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Instrument Panel Controls in Sedans: What Drivers Prefer and Why

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16. Abstract

Fifty-four drivers, ranging in age from 19 to 77, sat in a mockup of a sedan with a Velcro®-covered instrument panel. Drivers placed switches they preferred for 9 functions (cruise on/off, wiper, etc.) where they wanted them. There were 245 switch designs (stalk controls, pushbuttons, etc.) to choose among. Drivers also described the motion to operate each control and said why particular locations, switches, and motions were preferred. When the design was completed, drivers reached for each control while operating a driving simulator.

Drivers preferred hub-mounted cruise controls (rocker or pushbutton for on/off, pushbutton for set), ceiling-mounted dome light switches (rocker), stalk-mounted wiper/washer controls, column-mounted hazard switches (rocker), column-mounted ignition switches, and placing the headlights and panel brightness switches low on the left side of the panel. Most commonly, drivers said they preferred locations and switches because those items were expected or familiar, but the switches or locations they chose matched what was in their current cars less than half of the time. Except for switch preferences (which were linked to torso size), what drivers wanted was unrelated to their experience with vehicles, their age, sex, or physical characteristics.

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Background

Contemporary automobile design is customer-driven. People are more likely to buy products that have been designed to suit them. The experiment described in this report examines driver preferences for controls in a sedan.

The University of Michigan Transportation Research Institute (UMTRI) has produced two previous reports on this topic. In the first (Green, Kerst, Ottens, Goldstein, and Adams, 1987, Driver Preferences for Secondary Controls) data was collected on a instrument panel for a future sports car. The instrument panel had pods near the steering wheel on which controls could be placed. The content of the second report is indicated by its title (Green and Goldstein, 1989, Further Analysis of Driver Preferences for Secondary Controls).

This report examines a second instrument panel design not considered in the previous two reports, namely a flat (conventional) instrument panel commonly found in sedans. It also examines why drivers have particular preferences. Understanding why is important if the results of the research are to be generalizable.

Questions Addressed

Specifically, this report examines the following questions:

1. Where do drivers want controls on conventional instrument panels? What types of switches do they want? What methods of operation do they prefer?

2. What reasons do drivers give for their preferences?

3. How do the preferred locations and switches differ from the controls in participants cars?

4. How do preferences differ for controls on pod-based versus conventional instrument panels?

5. How do driver characteristics influence their preferences for locations and switches?

How the Data Were Collected

A total of 54 drivers participated in an experiment carried out at UMTRI. Nine men and 9 women were drawn from each of 3 age groups: 19-29, 30-54, and 55-77. Drivers sat in a mockup of a 1985 Chrysler Laser with a bench seat, no center console, and an instrument panel modified to represent a sedan Chrysler is designing. All of the surfaces where switches could be mounted were covered with Velcro®. Several controls for which a consensus had been identified in a previous study (horn, turn signal, beam switching, beam flashing) were installed in the

mockup. Surrounding the driver were panels on which 245 different types of switches (stalk controls, rocker switches, etc.) likely to be found in current production cars. Multiple copies of each switch were provided in some cases. All surface-mounted switches had a Velcro® backing.

Drivers selected the switches they preferred for 9 functions (cruise on/off, cruise set, dome light, front windshield washer, front windshield wiper, hazard, headlights on/off, ignition, panel brightness). Drivers also placed the switches where they wanted them and stated how the switches should operate. (This is referred to as the "Potato Head Method," after the toy, since drivers construct instrument panels in a manner analogous to how children construct faces.) Drivers also said why they preferred particular switches, locations, and methods of operation. To stimulate their thinking, an abbreviated list of reasons was in view.

After the data were recorded by an experimenter using a computer, drivers reached for each of the controls while operating a driving simulator. Problems drivers had in using their own design were reviewed with them and drivers were allowed to change their preferences.

There was no predominant reason why drivers preferred particular locations for controls. Familiarity/expectation was the most common reason (just under one out of five responses). In fact, sometimes people did place switches in locations matching those in their own car. Other reasons often cited included handedness (balancing the workload across hands) and frequency of use. These ideas--putting controls where people expect them, balancing the workload across the hands, and putting the most frequently used controls closest to the driver--are established human factors principles.

For switches, the most common reason was again familiarity/expectation. Other reasons included aesthetics (it looks nice), clear labelling, and lastly, actuation forces (properties of operation). Switch sounds, thought by many in industry to be an important characteristic, were rarely mentioned. Unlike location selection, people usually did not pick switches that were similar to those in their own cars.

Switches mounted on pods in the pod control study were redistributed to a wide variety of locations. For example, in sedans, there was a greater preference for dome light switches on the roof, hazard switches on the column, and washer switches on a stalk.

Finally, driver characteristics had almost no influence on driver preferences for control locations or switches. While there might have been male/female differences, the small sample size puts the results of the statistical test in doubt. Experience with particular types or numbers of vehicles had no impact on driver decisions.

Surprisingly, people with larger torsos (greater standing height, seated head height, seated eye height) were more likely to prefer switches that required grasping than people with shorter torsos. In contrast, anthropometric measures were unrelated to where drivers wanted switches.

Key Findings

Driver preferences for the functions examined are shown below.

Table 1. Summary of Preferences for Conventional Instrument Panels

Function	Pooled Zone (%)	Switch & Motion (%)
Cruise On/Off	Spokes (46) (right preferred) Stalks (20) (left preferred)	pushbutton/surface - push in (24) rocker - push in (22) stalk - push right (11)
Cruise Set	Spokes (57) (right preferred) Stalks (28)	pushbutton/surface - push in (35) stalk - push right (15)
Dome Light	Center Ceiling (26) Front Ceiling (26) Low, L Panel (24)	rocker - push up (11) pushbutton - push up (9) push-pull (15)
Front Washer	Left Stalk (30) Right Stalk (28)	stalk -push right (22) stalk - push left (13) stalk - pull out (11)
Front Wiper	Left Stalk (30) Right Stalk (28)	stalk - twist + & - y (28) stalk - twist + & - y (19)
Hazard	Column (33) Low, L Panel (24)	rocker - push down (9) rocker - push in (14)
Headlights On/Off	Low, L Panel (50) Left Stalk (24)	push-pull (24) pushbutton (11) stalk - twist + & - y (24)
Ignition	Column (61)	key - twist +&-Y (63)
Panel Brightness	Low, L Panel (56) High, L Panel (20)	push-pull - twist + & - x (17) knob twist + & -x (13) no clear preference

Implications for Future Vehicle Design

If preferences are the sole basis for selecting switches and locations for controls in sedans, then these data indicate the cruise controls should be on the steering wheel hub (rocker or pushbutton for on/off, pushbutton for set), the wiper and washer functions should be stalk-mounted, the hazard switch should be a rocker on the column, the ignition should be on the column, the panel brightness and headlights should be located low on the left side of the instrument panel, and the dome light should be a rocker switch on the ceiling, although a lower left panel location (using a push-pull rotary switch) could also be considered.

In most cases preferences were not clear cut. Most locations were preferred by less than half of those responding, and those preferences are for common controls. When switches were included, the most preferred combination was selected by only one out of four people. However, a clear message that came from driver comments was that instrument panels should be designed based on established human factors principles. Those principles should be considered in concert with the preferences described here.

PREFACE

This report is one in a series being sponsored as part of a project entitled "Automobile Driver Controls -- Human Factors Considerations." This research was funded by the Chrysler Corporation through the Chrysler Challