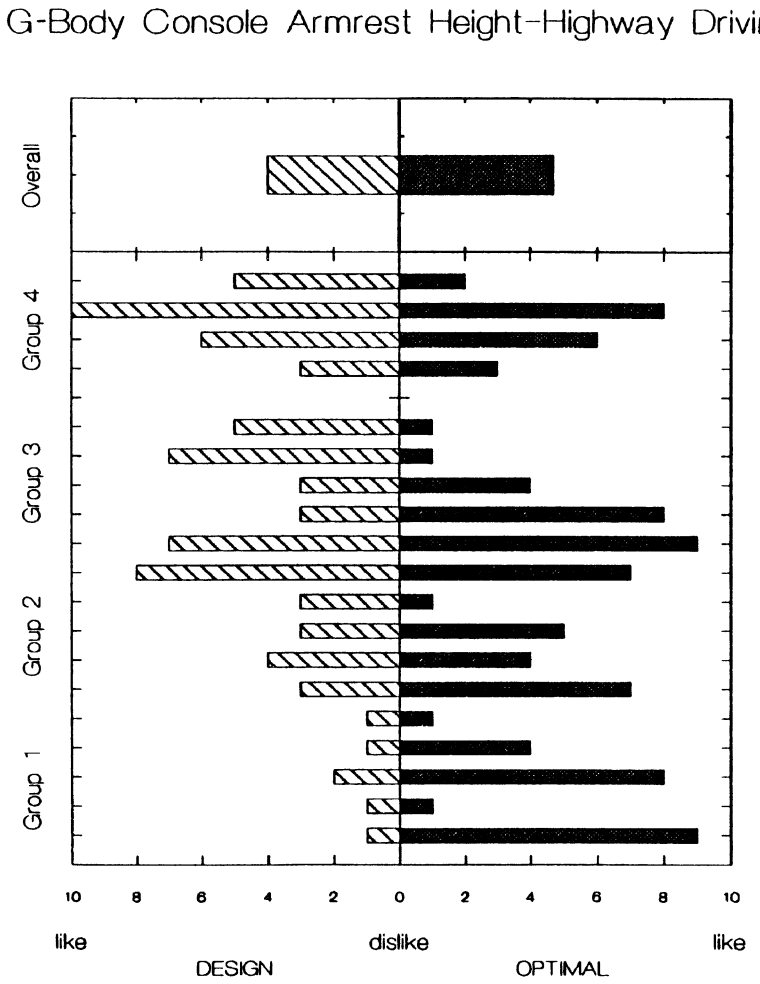

G-Body Console Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL
G-Body Console Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.3


G-Body Console Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

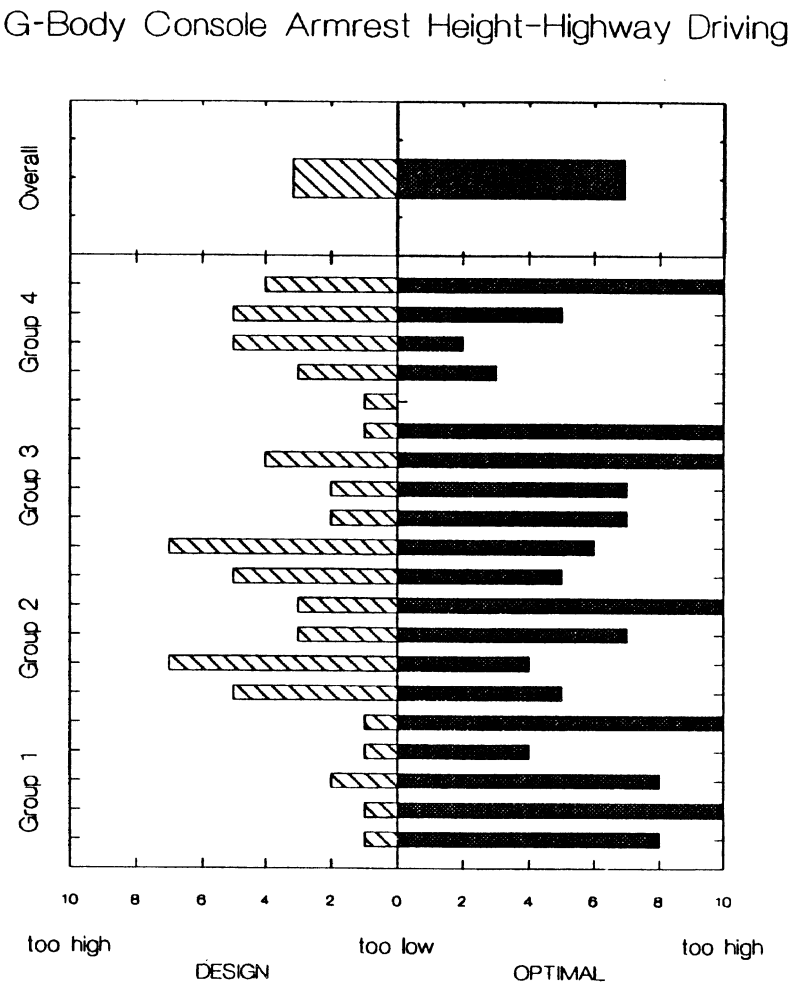
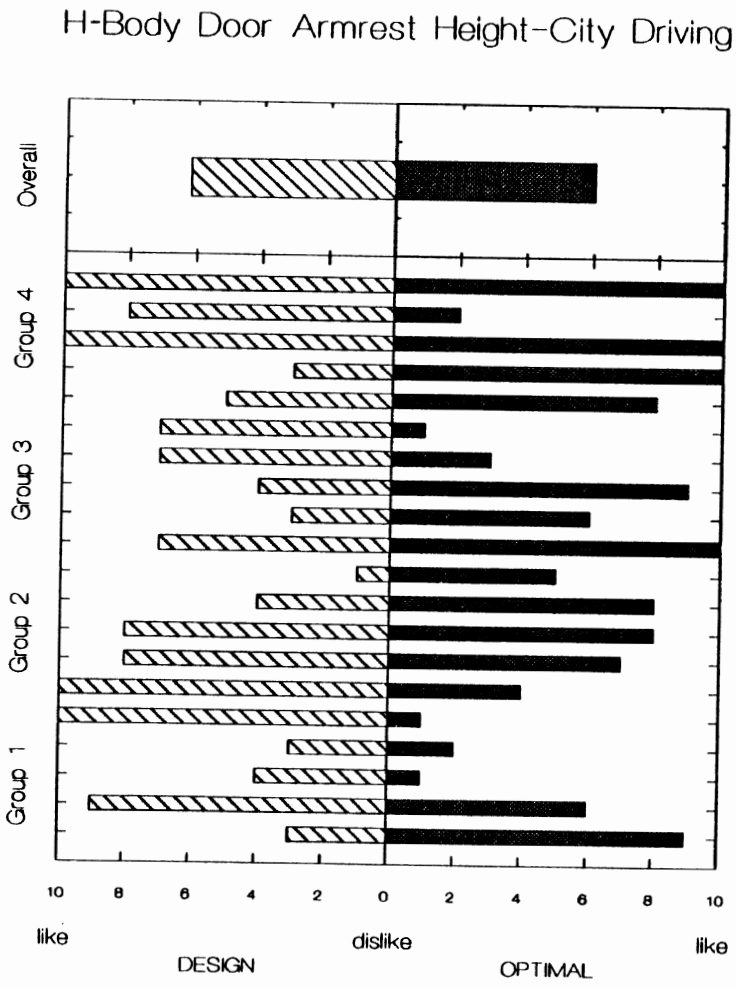

G-Body Console Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.4


H-Body Door Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

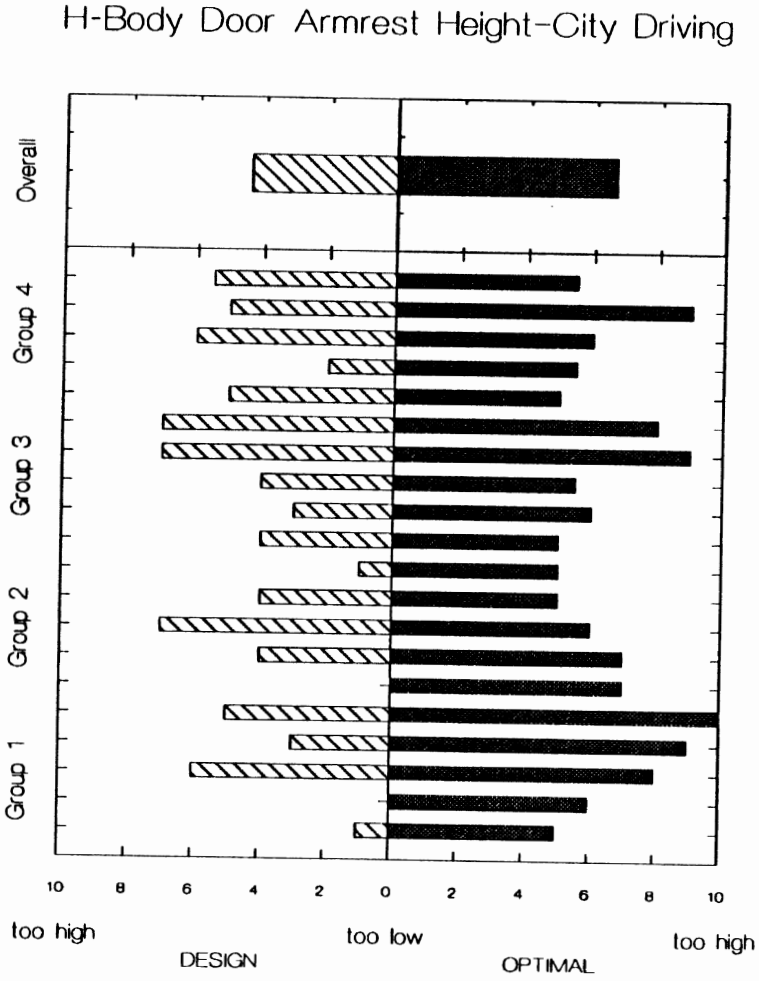

H-Body Door Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.5

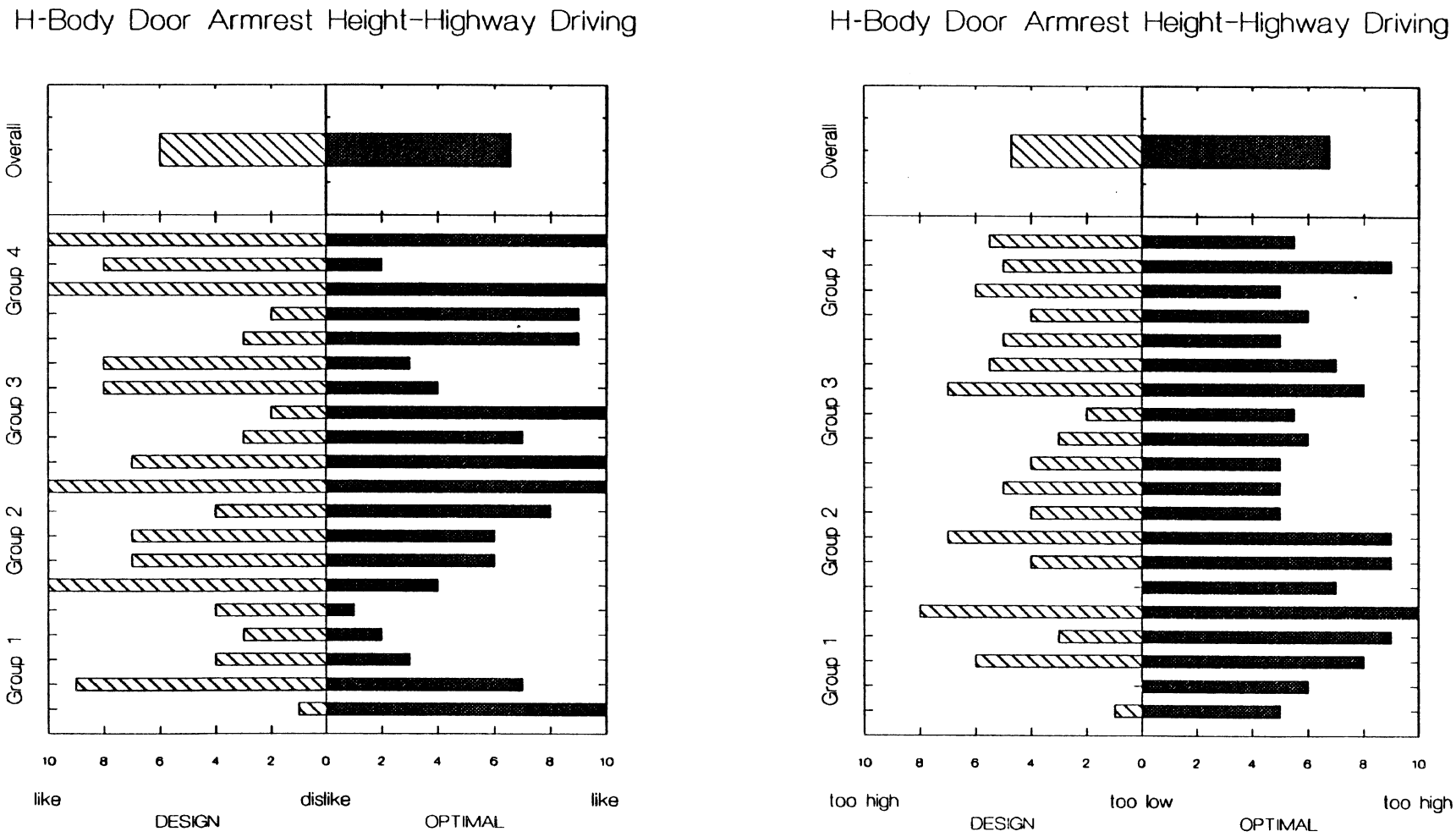
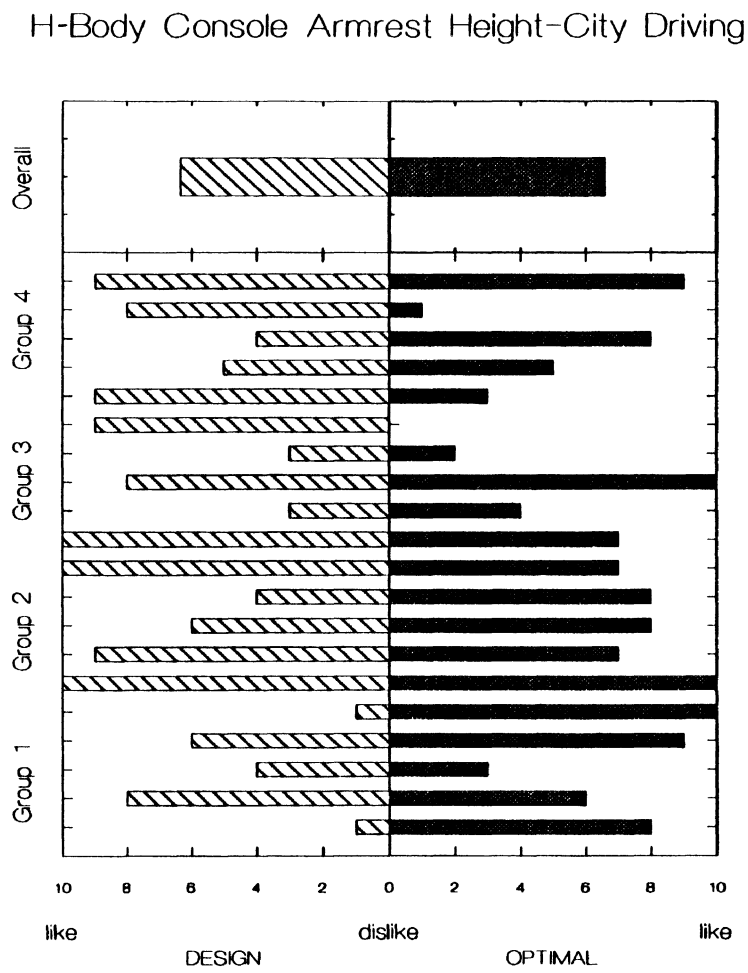

H-Body Door Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL
H-Body Door Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.6


H-Body Console Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

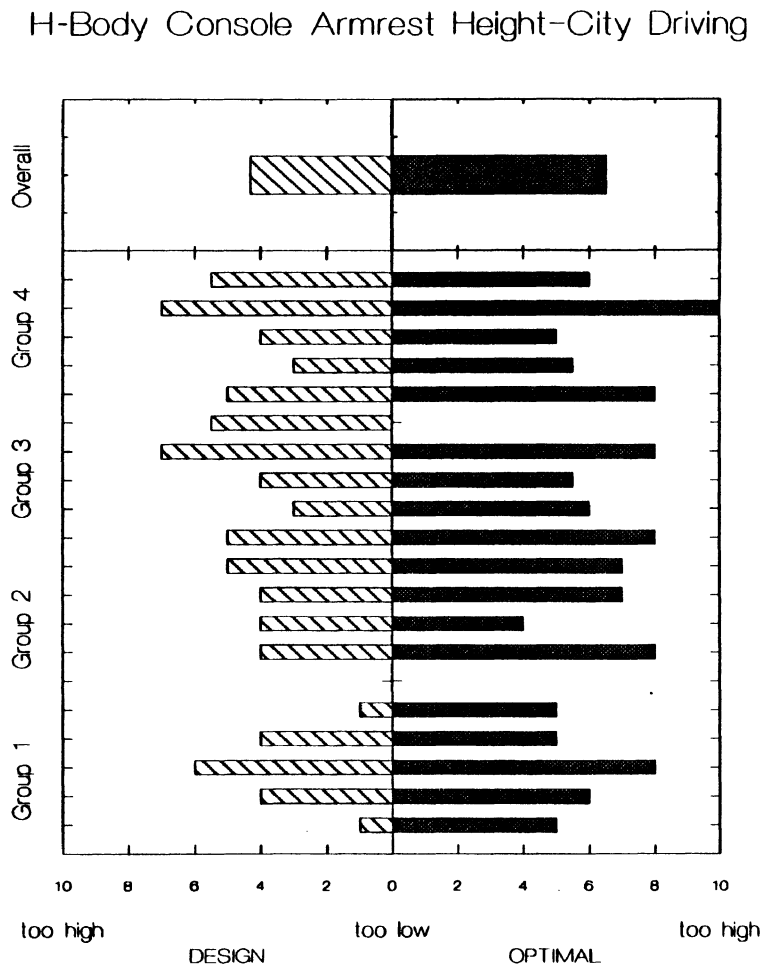
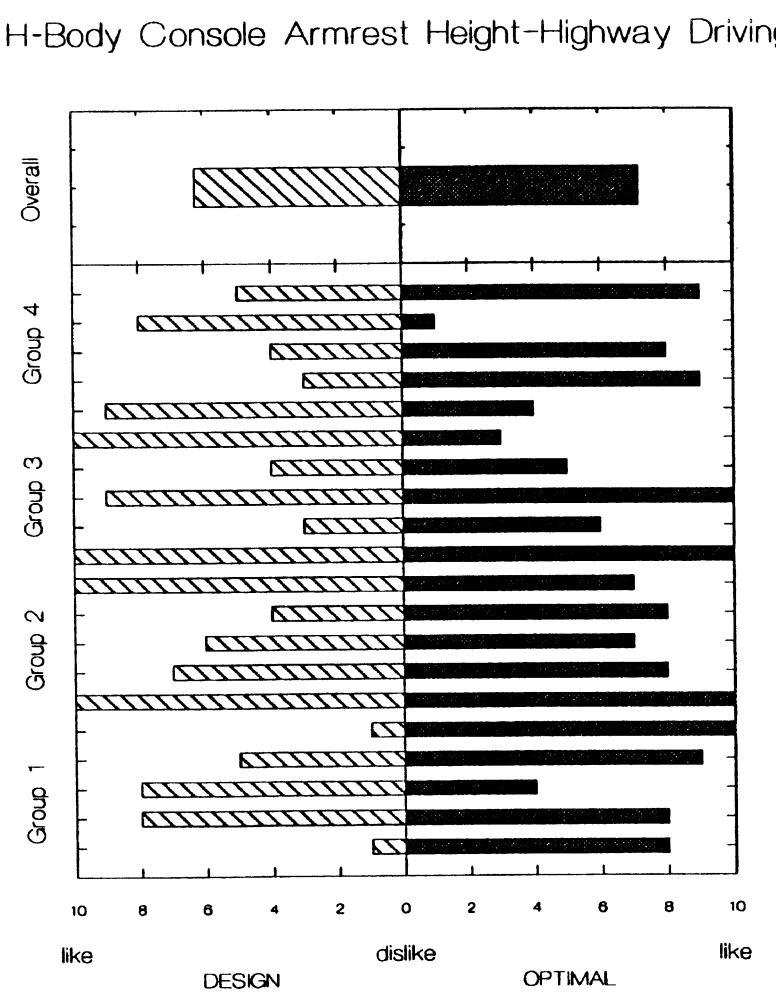

H-Body Console Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.7


H-Body Console Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

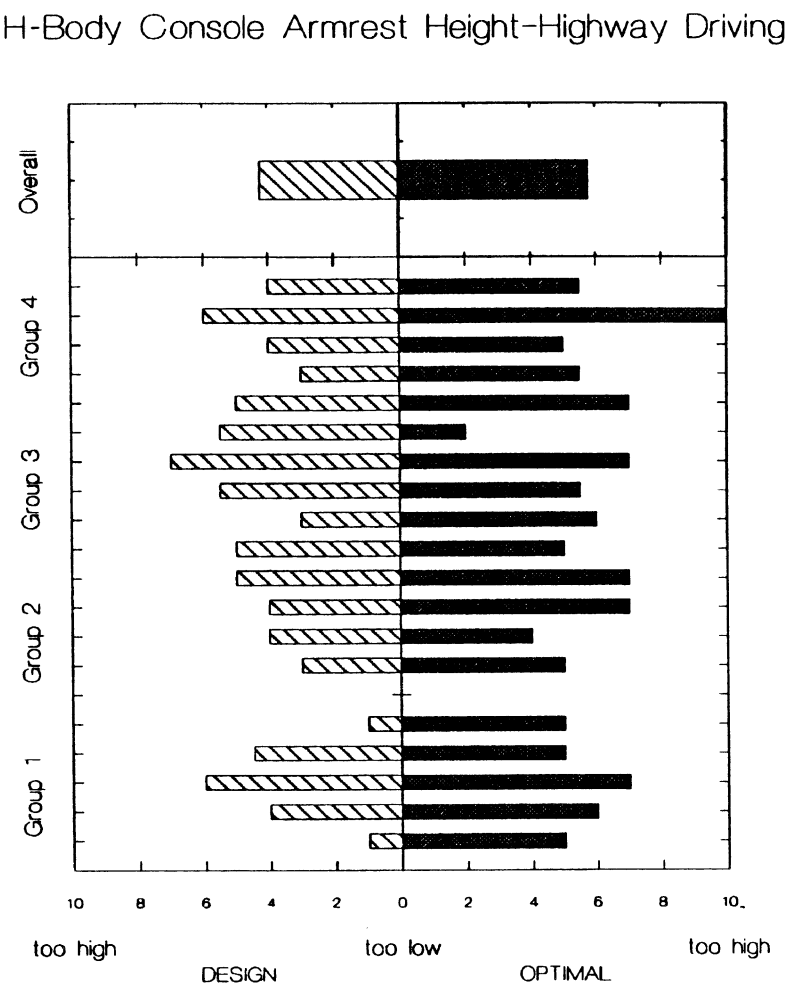

H-Body Console Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.8

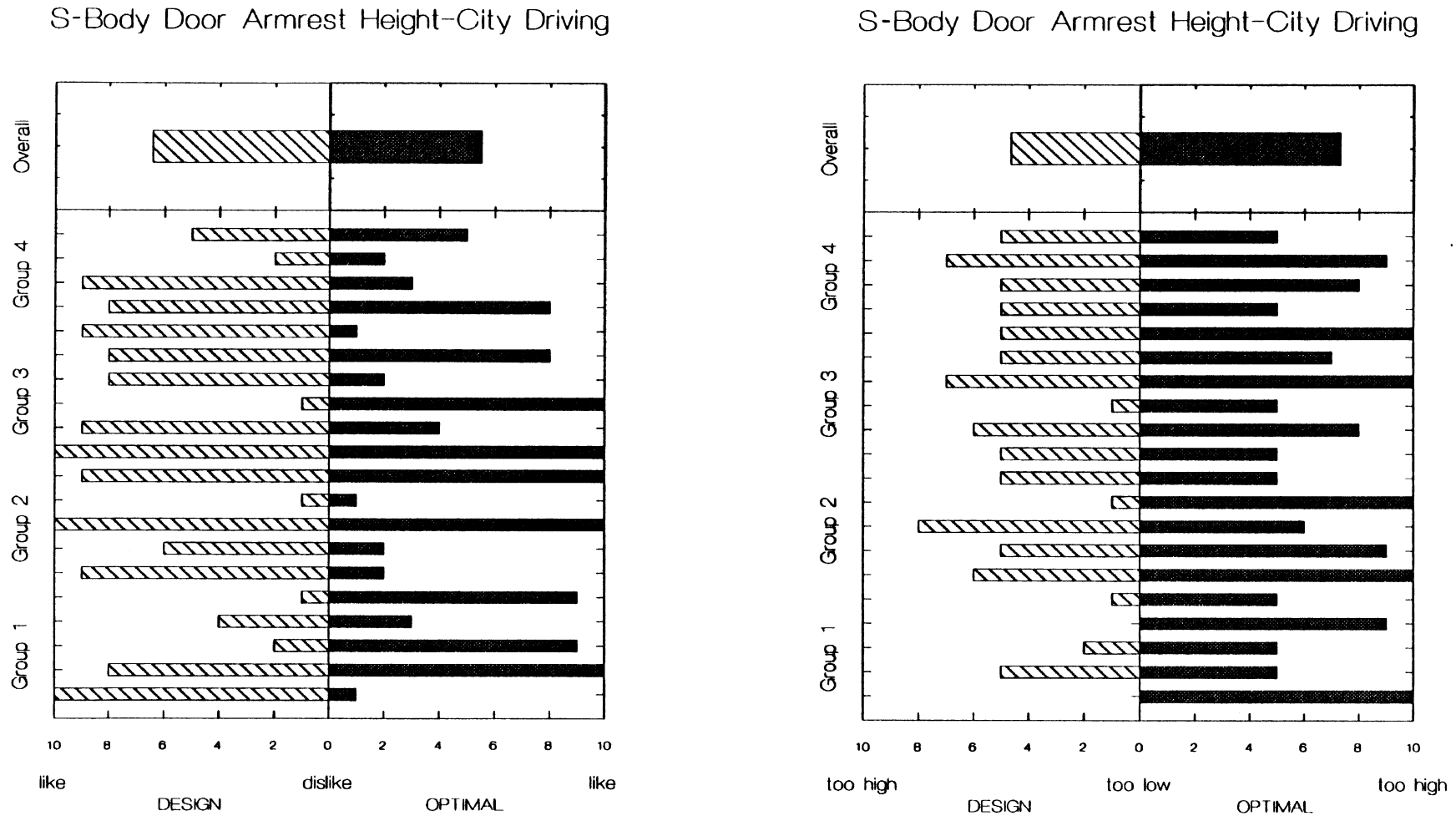

S-Body Door Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL
S-Body Door Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.9

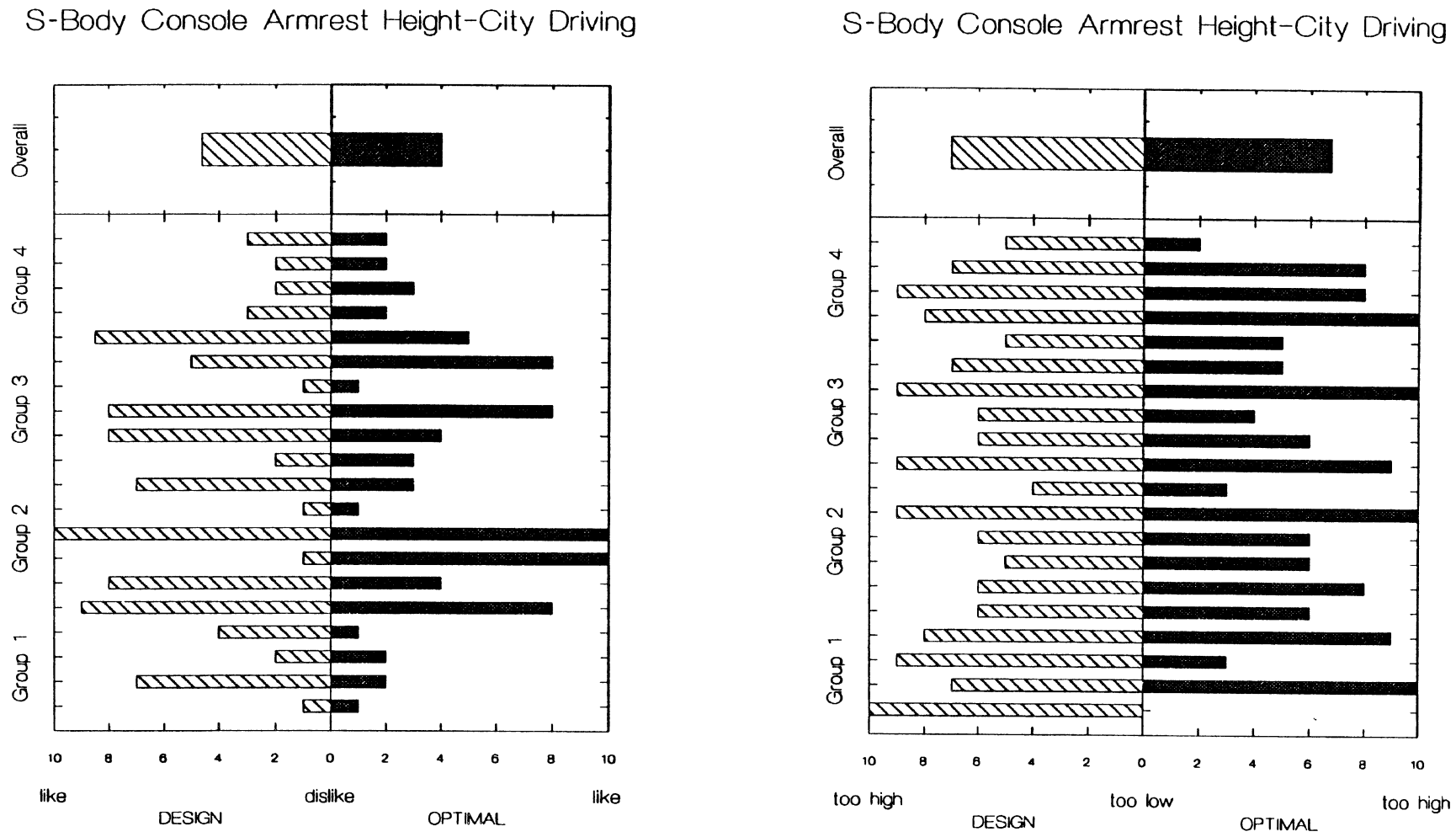
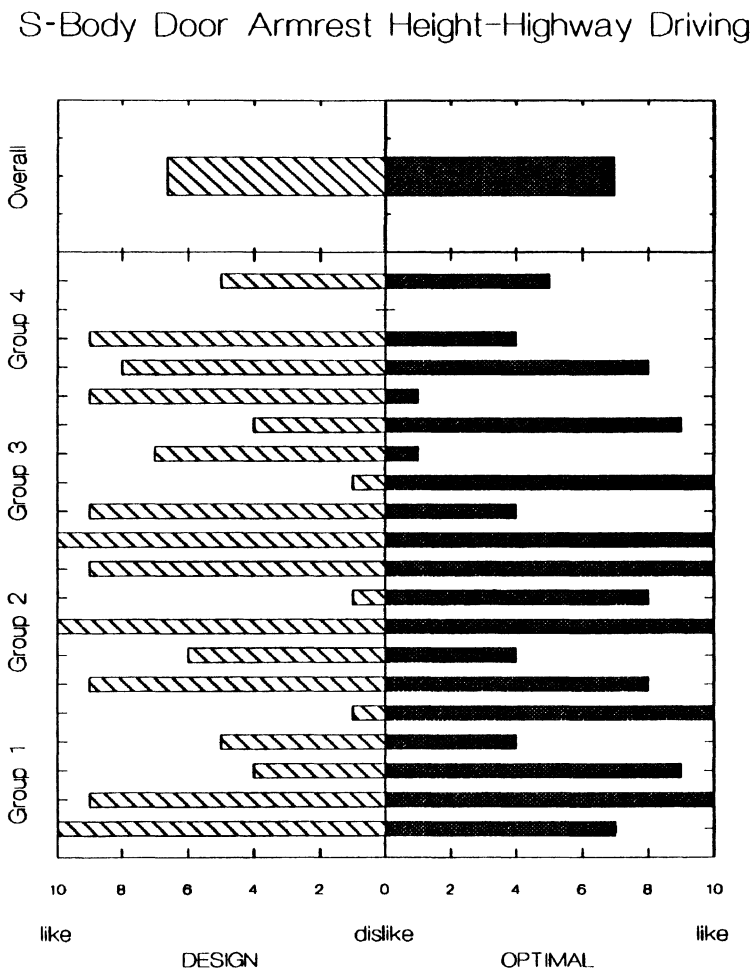

S-Body Console Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL
S-Body Console Armrest Height-City Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.10


S-Body Door Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

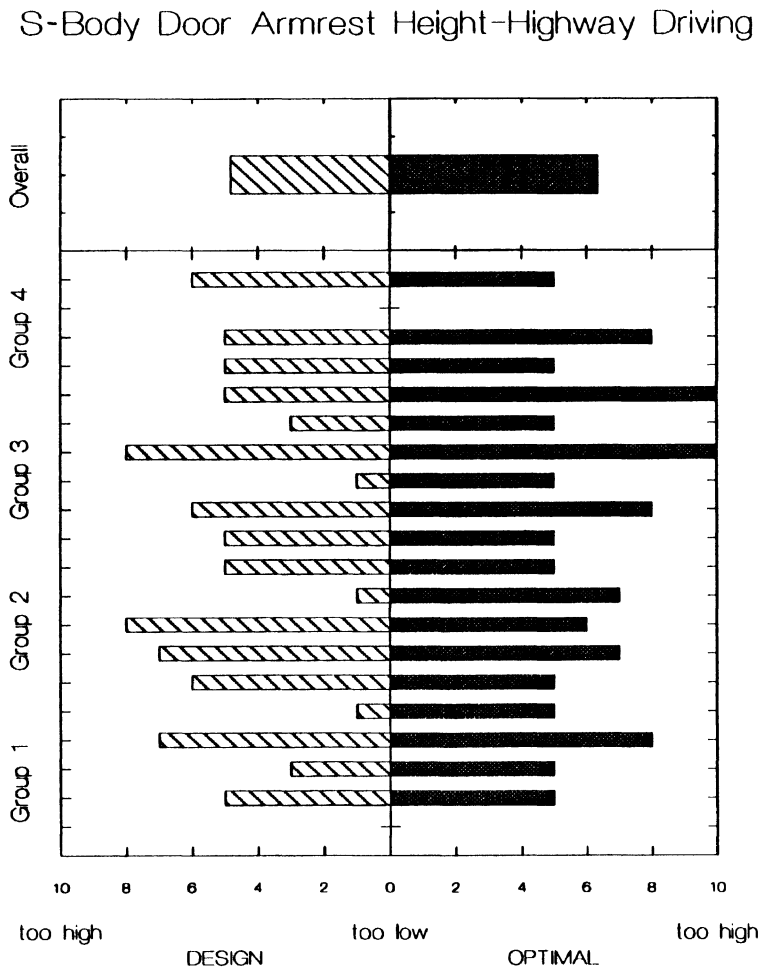
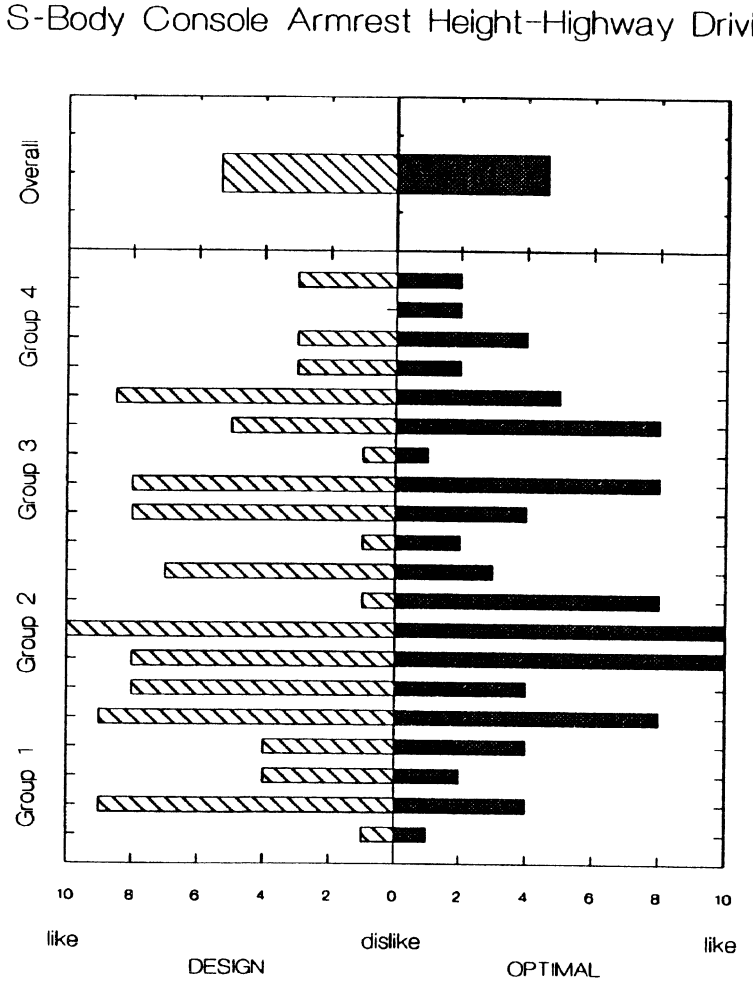

S-Body Door Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.11


S-Body Console Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

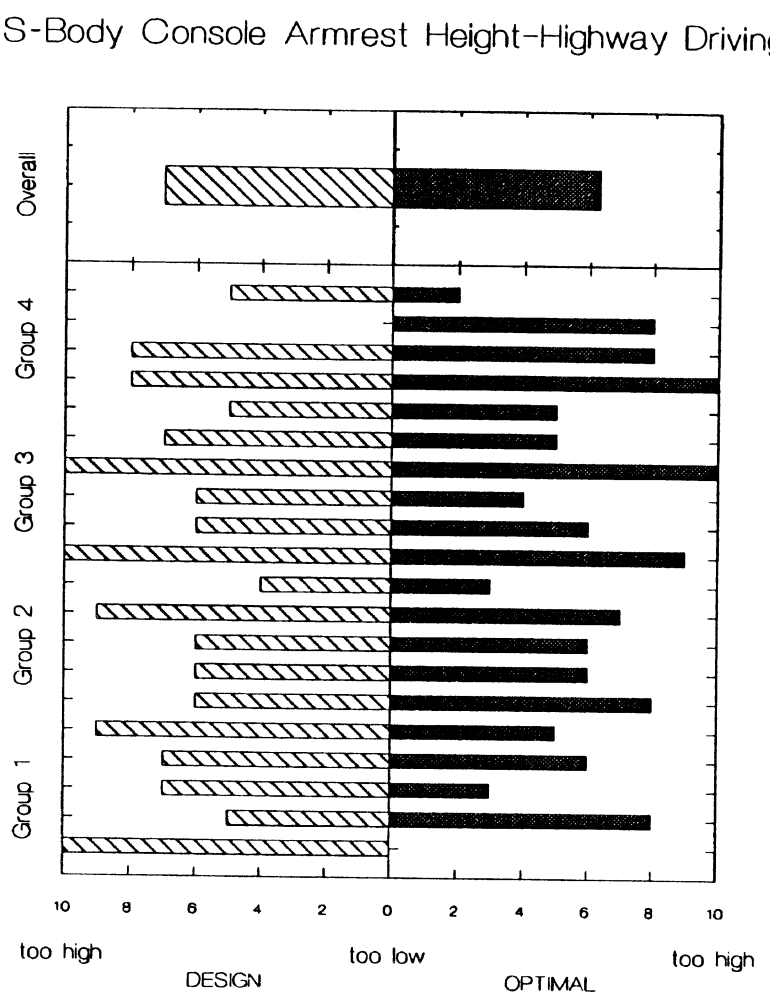
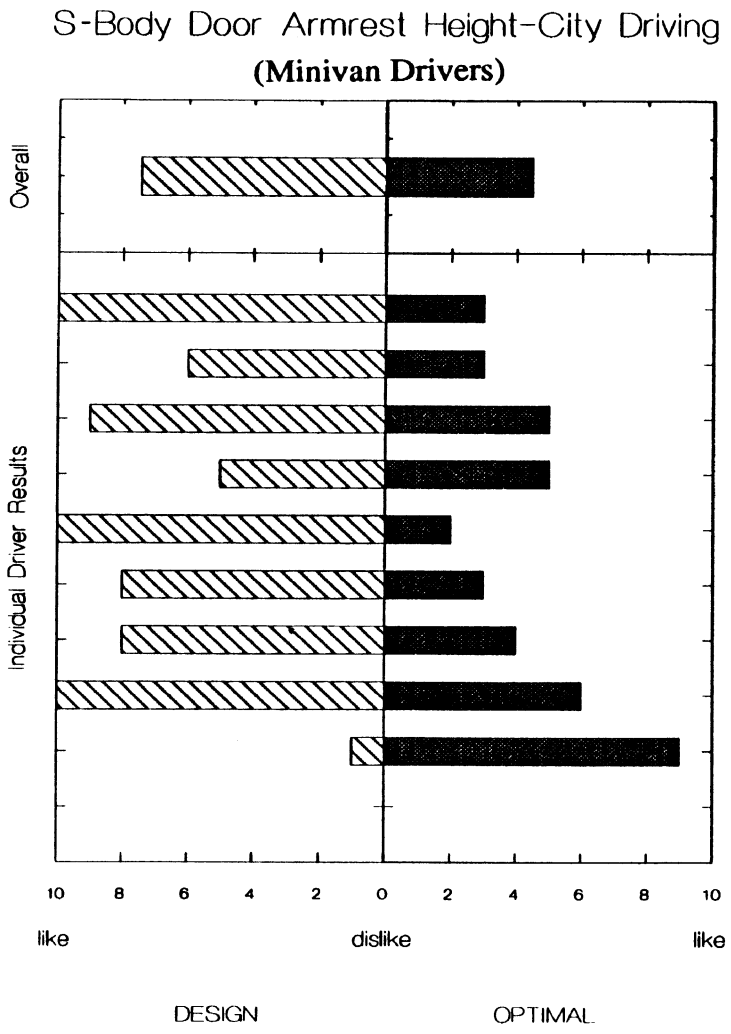

S-Body Console Armrest Height-Highway Driving
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.12


S-Body Door Armrest Height-City Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

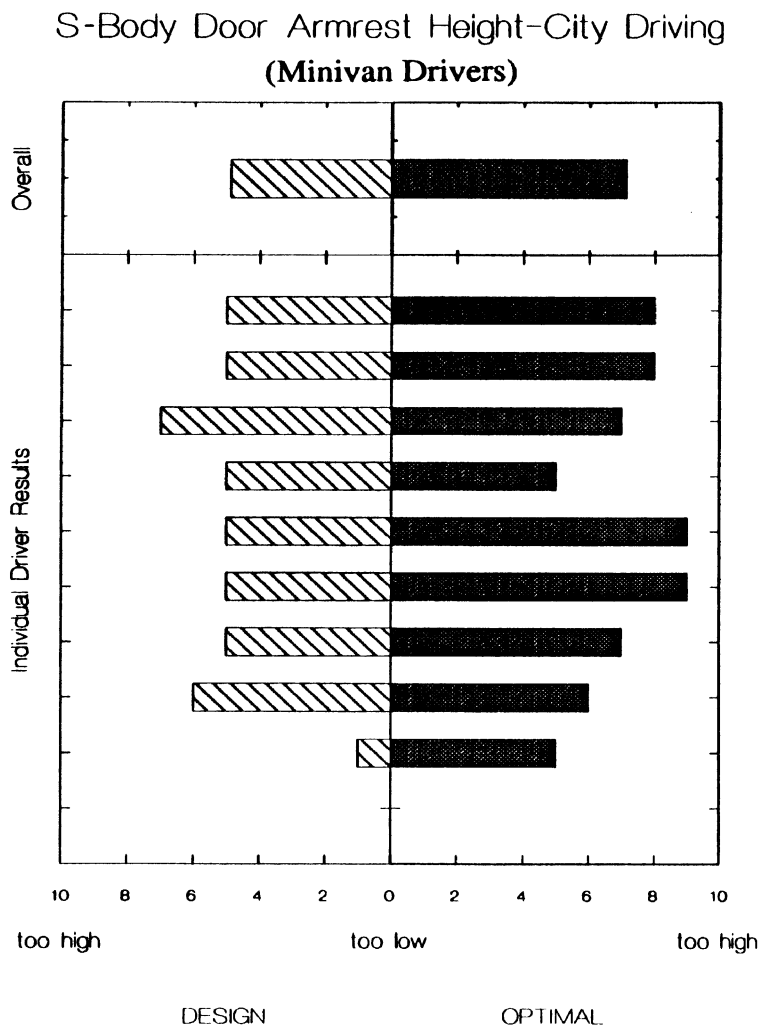
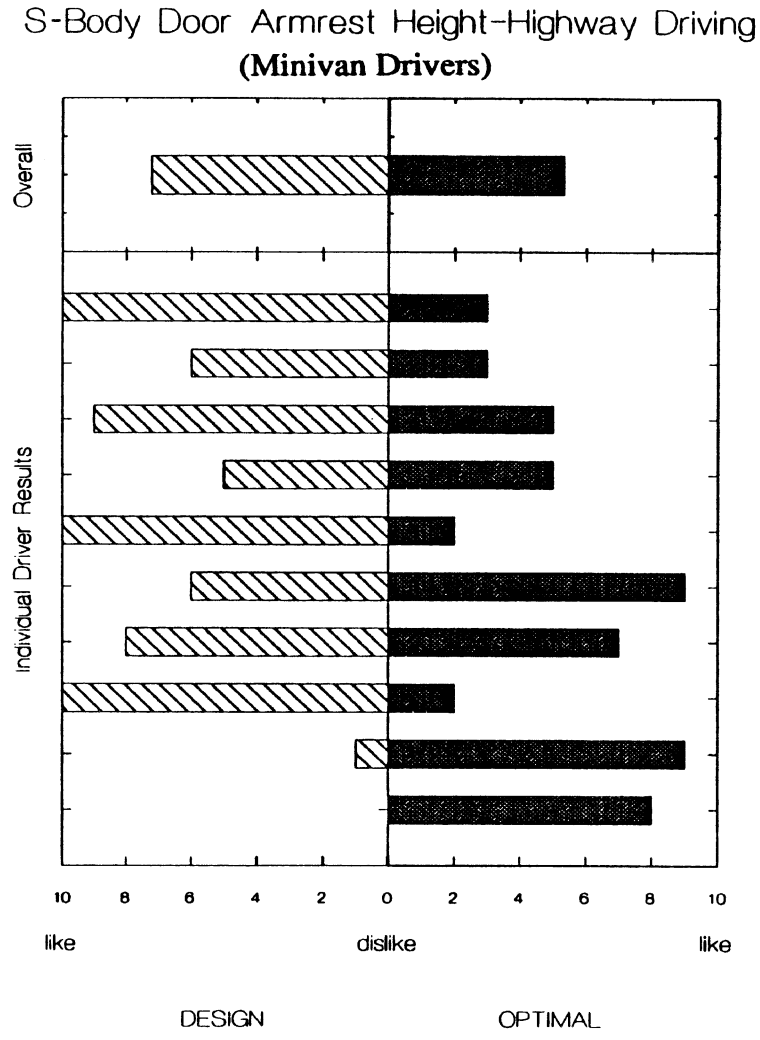

S-Body Door Armrest Height-City Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.13


S-Body Door Armrest Height-Highway Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

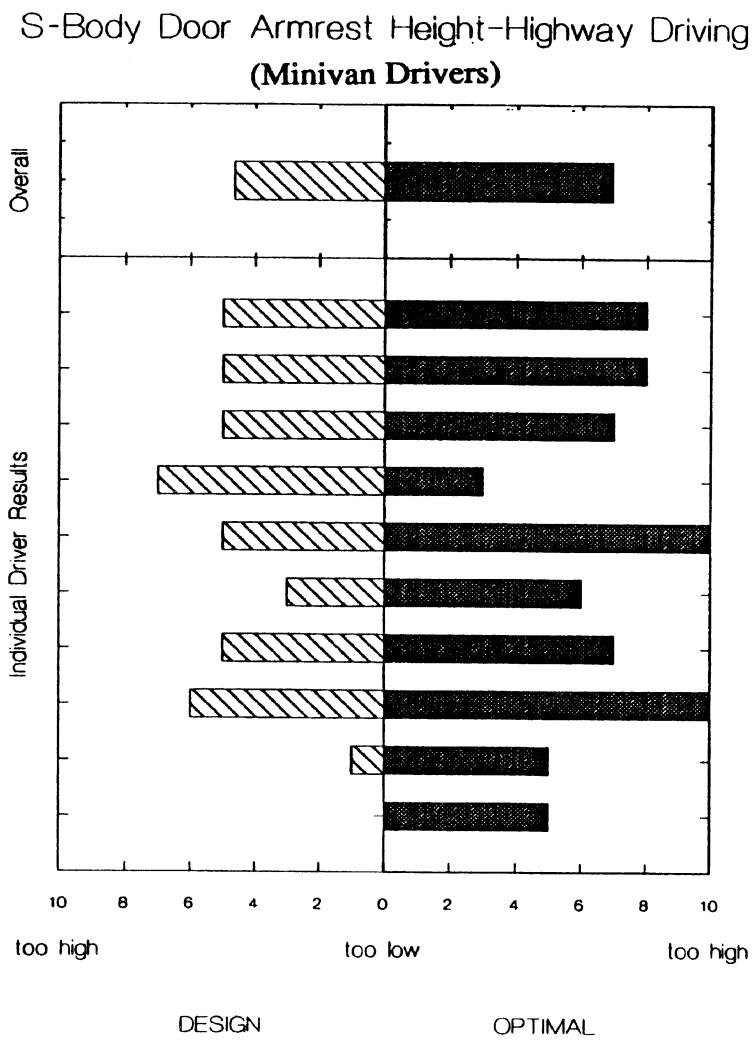
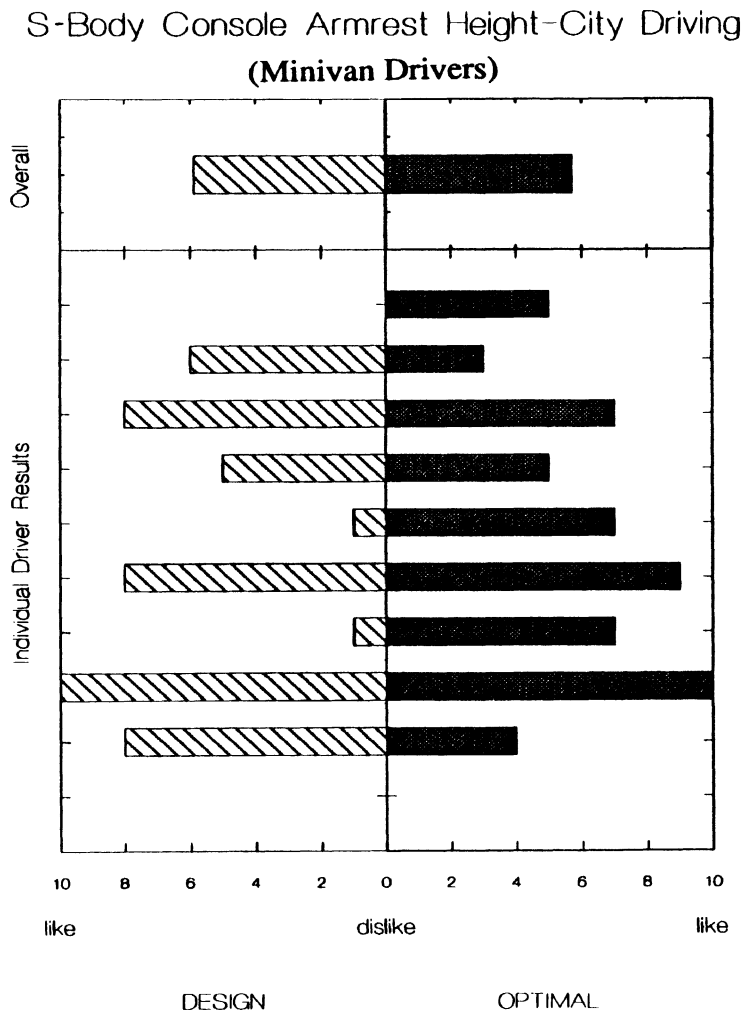

S-Body Door Armrest Height-Highway Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.14


S-Body Console Armrest Height-City Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

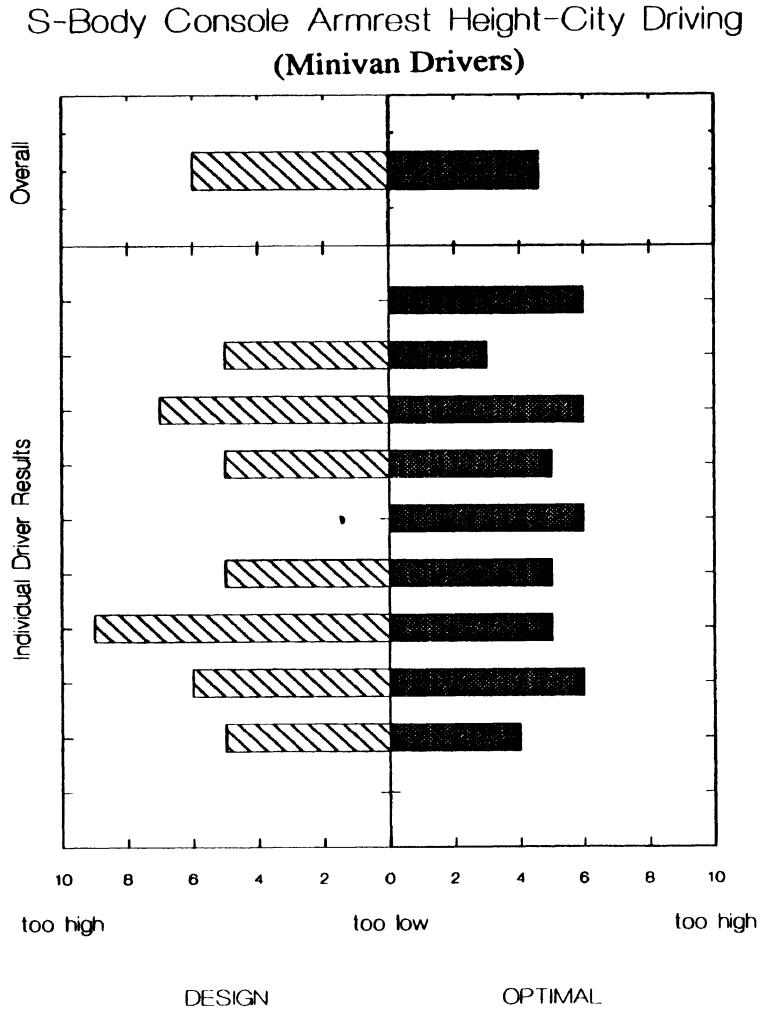
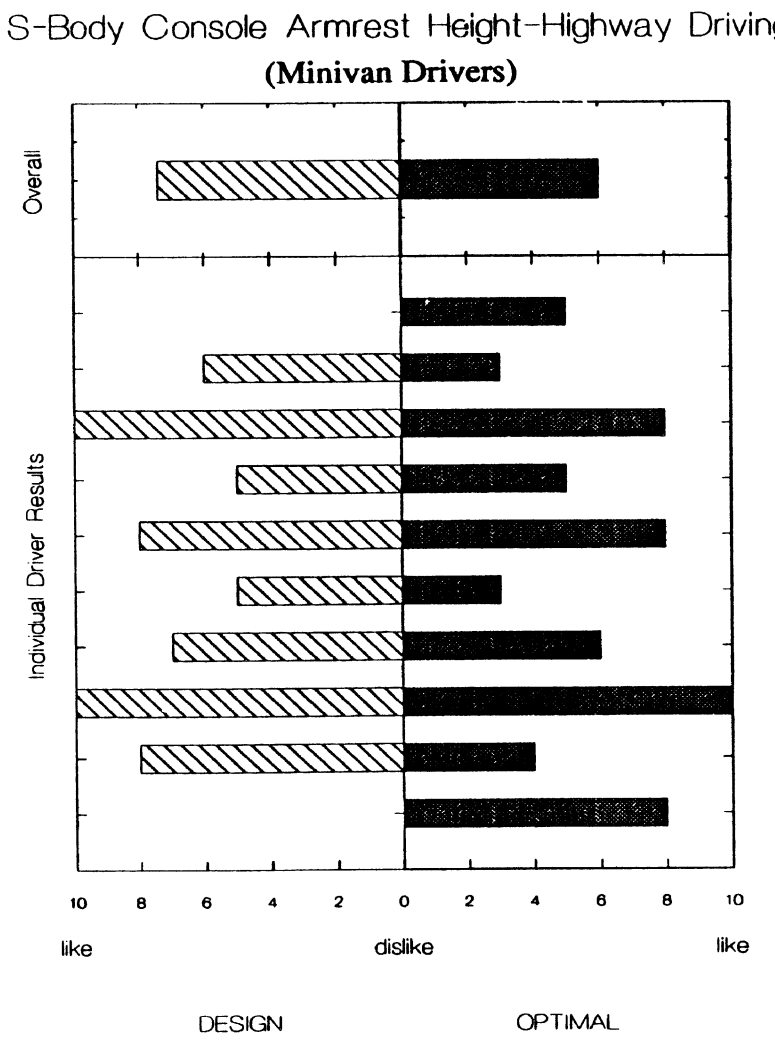

S-Body Console Armrest Height-City Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.15


S-Body Console Armrest Height-Highway Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

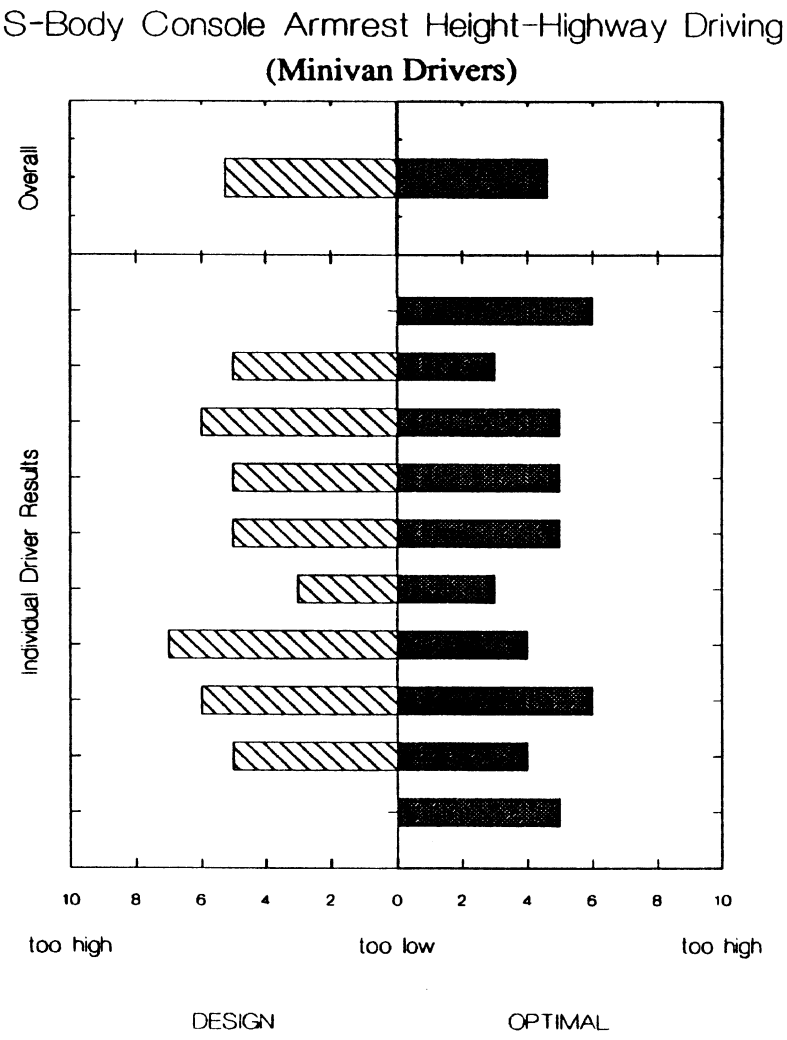
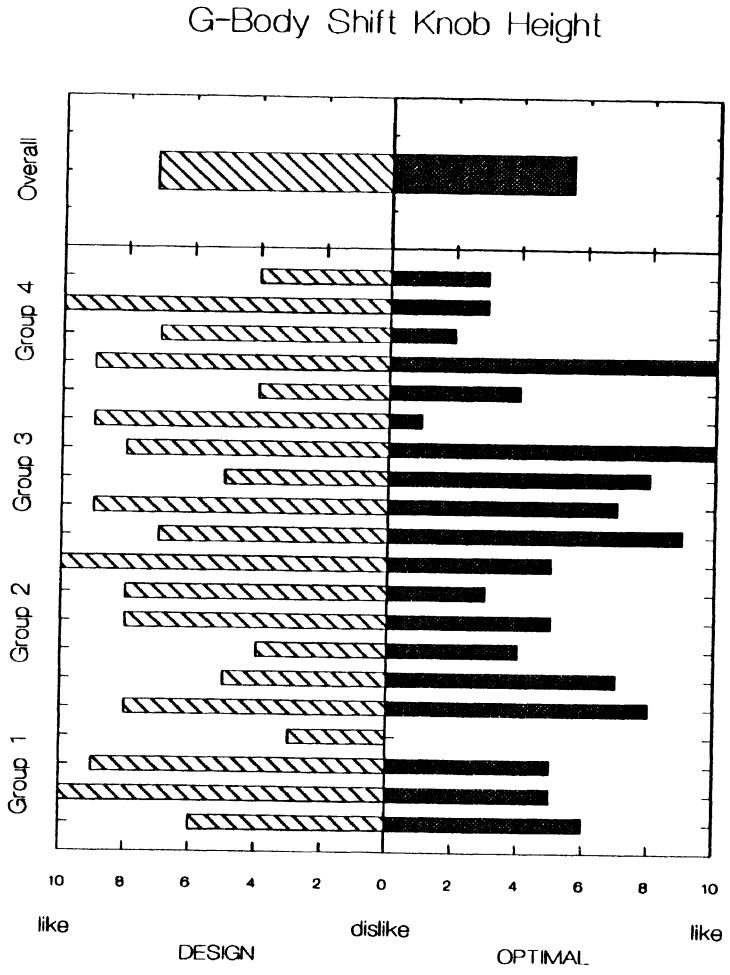

S-Body Console Armrest Height-Highway Driving
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE D.16

APPENDIX E

BAR GRAPHS OF OVERALL AND INDIVIDUAL SUBJECTIVE RATINGS FOR SHIFT-KNOB HEIGHTS


G-Body Shift Knob Height
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

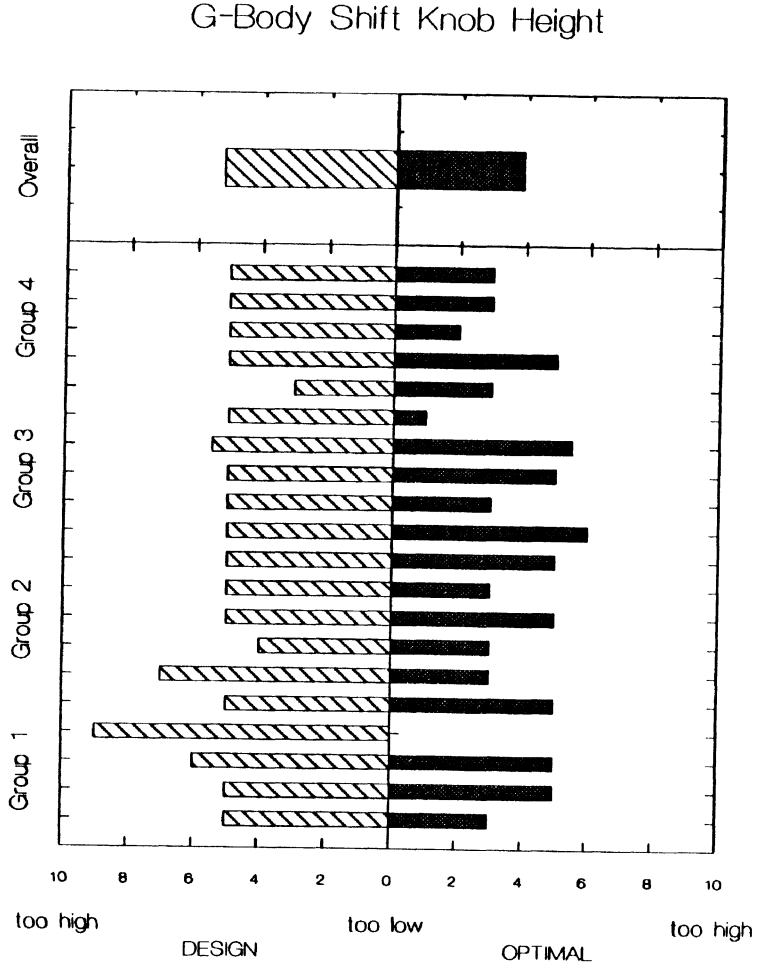
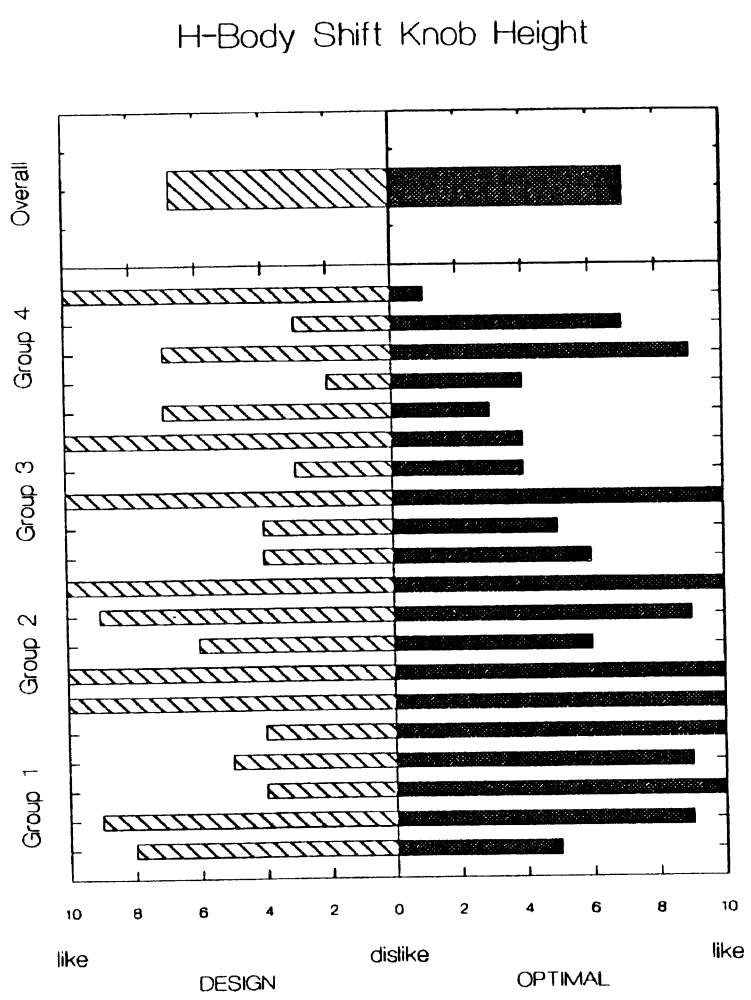

G-Body Shift Knob Height
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE E.1


H-Body Shift Knob Height
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

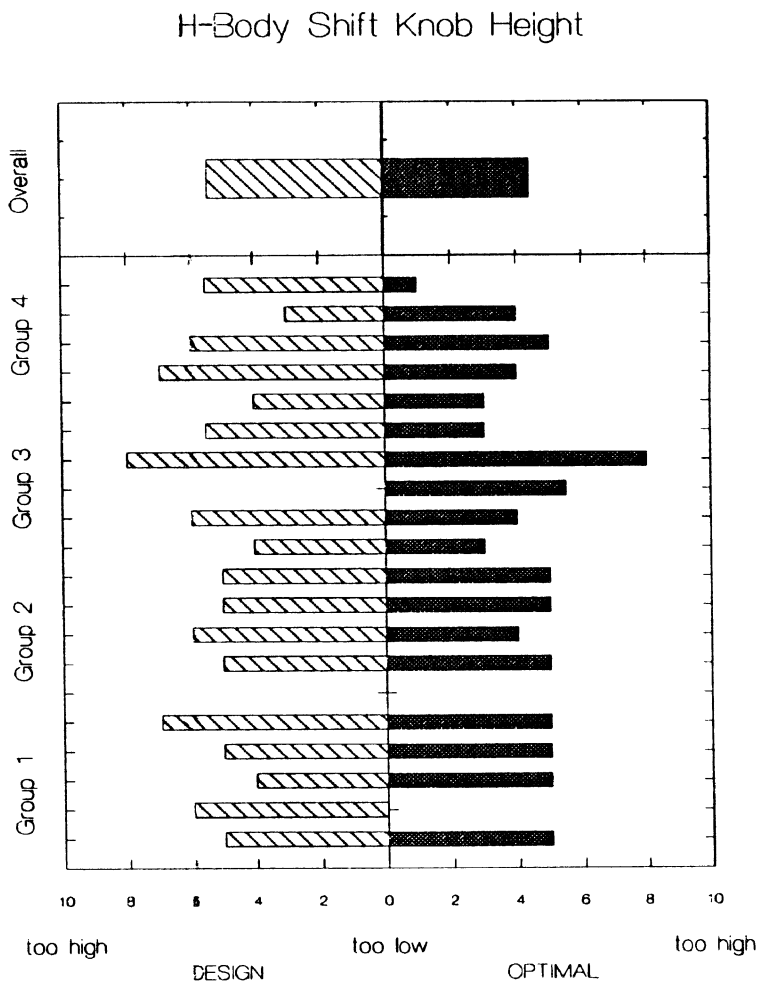
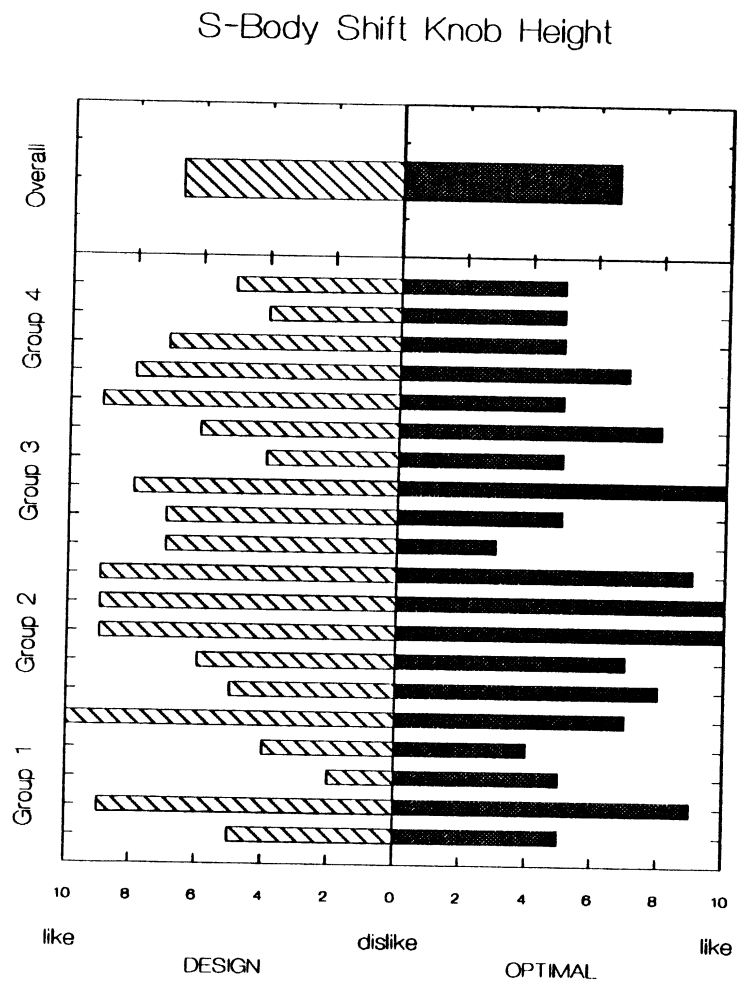

H-Body Shift Knob Height
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE E.2


S-Body Shift Knob Height
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

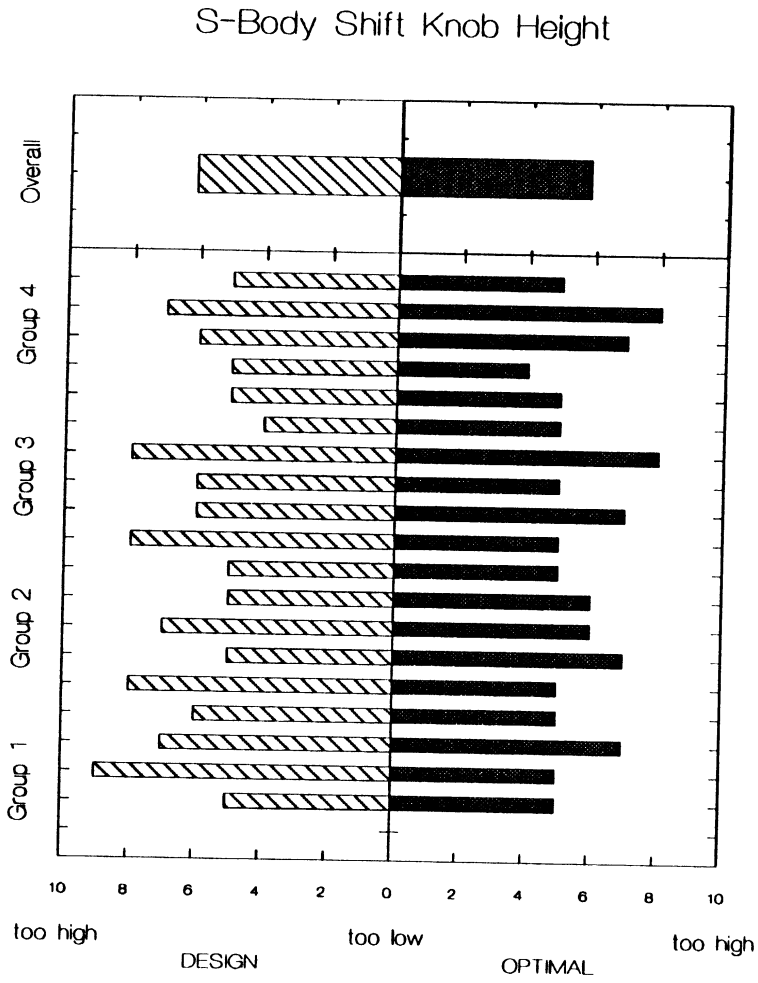
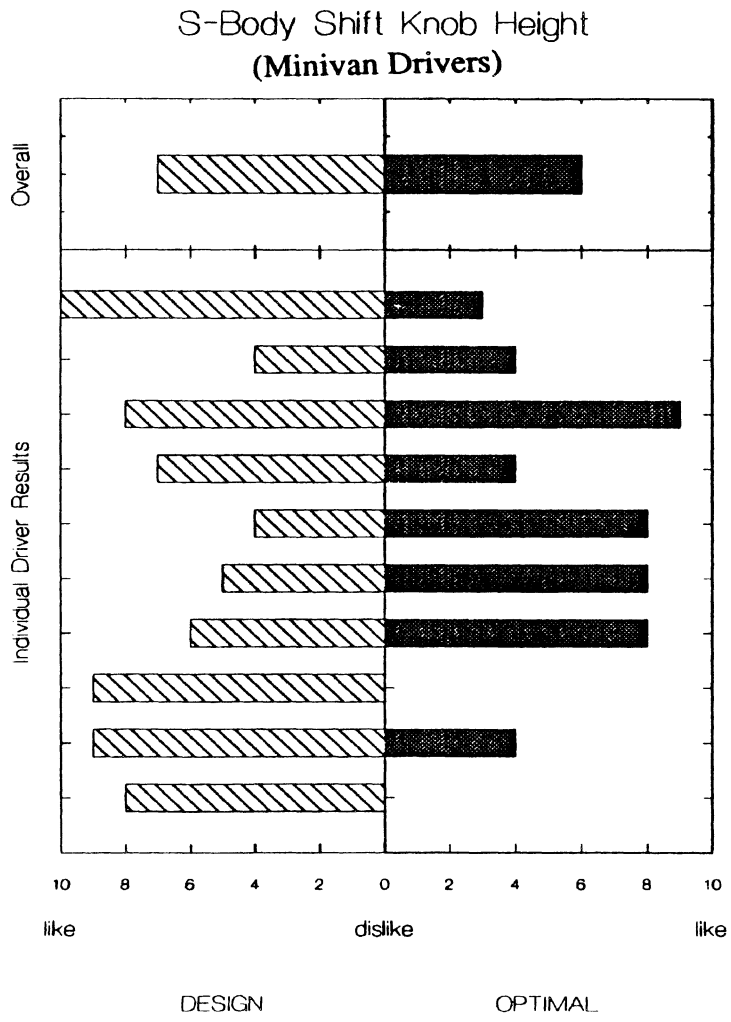

S-Body Shift Knob Height
Overall
Group 4
Group 3
Group 2
Group 1
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE E.3


S-Body Shift Knob Height
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
like
dislike
like
DESIGN
OPTIMAL

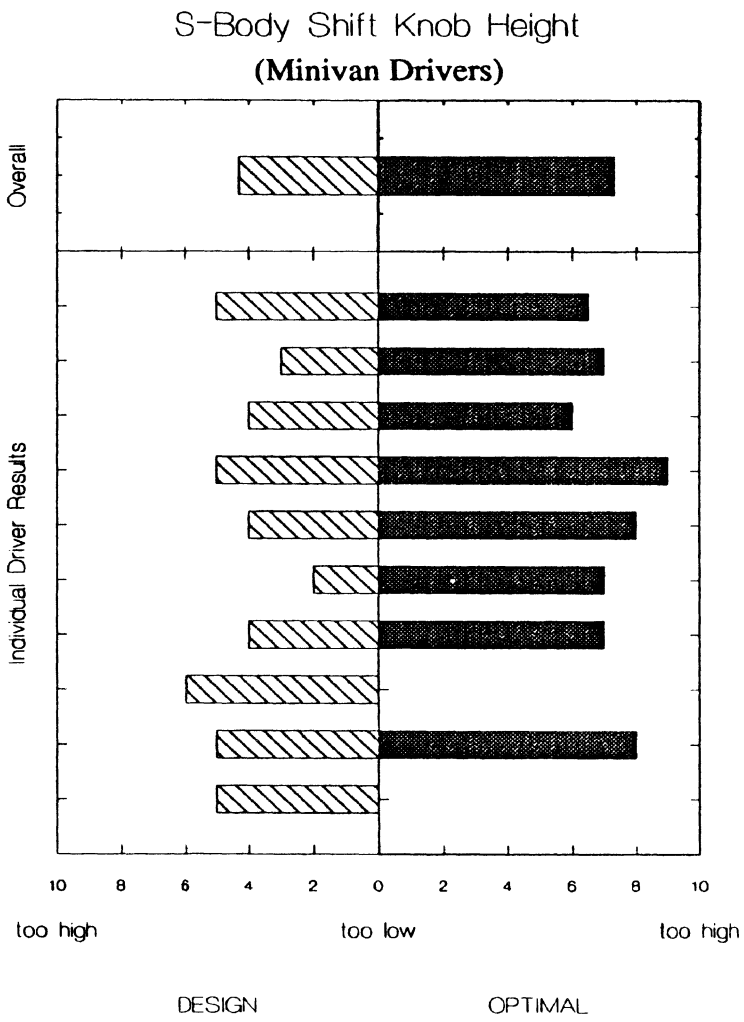

S-Body Shift Knob Height
(Minivan Drivers)
Overall
Individual Driver Results
10 8 6 4 2 0 2 4 6 8 10
too high
too low
too high
DESIGN
OPTIMAL

FIGURE E.4

APPENDIX F

COMPARISONS OF DRIVER SELECTED SEAT POSITION, SEATBACK ANGLES, AND CHIN-TO-WHEEL DISTANCES IN OPTIMAL- AND PRODUCTION-PACKAGE CONFIGURATIONS

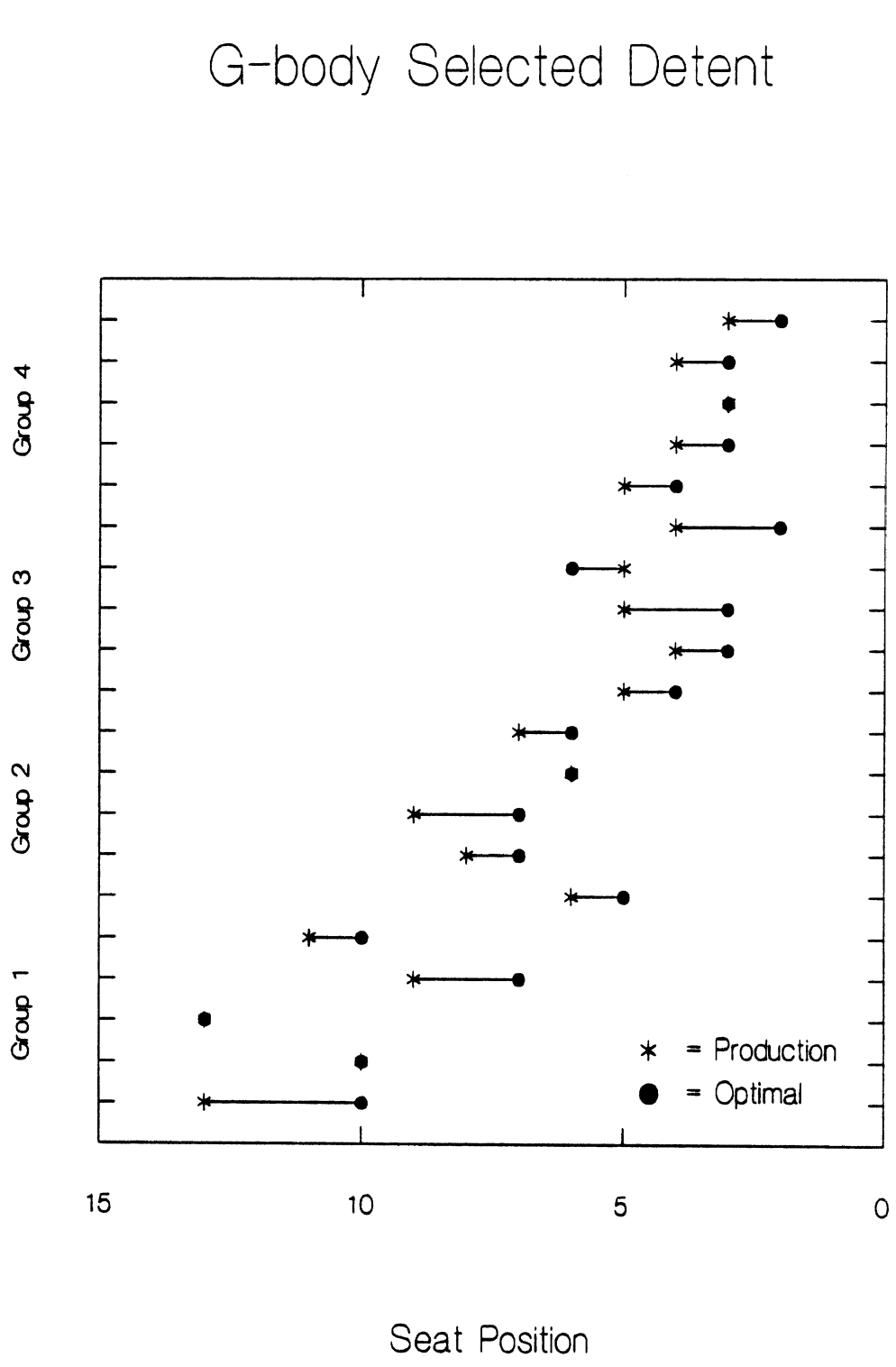

G-body Selected Detent
Group 4
Group 3
Group 2
Group 1
* = Production
● = Optimal
15
10
5
0
Seat Position

FIGURE F.1

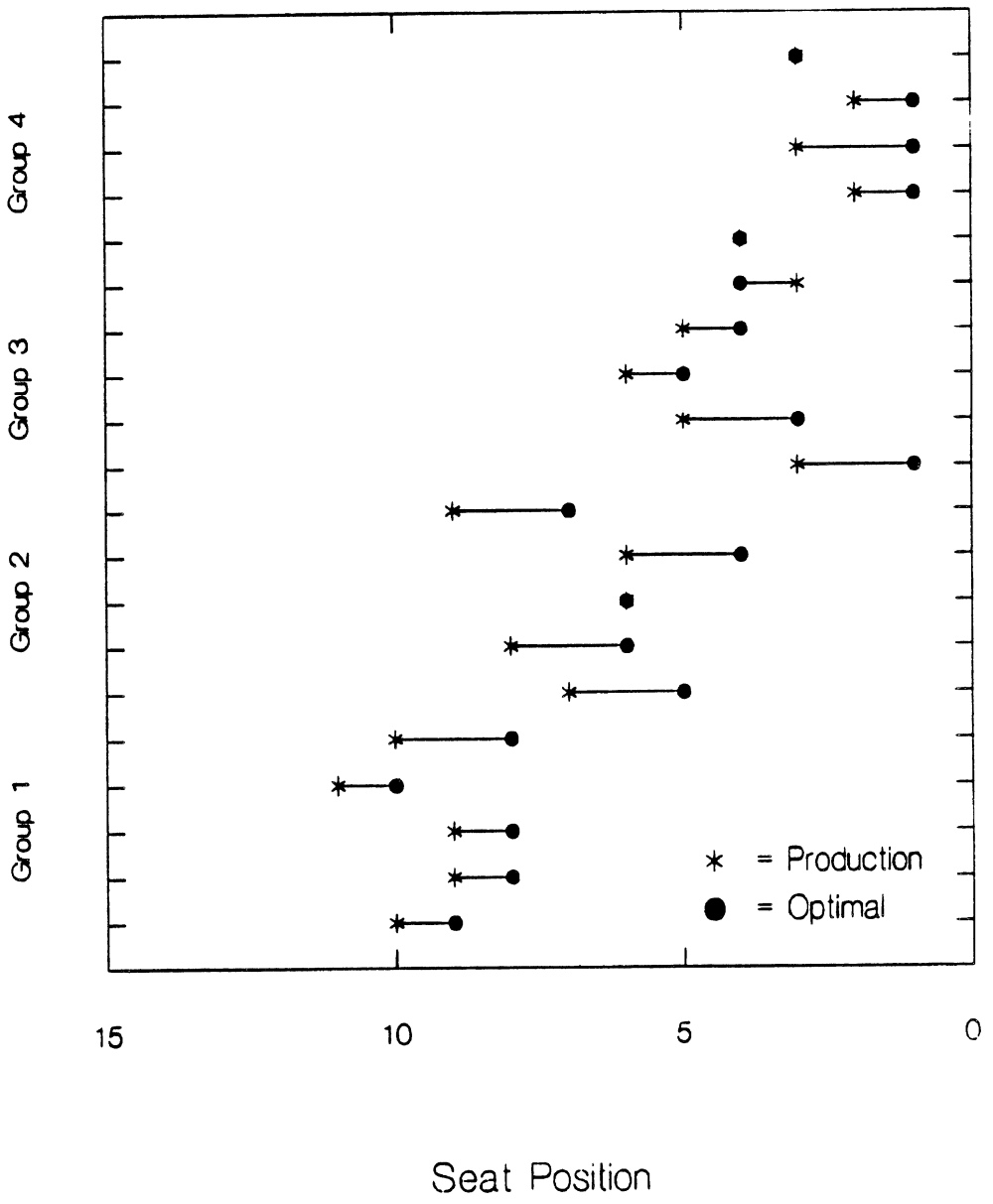

H-body Selected Detent
Group 4
Group 3
Group 2
Group 1
* = Production
● = Optimal
15
10
5
0
Seat Position

FIGURE F.2

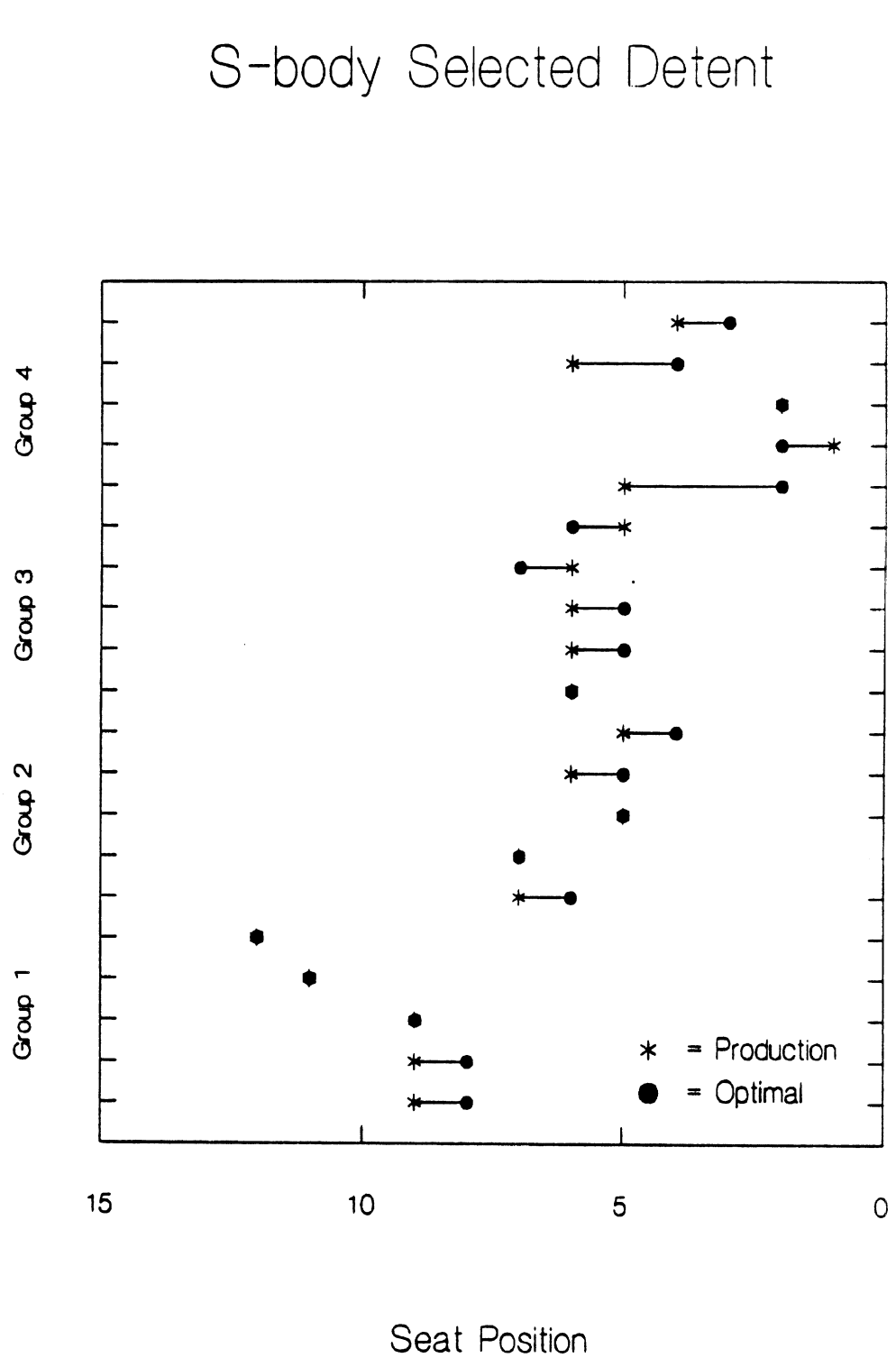

S-body Selected Detent
Group 4
Group 3
Group 2
Group 1
* = Production
● = Optimal
15
10
5
0
Seat Position

FIGURE F.3

G-body Selected Seat Back Recliner Angle

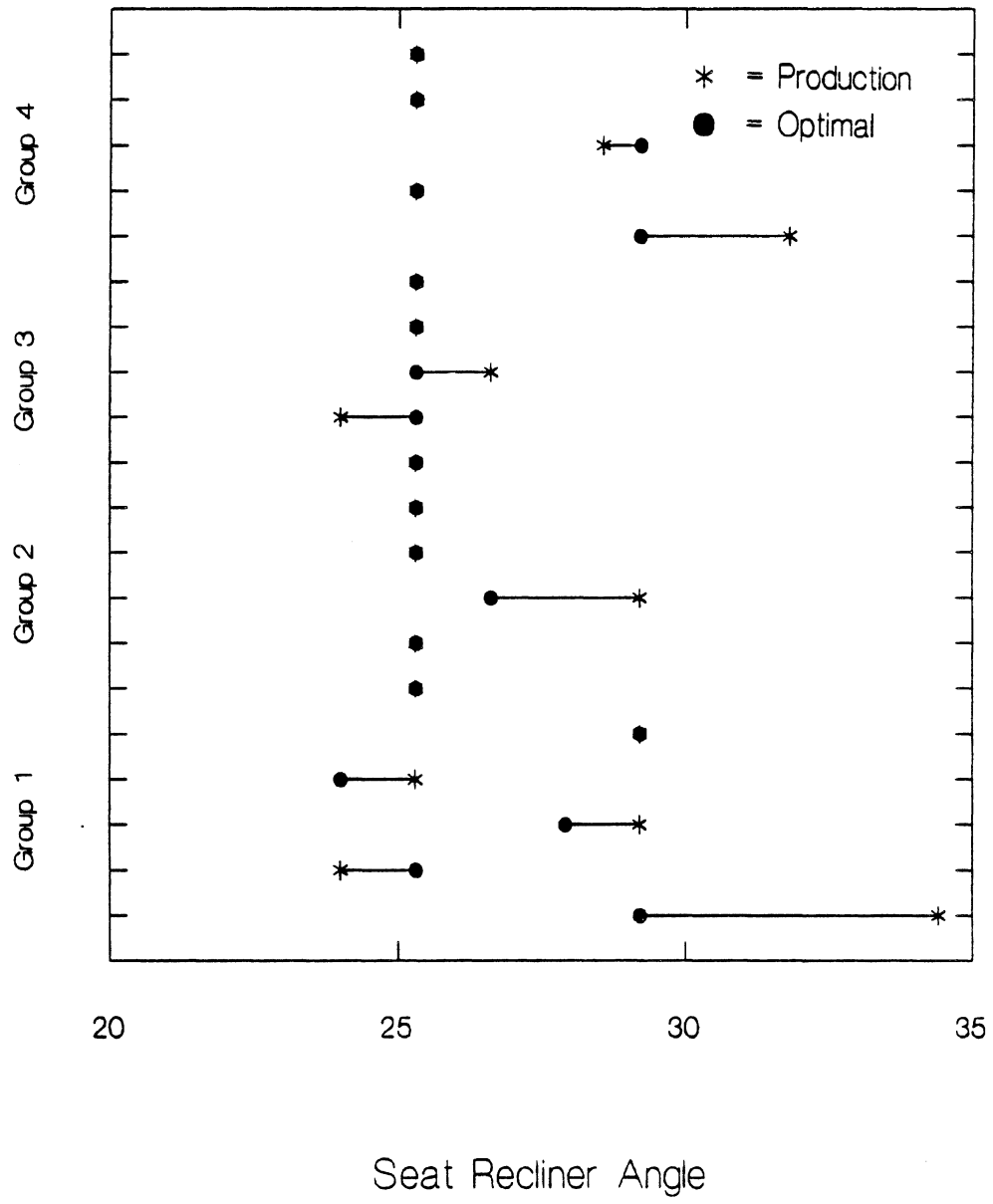


FIGURE F.4

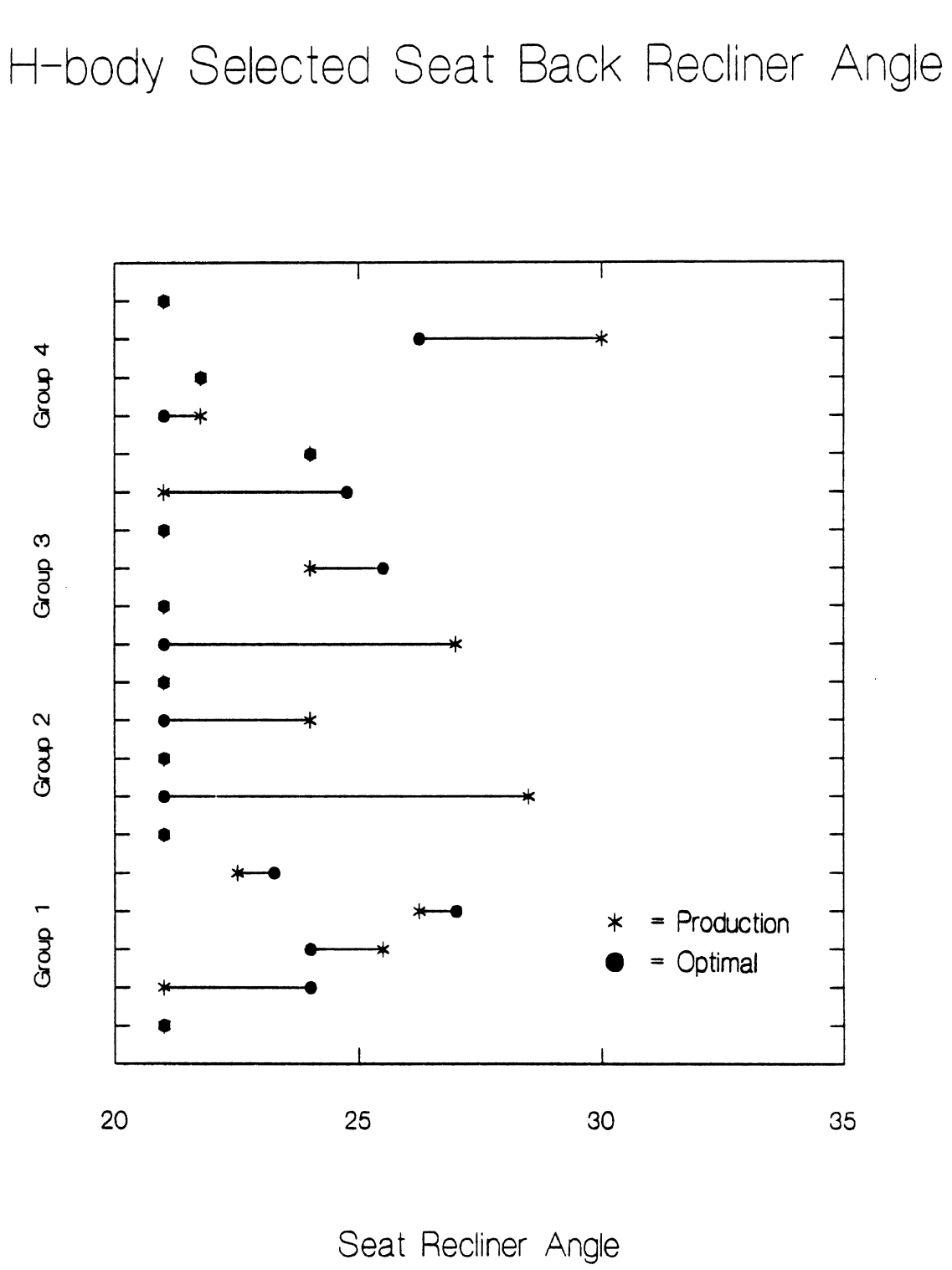

H-body Selected Seat Back Recliner Angle
Group 4
Group 3
Group 2
Group 1
* = Production
● = Optimal
20
25
30
35
Seat Recliner Angle

FIGURE F.5

S-body Selected Seat Back Recliner Angle

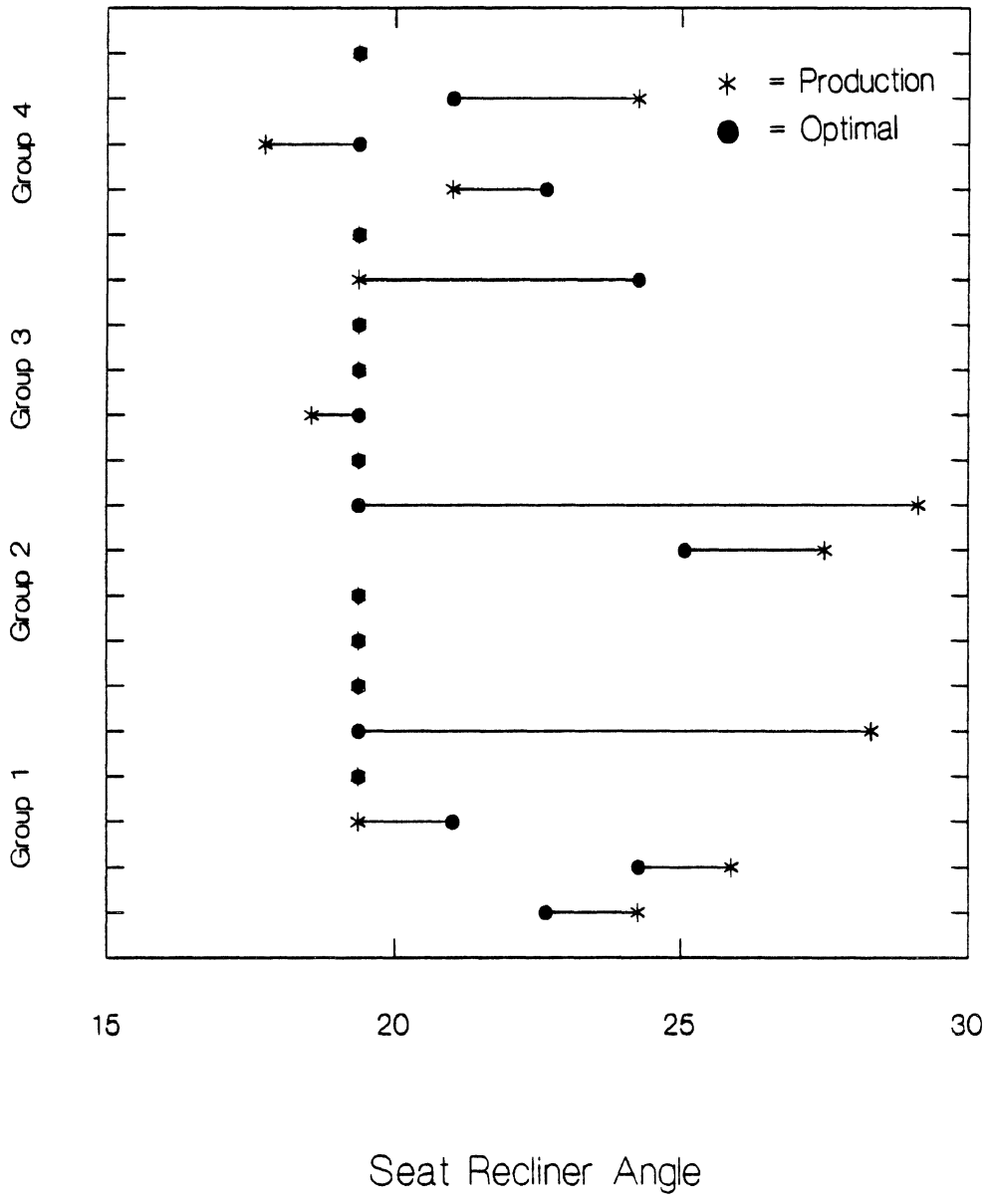


FIGURE F.6

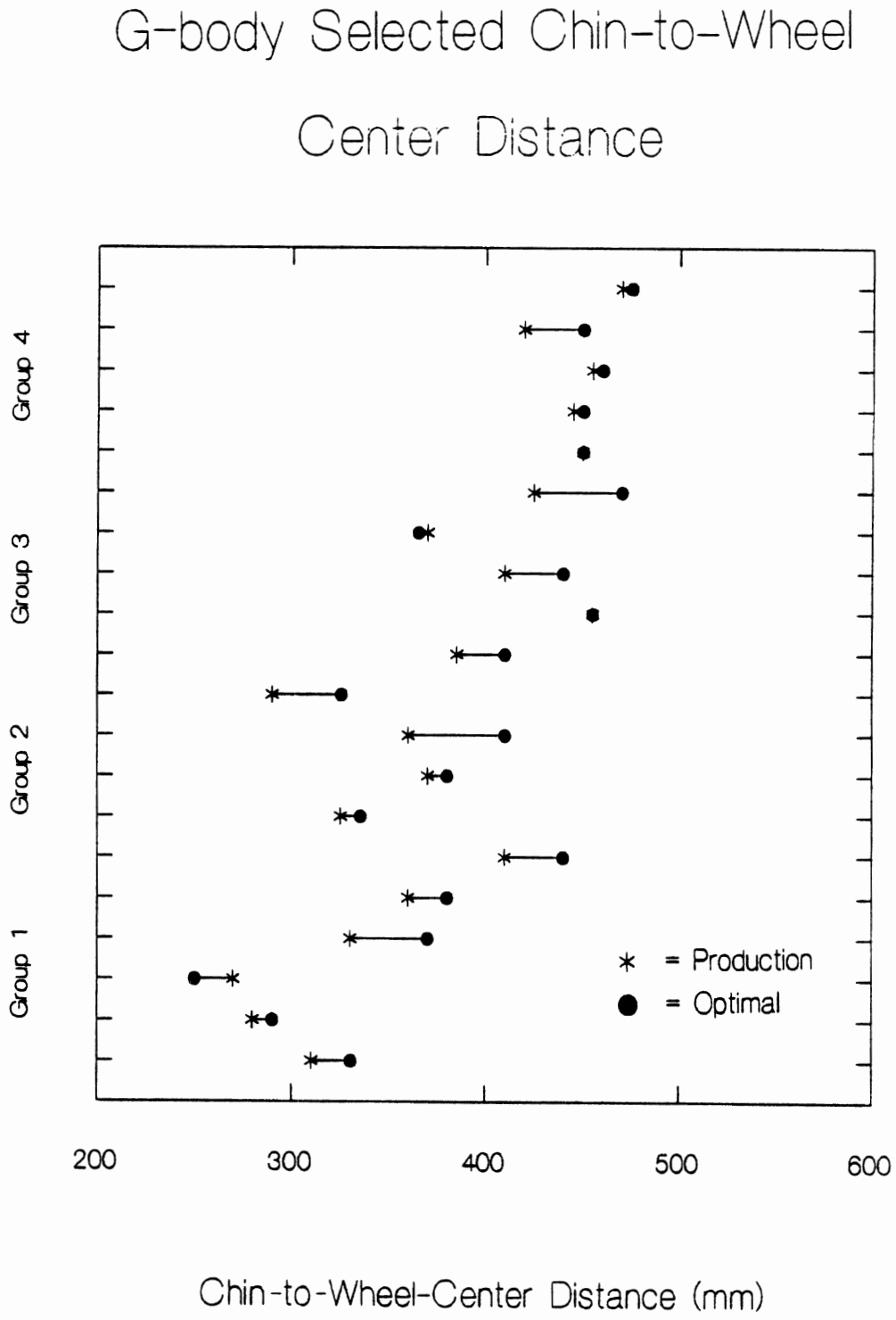

G-body Selected Chin-to-Wheel
Center Distance
Group 4
Group 3
Group 2
Group 1
* = Production
● = Optimal
200
300
400
500
600
Chin-to-Wheel-Center Distance (mm)

FIGURE F.7

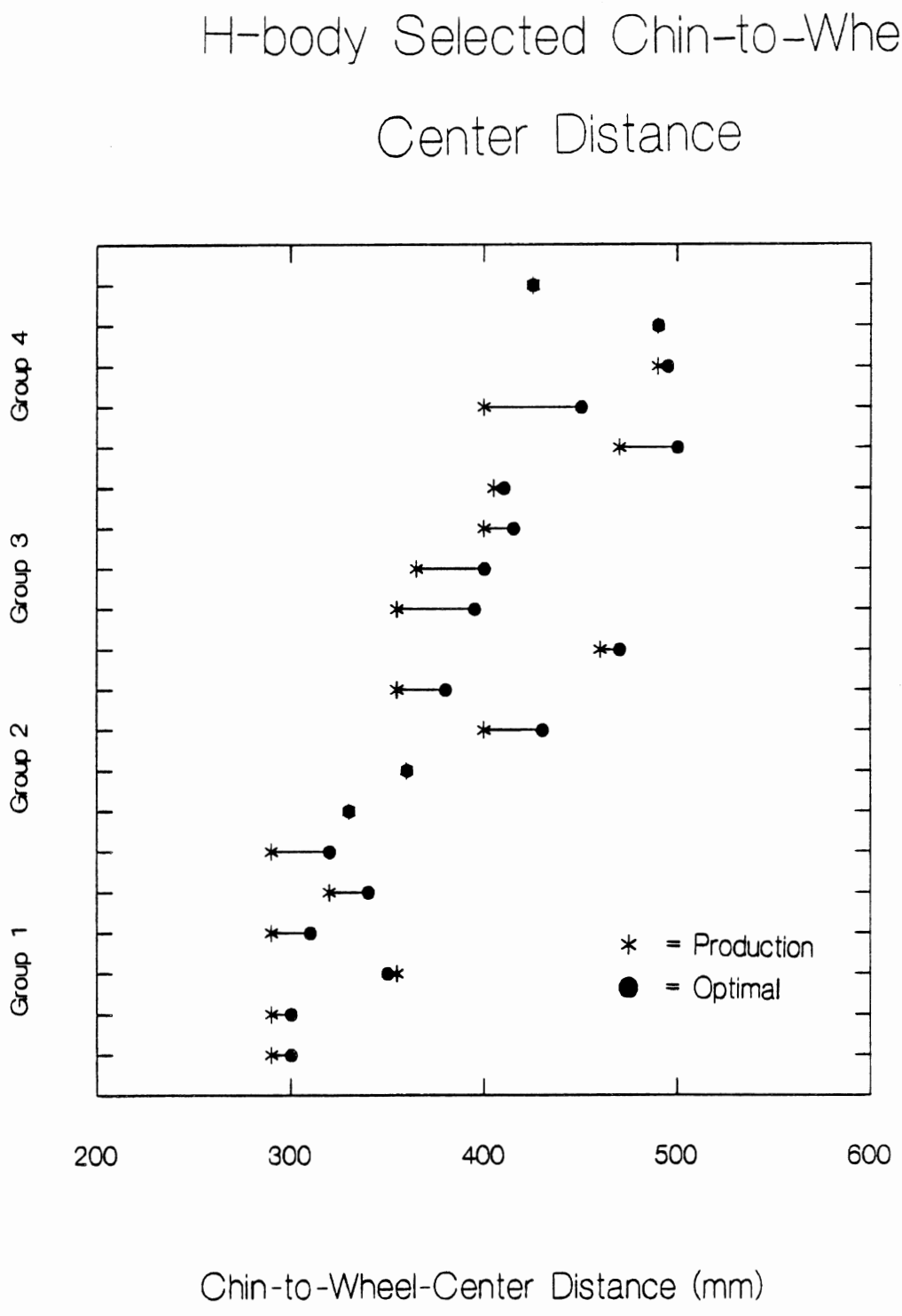

H-body Selected Chin-to-Wheel
Center Distance
Group 4
Group 3
Group 2
Group 1
* = Production
● = Optimal
200
300
400
500
600
Chin-to-Wheel-Center Distance (mm)

FIGURE F.8

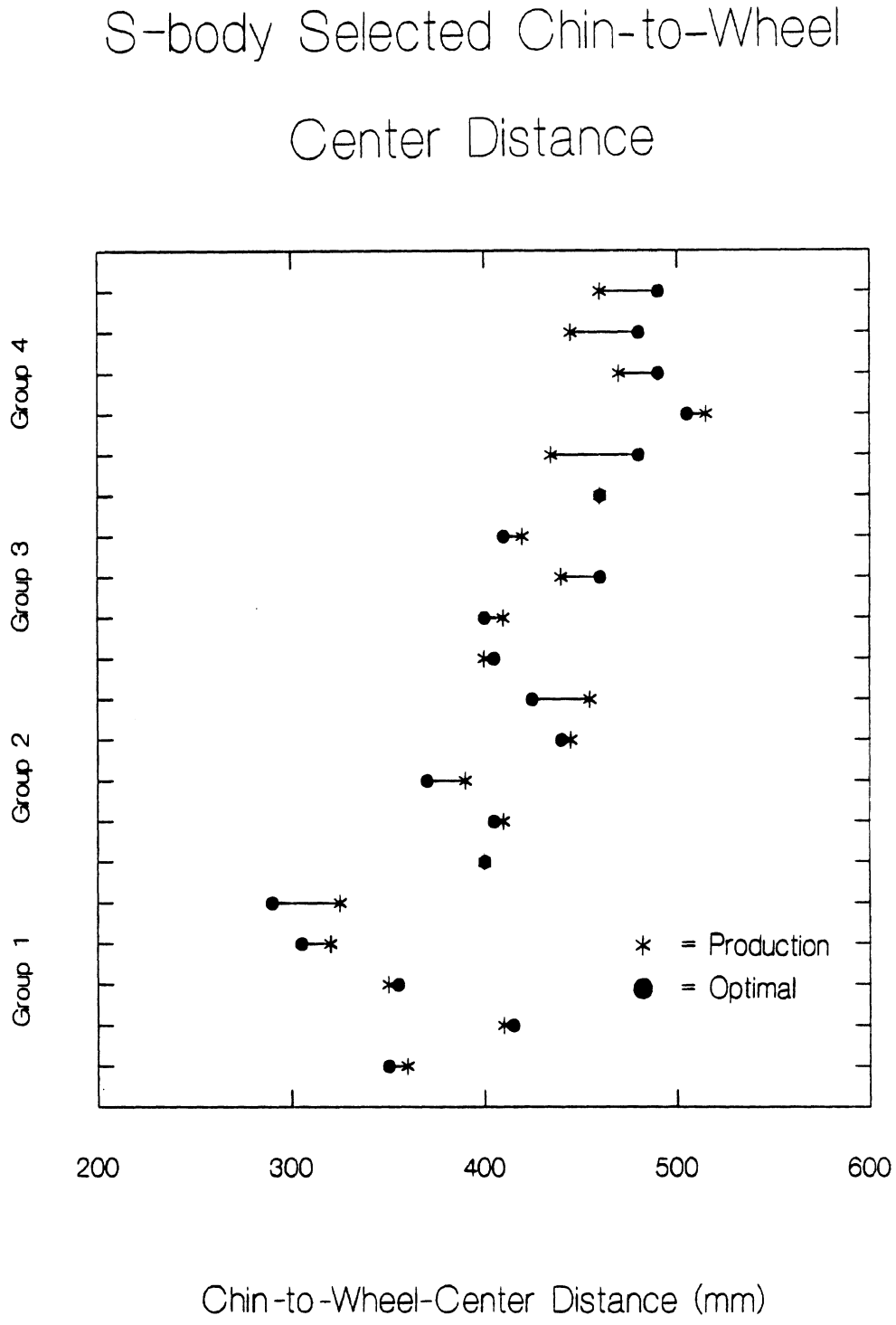

S-body Selected Chin-to-Wheel
Center Distance
Group 4
Group 3
Group 2
Group 1
* = Production
● = Optimal
200
300
400
500
600
Chin-to-Wheel-Center Distance (mm)

FIGURE F.9

APPENDIX G

SUBJECT COMMENTS WITH REGARD TO BRAKE SYSTEM RESPONSIVENESS IN OPTIMAL AND PRODUCTION PACKAGES

TABLE G-1

SUBJECT COMMENTS TO BRAKE PEDAL RESPONSIVENESS

Subject	Production Brake	Optimal Brake
G-Body		
G20101	Great	Great
G20102	Good	Good
G20l03	Fine	Great
G20104	Good	Good
G20105	Brakes were very good.	Good—no trouble stopping.
G10201	Great; same as before.	Fantastic
G10202	Hard. Had to apply more pressure than normal.	No play in pedal; same as last time.
G20203	Seems fine.	Fine; not too sensitive or unresponsive.
G20204	Good	Good
G10205	Brake pedal too large; caught it with my left foot as [I] pushed in the clutch.	Good
G10301	Very good	Very good, almost too good (getting touchy or oversensitive).
G10302	Brake responsive	Brake is responsive; same as first time.
G20303	OK	OK
G20304	OK	Very good
G20305	Excellent	Not very good; poor (both brake and clutch became "loose" on the second drive, did not respond as quickly as they should).
G10401	Brake is fine.	Good
G10402	Average; could have been more responsive. Responsiveness was the same on both drives.	Average
G10403	Felt alright; same as first drive.	No problems
G10404	Very responsive	Good
G10405	No "feel," a little better feel this time, might be getting used to this car.	Too stiff, more assist needed.

TABLE G-1 (continued)

Subject	Production Brake	Optimal Brake
H-Body		
H20106	Fine	Fine
H20107	Good	Good
H20108	Very good (might have responded quicker).	Very good
H20109	Alright (same as first time).	Good—average response (not too tight or loose).
H20110	Good	Good. (A little better than first drive, might just be getting used to it. They felt smoother.)
H10206	Excellent	Same as on first drive.
H10207	Excellent (no difference between drives).	Good. (Location to accelerator ideal, height good. Responsiveness to applied pressure was excellent.)
H20208	Good. (Preferred brakes this time.)	Good
H20209	Good. I felt in control without brake being too touchy.	Good (smooth, felt safe and had good control).
H20210	Good	Good (same as first time).
H10306	Decent	Brake responded very nicely.
H10307	Good (first drive felt more comfortable).	Good
H20308	Very good, smooth stops.	Pretty smooth (pedal felt further under ball of foot, felt like [it] had more control or less travel).
H20309	OK—might need to grab sooner.	Good—response was appropriate.
H10310	Good	Good
H10406	Nice! Not too touchy.	Very good, nice feel (same as before).
H10407	Very good, parallels accelerator well. (Range of motion and pressure required are very similar in the two pedals.)	Very good, pressure nice, but seating adjustment offset the benefit.
H10408	Fine, encountered no problems.	Good braking power.
H10409	Fine	Fine—nothing unusual.
H10410	Makes me feel in control (firm not spongy).	Good firm feel but too far left of accelerator.

TABLE G-1 (continued)

Subject	Production Brake	Optimal Brake
S-Body		
S20111	Great	Great. Didn't lift leg as much this time.
S20112	OK. Felt a little slow to respond.	Good, felt better this time.
S20113	Good	Felt fine—maybe easier to push in this time.
S20114	Same as before.	Okay, no noticeable forced adjustment.
S20115	Good	Good
S10211	Fine	Good
S10212	Good, smooth stop.	Good, no different.
S20213	OK	OK
S20214	Good, better than before but I could just be getting used to it.	Not as quick as I'd like.
S20215	OK. Seemed better this drive.	Too long (a stroke) to actually begin braking action.
S10311	Fine	Fine, no difference.
S10312	Excellent	Good, felt different this time but never got as comfortable as first time.
S20313	Good response	Good response, brakes quickly, same as before.
S20314	Fine	Worked fine.
S20315	Seemed more responsive than other drive.	Excellent
S10411	Good	Good
S10412	Seemed tighter on other drive (less travel).	Good
S10413	Very good to excellent brake feel, very responsive, smooth stops.	Felt slightly spongy, but still felt responsive, steady smooth stopping. Seemed closer to the floor, hence better brake-to-accelerator lift-off (seemed to grab more this time).
S10414	Good	Rained but wet brakes worked well.
S10415	A little play before it responds.	About same as before, probably easier to brake sitting further back (as I am) than first drive.

APPENDIX H

SUBJECT COMMENTS WITH REGARD TO OTHER INTERIOR DESIGN FEATURES

Subject Comment from Questionnaire
Vehicle Body Type "G"

Subject #1: Any strong likes or dislikes

Group #	Freq.	Comment
1		No Comment
1		Reflection from hood creates glare on the windshield which the subject does not like.
1		Difficult to see the end of the hood.
1		Car handles well.
1	2	Subject likes steering.
1		Subject does not like car, would not buy it. Not a smooth driving car. Acceleration and shifting are not smooth.
1		Dashboard is a couple inches too high.
2		Headrest obstructs visibility to the rear on the left side.
2		Molding in the back (B-pillar) obstructs visibility on both sides, but especially on the left side.
2		Rear window defrost button is in a good place, but it's hard to use. Should be lower on the console.
2		Subject hates the turn signal. It is hard to move, he feels like he is braking it.
2		Subject likes the windows - large viewing area.
2		The seat needs more lower back support, and a lower back lever.
2		Subject does not like sitting so low. Knees hit steering wheel. Likes lowness of car.
2		Lower dash comes out too far. Subject would like to see feet when driving.
2		Nice sound system.
3		Vehicle is underpowered.
3		No comment

Group #	Freq.	Comment
	3	Nice car overall, would consider buying it.
	3	O.K.
	3	Subject hates velvet plush (cloth) interior.
	3	Likes the car - comfortable.
	4	Subject feels like he is sitting too low in relation to the hood.
	4	Liked the positioning of the shift handle.
	4	Subject could never find a comfortable seatback angle.
	4	Does not like the way the door armrest is angled.
	4	Would like to see the pedals. The steering wheel column and lower part of dash block view.
	4	Tachometer looks too much like speedometer.
	4	The stick material is too slick to hold.
	4	Door armrest slopes too much inward.

Subject Comment from Questionnaire
Vehicle Body Type "G"

Subject #2: Personal Space/Headroom

Group #	Freq.	Comment
1		Lots of legroom, likes footrest
1		Fine
1		No problems, except steering wheel is too close.
1		Sun visor is just above head, limiting headroom.
2		Knees hit wheel when clutching.
2	2	No comment
2		Fine
2		The amount of legroom is impressive, particularly for the left foot.
3		Everything is planned out well within reach. Minimum amount of movement required, yet not cramped.
3		Pretty Good
3		Good
3		O.K.
3		Not enough elbow room.
3		Would like a little more headroom.
4		Car is very roomy relative to his Prelude.
4		Headroom is nice.
4	2	Legroom is good.
4		Headroom is fine.
4		Comfort isn't bad.
4		Room is good.
4		Center console cramps right leg - too wide.

Subject Comment from Questionnaire
Vehicle Body Type "G"

Subject #3: Visibility/Mirrors

Group #	Freq.	Comment
1		Blind spot on B-pillar.
1		Driver side mirror did not give adequate amount of visibility.
1		A-pillar causes a blind spot which bothers driver. Feels her visibility is not good.
1		No problems.
1		Other than the dashboard, visibility is good.
2		Likes the electric mirrors.
2		Rear window is low enough that it offers good visibility out the back.
2		Fine
2		Would like the door windows to be a bit lower.
2		Real good, mirrors are also good.
2		B-Pillar is too large.
2		Visibility over front hood is bad. Mirror visibility is fine.
3		Very good, all three mirrors are perfectly located. Did not notice any blind spots.
3		Good
3		Less visibility than used to. Posts seem thicker than what she is used to, and are placed in awkward locations. Also, rearview mirror could be bigger.
3		Windows are too small.
3		B-pillar causes blind spot.
3		B-pillar and headrest obstruct view when changing lanes.
4	2	A-pillars are too large.

Group #	Freq.	Comment
4		Windshield seems narrow.
4		Would like rearview mirror to be wider by about an inch.
4		Dashboard is too high.
4		Visibility is obstructed in left rear by B-pillar.
4		Rearward vision is very limited, blind spots at 4 and 7 o'clock are very severe.
4		All mirrors are a bit too small. Rearview mirror 2-3 inches too narrow.
4		Would prefer rectangular side mirrors.

Subject Comment from Questionnaire
Vehicle Body Type "G"

Subject #4: Dash: layout, visability/readability, usability

Group #	Freq.	Comment
1	2	Good
1	2	Speedometer and tachometer are in opposite places compared to her car.
1		Radio is a little too far away requiring subject to lean over to use it.
1		Steering wheel blocks visibility of speedometer.
2		Climate controls and radio are in a good position where they can be seen and operated easily.
2		Steering wheel covers entire dashboard when turning. It is fine when driving straight though.
2		Good view of dash through wheel.
2		Subject liked the warning lights separated from the other gauges.
2		Optimal armrest is comfortable in 2nd and 4th gears, but not in 1st and 3rd.
2		Used to tachometer on the left.
2		Gauges are easy to read.
2		Subject loves all the gauges - hates digital displays.
2		Likes the dials on the radio. Hates push putton radios.
3	2	Used to tachometer on the left and the speedometer on the right. Harder to understand (in this car).
3		Gauges on the left are sometimes obscured by the wheel.
3		Steering wheel is in the way of the speedometer. Center panel is too large.
3		The gauges (oil,water,fuel) are not clearly labeled (the values indicated).

Group #	Freq.	Comment
	3	Likes dashboard layout.
	3	Wants "shift points" registered on the speedometer.
	3	Wheel obstructs view of gauges.
	4	Climate control buttons are far away.
	4	Layout is average. Visibility and readability are o.k.
	4	Couldn't reach center dash (radio, etc.).
	4	Wheel hides dash when turning.
	4	Gauges are easy to read.
	4	Can see all gauges. None are blocked by steering wheel.
	4	Gauges are hard to tell apart. Symbols and shapes are too similar.
	4	The style of the numbers gives the gauges a bland look.
	4	Would like speedometer to have 10 mph increments starting at 10 mph. It shouldn't go to 125 mph because 1) it wouldn't make it there and 2) the portion of the speedometer most often used is too small.
	4	Top of dash is too busy, and it also gives bad reflections on the window.

Subject Comment from Questionnaire
Vehicle Body Type "G"

Subject #5: Wheel Shape

Group #	Freq.	Comment
1		Doesn't like horn.
1		Used to horn being in the center of the wheel.
1		Likes to rest hands in the center of the wheel, but is unable to because of the center hub. Also likes the center horn.
2	2	Fine
2		Does not like the lack of spokes, which she likes to rest her arm on.
2		Subject likes it.
2		No comment
3		Subject likes shape, feels it gives more control.
3		Comfortable
3		Center panel (airbag) would not allow her to wrap her fingers around wheel spoke and operate the vehicle in that manner.
3		Likes the shape of the wheel. It is better than the wheels used in Ford cars.
4		Couldn't find a comfortable hand position. The spokes always seem to be in the way.
4		No comment
4		Used to the horn in the middle.
4		Likes the shape and the spokes, but doesn't like the big block in the center.
4		Likes the shape of the wheel, but doesn't like the placement of the horn.
4		O.K.
4		Horn is difficult to get to.
4		Material of the steering wheel is slippery and hard to grip.

Subject Comment from Questionnaire
Vehicle Body Type "G"

Subject #6: Door controls: windows, latch

Group #	Freq.	Comment
1		Window crank is too low.
1	2	Fine
1		Subject has to lean forward to use window crank.
2		Fine
2		Likes side mirror adjustment.
2		Window crank is a too low and hard to get to.
2		Subject doesn't like the window crank.
2		(Latch) is too far back, have to twist arm back to use it.
3		Likes mirror adjustment control.
3		Window crank seems too far forward.
3		Window crank is too low and hard to find.
3	2	No comment
4		Door latch is hard to reach overall. Have to use right arm instead of left to pull it back comfortably.
4		O.K.
4		Would prefer electric controls.
4	2	Window crank is too low and too far forward.
4		Door latch is too narrow, can only get one finger in it.
4		Door handle is a long reach, which could distract attention from road.

Subject Comment from Questionnaire
Vehicle Body Type "G"

Subject #7: Seats: comfort and design

Group #	Freq.	Comment
	1	Do not like optimal center armrest. It is in the way when shifting, and seems too close.
	1	Fine
	1	Very comfortable, good back support. Headrest height is nice.
	1	Do not like headrest. It comes forward and rubs against back of head.
	1	Side of seat rubs against arm when shifting.
	2	Needs lower back support.
	2	The seat should hug the driver better. The subject feels he might fall out during the turns. Also would want it more upright.
	2	Good, good headrest
	2	Headrest is too wide to see around.
	2	Design of the seatback is too wide. It hits the subject's arm when shifting into 2nd and 4th.
	2	No comment
	2	Wonderful. Firm cushions, good lumbar and back support.
	3	The seat contours to his back well.
	3	Good
	3	Does not like it at all. Feels she is sitting too low. She feels this way partly because the windows are so high.
	3	Comfortable
	4	Seat is a bit narrow.
	4	Likes the back adjustment. Would like smaller increments on seat detent.

Group #	Freq.	Comment
4		Could never find a comfortable seat back angle.
4		Good
4		Comfortable. Adjustment knobs are easy to operate.
4		Seat is too low in relation to the dash.
4		Design should be firmer. It should include side booster, lumber support, and wider back.

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #1: Any strong likes or dislikes

Group #	Freq.	Comment
	1	Nice car overall. Lots of play in the gas pedal at high speeds. Something the subject is not used to.
	1	Subject likes it (car) very much.
	1	Really likes position of wheel relative to the pedals. Wheel is low and far enough from dash - lots of room.
	1	Could reach controls really well.
	1	The seat belt cuts into the subject's neck.
	1	Prefers handbrake to a footbrake.
	2	Things have to be pretty bad before the subject will complain. Reliability is everything.
	2	No place to rest toe of foot when not on clutch.
	2	Prefers hand parking brake to foot parking brake.
	2	Would prefer a longer car in case of an accident to protect the driver.
	2	Drives well in fifth gear.
	2	Subject likes the drink holder, however, it could be a double drink holder.
	2	Smooth, comfortable ride.
	2	Likes position of shift knob and how it shifts.
	2	Likes the optimal armrest on the door, but not on the console.
	2	No true "dislikes"
	3	Didn't like the performance. Handles nicely, but is a dog.
	3	Subject has to reach too far for the stereo.
	3	Likes the mirror adjustment.

Group #	Freq.	Comment
	3	Likes knobs at 10 and 2 o'clock on the steering wheel.
	3	Doesn't have a great deal of pick-up.
	3	Rides very smooth and handles nicely.
	3	No comment
	3	Didn't care for left footrest. Would prefer to rest foot on the floor.
	3	Seatbelt doesn't tighten and stay tight.
	3	Likes reverse in the upper left position (in the gear box) rather than the lower right position.
	3	Quiet, handles well.
	3	Driver visibility is good.
	4	It is a dog.
	4	Would like to lower the steering wheel.
	4	No comment
	4	Performs and handles well.
	4	Dislikes vehicle.
	4	Peppy

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #2: Personal Space/Headroom

Group #	Freq.	Comment
1	2	Good
1		Very good
1		Would like the door armrest to be a little wider.
1		A lot of room
1		O.K.
2		Good
2		Very good
2		Adequate in all regards. In "production" the lack of extra height of the armrest leaves the subject feeling as though there might be too much room. He misses the lateral support.
2		Plenty of legroom for legs to stretch out.
2		Brake (Pedals?) seems too close together.
2		Good, legs and head didn't feel cramped.
3		Would like a "U"-shaped dash to reach things easier.
3	2	Good.
3		Would like more overall room, but wants this in all cars (generally feels claustrophobic in cars).
3		Headroom is nice.
3	2	Legroom is good/nice.
3		Easy entry
3		Wants more room between accelerator and rightside wall.
4		Too much armroom on doorside, would like it closer.
4	2	Good headroom

Group #	Freq.	Comment
	4	Headroom is surprisingly good. Nothing is near his head (B-pillar, shoulder belt harness, etc). This is a little unusual.
	4	Headroom and headrest are excellent. Headrest especially well situated for a tall person.
	4	Might want more legroom
	4	Would like less room on the doorside. Has to slump to one side to use armrest.

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #3: Visibility/Mirrors

Group #	Freq.	Comment
1	2	Good
1		Headrest blocks part of the view out of the rearview mirror.
1		Dashboard is too high, can't see hood.
1		Visibility would be better if subject could sit higher. Steering wheel blocks view of road.
2		Good
2		Right-rear visibility is very good. All visibility is good.
2		Excellent
2		Would like an automatic adjuster for side mirrors.
2		Headrest is comfortable, but obstructs vision when backing up.
2		Mirrors are good.
3		Right-rear has a bothersome blind spot, but isn't too bad.
3	2	Good
3		Rearview mirror not quite wide enough.
3		Would like to be able to adjust right-rear mirror from driver's seat.
3		Headrest obstructs view when trying to see out to right-rear.
4		Rear mirrors are touchy to adjust.
4		Rearview mirror is too narrow.
4		Good
4		Good view from all perspectives
4		When headrest is in the high position, it blocks the lower left corner of the rear window as seen in the rearview mirror. This causes a dangerous blind spot.

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #4: Dash: layout, visability/readability, usability

Group #	Freq.	Comment
	1	Turn signal is a little complicated. Too much on it.
	1	O.K.
	1	Good
	1	Can't see AC.
	1	Steering wheel blocks visibility of radio.
	1	Climate controls are hard to understand for the first time (while driving).
	1	Subject doesn't like speedometer because it has too many numbers on it and they are too close together. Should also get rid of some of the lines between the numbers.
	2	Wheel obstructed view of the alternator gauge.
	2	Subject would prefer words over symbols. For example, the word "gas" instead of a picture of a gas pump.
	2	Good, very pleased.
	2	O.K.
	2	Everything is visible.
	2	Speedometer seems cluttered (too many lines).
	2	Good
	3	The small dials on the left could be separated for easier readability. Subject likes the gauges.
	3	Very good
	3	Would like a clock.
	3	The numbers on the speedometer could be a bit larger. The speed and miles look alike.
	3	Turn indicator makes very little noise causing uncertainty to whether or not it is on.

Group #	Freq.	Comment
3		Subject likes placement of the parking brake release.
3		Layout is logical and visible.
3		Excellent, can read numerals.
3		Cruise control does not work.
3		Steering wheel obstructs view of radio.
4		Warning center is hidden by wheel.
4		Would like the ashtray behind the stick.
4		Wheel obstructs radio.
4	2	Steering wheel obstructs the view of many of the gauges.
4	3	Speedometer is cluttered.
4		Would like a "standard" for the speedometer readings. For example, the 12 o'clock position always corresponds to 55 mph.
4		Everything is handy and self-explanatory.
4		Doesn't like layout. Too far from radio and climate controls. Must lean forward when reading to use the lights.
4		The turn indicator lever and it's various controls are at an odd angle for his hand to reach.
4		Would like turn indicator lights to be at the top of the dash rather than at the bottom, as is now.

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #5: Wheel Shape

Group #	Freq.	Comment
	1	Spoke at 6 o'clock got in the way. Would not want one there.
	1	Very good, easy to hang on to.
	1	Good, comfortable
	1	Would like the well down lower and closer to the dash.
	1	Could not get comfortable with the spokes.
	1	Subject likes the knobs. They are in a good position for resting hands.
	2	Shape obstructs visibility of the gauges.
	2	O.K. Horn doesn't work. (Wheel) seems a little small.
	2	Good
	2	Wheel spokes are too thick, limiting where subject could place his hands.
	2	Found "hand placement knobs" on wheel useless but not annoying.
	2	Thick spokes make seeing the dash hard at times.
	3	No comment
	3	Subject doen't like the lower spoke.
	3	The height of the wheel is very good with respect to the height of the dash - good visibility.
	3	Subject likes the knobs at 10 and 2 o'clock.
	3	Nice grip. Vinyl texture is nice. The wheel is pleasant to hold.
	3	Subject wants the wheel rim to be thinner.
	3	Likes it. The knobs help control the wheel.

Group #	Freq.	Comment
	4	Liked the placement of the spokes at 4 and 8 o'clock.
	4	Turn signal is too far from the wheel.
	4	Like the material of the wheel. Non-slip, feels good.
	4	Knobs in the right place for good control.
	4	Comfortable, secure, handles well.
	4	Likes it. Crossbars are convenient for resting fingers on while driving.
	4	Width of spokes adds to the visibility problem of the dash.

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #6: Door controls: windows, latch

Group #	Freq.	Comment
1	2	O.K.
1	2	Good
1		No problems
2		Lock is a good anti-theft design
2		Subject doesn't like door release. Subject has to fumble around looking for a loop to put fingers through. Too small and complicated to easily work.
2		O.K. for manual windows.
2		Good, normal
2		Easy to adjust side mirrors.
3		Has to reach too far for window knobs.
3		Loves placement of window adjuster.
3		Convenient
3		Fine
3		No problems
3		O.K.
4		Subject hits armrest when operating window.
4		Door latch is too small. Can only open with 1 finger. This hurts subject.
4		Subject likes locking mechanism.
4		Lock is not intuitive. Have to inspect it before you know how to operate it.
4		Accessible, works fine.
4		No comment
4		No problems

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #7: Seats: comfort and design

Group #	Freq.	Comment
	1	O.K.
	1	Very good. Likes back support especially for highway driving.
	1	Great, really likes it.
	1	Could be better, but not sure how. Higher.
	1	Would like to be able to adjust seat height, otherwise comfortable.
	2	Prefers bench to bucket.
	2	Wishes seat were higher from floor.
	2	Would like a 6-way seat. He wonders if the seat bench angle is the right one for him.
	2	Would like more support in lower back.
	2	The headrest pushes his head out too far. Overall, subject feels squished over.
	2	"Held" subject into seat.
	2	Seat offers support over entire range of back so subject never has to exert herself to be in a good/safe driving position. Good lower back positon.
	2	Really good
	3	Pretty good
	3	Very comfortable
	3	Upper back is comfortable. Would like a little more side support. Lower back control is a strong must for her.
	3	Seat is not comfortable. Doesn't like bucket seats. Wants to be more upright.
	3	Bucket seat is so tight he has to remove his bilfold because it is being forced into his skin.

Group #	Freq.	Comment
	4	Would like the contour of the seat to curve out for a secure feeling.
	4	Likes headrest.
	4	Lower back support is good but the upper back support is at the wrong height. Strokes him between the shoulder blades. Padding is soft.
	4	Headrests don't come forward enough.
	4	Good lumbar and neck support.
	4	Pretty Good
	4	Would like to sit more upright.
	4	Would like more lumbar support.
	4	Seat is narrow.

Subject Comment from Questionnaire
Vehicle Body Type "S"

Subject #1: Any strong likes or dislikes

Group #	Freq.	Comment
	1	No comment
	1	Armrest is nice to rest arm on when not shifting, but is too high for comfortable shifting.
	1	Subject doesn't like keylock safety feature.
	1	Uncertain of gears when shifting down.
	1	Likes cup holder.
	1	Turn signal doesn't turn on easily.
	1	Subject likes accelerator.
	1	(Car) is too top heavy on curves.
	2	Windshield seems poorly fit into frame. You can see the black edging inside the vehicle. Edging size is uneven. This reflects general poor quality in construction.
	2	Do not understand fuel-pacer light.
	2	Car ran quietly.
	2	Upholstry is excellent.
	2	Good radio.
	2	Likes cup indentations on dash and envelope holders in sun visor.
	2	Nice except for armrests.
	2	Would like turn indicator lever closer to the wheel so it can be used without removing hands from the wheel.
	2	Very comfortable for it's size, smooth ride.
	2	Would like door armrest in between 2 two heights. Console armrest is not wide enough.
	2	Really likes the speed and handling.

Group #	Freq.	Comment
2		Likes concept of a small van as a family car. Seems noisy though.
3	2	Likes car, but not anything specific.
3		5th gear has way too long a throw. Seems excessively long compared to the other gears.
3		Suspension seems a bit soft for a bouncy ride.
3		No comment
3		Aside from the right armrest, it is quite comfortable to drive.
3		Dislikes position of detent adjustment lever.
4		Hated the 2nd ride. Would buy the first car, but never the 2nd ride.
4		Distance from wheel to pedals doesn't leave enough kneeroom to work clutch.
4		Would like to drive this on his upcoming trip. Comfortable ride.
4		Handles well, good acceleration, one of the best manuals he has driven.
4		Would like parking brake in the center.
4		Shiftthrow to 3rd and 5th a bit long as he is sitting far back.
4		Fuel-pacer is confusing.
4		Great air-conditioning.
4		Likes the drink holder in the dash.

Subject Comment from Questionnaire
Vehicle Body Type "S"

Subject #2: Personal Space/Headroom

Group #	Freq.	Comment
1		Likes it a lot, console and dash are easily accessible.
1	3	Good
1		Getting in and out is difficult for a short woman.
1		No comment
2		Fine
2		Plenty of footroom around pedals which is nice.
2		Would like the right armrest to be out a little.
2	3	Good
3		Good
3		Very good
3		Real good, likes the room between the front seats.
3		The room side to side is bad because the armrests wedged him in. Legroom is cramped by the steering column.
3		Roomy, but not excessively.
4		During 2nd ride, subject felt slumped/hunched over and tilted to the right. Terrible room. First time was great.
4		O.K.
4		Adequate. Feels more like a passenger car than a truck.
4		Excellent
4		Legroom is good when he moves the seat back. Wheel and column do not interfere with legs then.

Subject Comment from Questionnaire
Vehicle Body Type "H"

Subject #3: Visibility/Mirrors

Group #	Freq.	Comment
1		Difficult to see low object next to the right side of the car because door panel is too high.
1		Rearview mirror could be one or two inches wider in order to cover all of the back window.
1	2	Good
1		Could see over dash easily.
1		Mirrors are easy to adjust, and their placement is good.
2		Good
2		Rearview mirror requires constant adjustment. Subject believes this is because it is too narrow (top to bottom).
2	2	Rearview mirror seems too small.
2		Would feel more secure if all mirrors were larger.
2		Prefers electric mirror adjusters.
2		Would like to see the front end.
2		Excellent
2		B-pillar on left side obstructs vision.
3		Good
3		Very good
3		Passenger seat headrest might be in the way when looking over right shoulder.
3		Would prefer mirrors that are true to life rather than making object "closer they than they appear".
3		No major blind spots. Felt she was getting a good safety vehicle.
3		Good, no blind spots that he could say.

Group #	Freq.	Comment
4		Was more aware of the front of the car in the first vehicle than this one.
4		O.K.
4		Fine. Back window became clouded by rain and frame was hard to see. Did not know about the back wiper.
4		Excellent visibility
4		Would prefer electric mirror adjusters.
4		Would like a larger rearview mirror.
4		Driver's side B-pillar obstructed view when turning.
4		Seeing over hood is difficult, particularly determining where the hood ended.

Subject Comment from Questionnaire
Vehicle Body Type "S"

Subject #4: Dash: layout, visability/readability, usability

Group #	Freq.	Comment
	1	Fine
	1	Would like markings on speedometer for exactly 20, 30, 40 mph etc.
	1	Would like a clock on the dash.
	1	Would like the speedometer markings to be every 5 mph.
	1	Good radio display, easy to read.
	1	Wheel cut off view of the top of the gauges.
	1	The climate controls are hard to understand while driving.
	1	Wheel obscures view of speedometer and oil light. Otherwise, clear and easy to understand.
	2	Radio is a little difficult to understand. Could not operate it without looking at it.
	2	Do not like the large fuel gauge. It distracts attention away from the speedometer.
	2	Took subject a while to find the front windshield wipers (found the back wipers first). Also had to look around the wheel to operate climate controls.
	2	Radio is hard to reach. It requires the subject to bend forward.
	2	Once subject activated wipers when using the turn signal.
	2	Would prefer that the speedometer and gas gauges were switched.
	2	Climate controls are a bit of a reach.
	2	Radio is a reach.
	3	Subject had some difficulty finding the speedometer at first. Looked on the right side of the dash first. Speedometer also seems a little small.

Group #	Freq.	Comment
3		Wheel partially obstructs view of speedometer, oil, and alternater gauges.
3		Turn signal doesn't have a real positive "click" to it when signaling.
3		Would like some markings for every 10 mph on the speedometer.
3		Cupholders and ashtray are far away from the driver.
3		Noticed "low fuel light" immediately which means it works as a warning light. Turn signal lights are very easily seen. For the most part everything is readable.
3		Likes gas gauges that continue to give a true reading when engine is off.
3		Does not like placement or understand the "rearwash and wipe buttons".
3	2	Does not understand "fuel-pacer light".
3		Everything is in plane view. Would like radio up higher.
4		"Fuel-pacer" is confusing to understand.
4		Likes graphics on the radio.
4		The gauges were easier to see than in the first drive where they were partially blocked.
4		Radio is a little hard to reach while driving.
4		The oil and alternator gauges are obscured by the wheel.
4		Controls are far away.
4		Wheel obscures oil pressure gauge which should be more central.
4		Steering wheel crossbar obstructs the view of the climate controls, turn indicator lever, and defrost/rear window wiper buttons.
4		The large gas gauge distracts the subject when he is actually looking for the speedometer.

Subject Comment from Questionnaire
Vehicle Body Type "S"

Subject #5: Wheel Shape

Group #	Freq.	Comment
1	2	Good
1		Good, likes a smaller wheel.
1		Subject would like the spokes placed somewhere else so he could place his hands inside the wheel at 10 and 12 o'clock. The placement of spokes hinders this.
1		No comment
2		The shape is fine, but it blocks the view of the speedometer and oil light.
2		Likes the feel of the wheel.
2		O.K.
2		Good
2		Wheel seems a little thick to her.
2		Fine
3		Likes it.
3		Likes the position of spokes.
3		Wheel is off-center when driving straight. (Cross-bar of wheel makes an angle with the horizontal rather than being perfectly horizontal when driving straight.)
3		Good
3		Would like wheel in a more vertical position. Cross-bar is where she wants to rest hands.
3		Fine
4		Spokes seem in the way. Everything was so comfortable the first time.
4		Good
4		No comment
4		O.K. - Neutral
4		Alright, it is thick which is comfortable.

Subject Comment from Questionnaire
Vehicle Body Type "S"

Subject #6: Door controls: windows, latch

Group #	Freq.	Comment
1		O.K.
1		Side mirror control is easy to use, but had to reach for it especially when driving. It could be lower.
1		Window knob is too low and too far forward.
1		Likes placement of lock and mirror adjustments.
1		Had a hard time understanding how to operate lock.
1		It is very difficult to reach window handles especially in ride #2. Also could not reach door latch on opposite side.
2	2	Fine
2	2	No comment
2		Hard to tell when vehicle is locked and unlocked.
3	3	Fine
3		Window knob is too far down.
3		Had a hard time understanding how to use the latch and lock.
3		Not able to reach the right door lock. The window crank is also a reach.
3		Doesn't like the manual locks.
4		The first time was great. Could rest knee comfortably against door without hitting anything. Can't the second time. Controls are not bad.
4		Good
4	2	Window crank is rather a long reach.
4		Window crank is hard to reach. Too far forward and down.

Subject Comment from Questionnaire
Vehicle Body Type "S"

Subject #7: Seats: comfort and design

Group #	Freq.	Comment
1		Really comfortable
1		Good
1		Seat is too long, it catches under knee. This is uncomfortable.
1		Doesn't like calves rubbing against front of seat.
1		Nice. Lumbar support is very good. Felt the seat kept you secure/held in.
1		Bench is too long, but otherwise comfortable.
2		Armrest is too narrow and seat rocks slightly (our fault because of design changes).
2		Would like to be able to sit more vertical.
2		Armrest causes her wrists to hurt because they force her hands to be at a severe vertical angle. This effect is lessened on the x-way (highway?) when she could rest hands at the bottom of the wheel.
2	2	Fine
2		Likes it overall.
2		Would rather have a bigger headrest.
3		Feels seat is better secured than first.
3		Good, very comfortable
3		Would like to sit higher to see hood and be better able to judge where it is.
3		Good design of seat. Would like headrest to stick further out to support head in a more natural position.
3		Would like seat to come up to a more upright position. Otherwise rather comfortable.
3		Good

Group #	Freq.	Comment
	4	The first time was great. (Body) weight seems to be concentrated at the base of the spine during the second ride.
	4	Would like the option of lumbar support.
	4	There could be more support in the headrest, similar to a dentist's chair.
	4	Good
	4	Comfortable
	4	Could use a bit more lumbar support. Design is good, very comfortable.
	4	The right side armrest is too close in and too narrow, as was mentioned before.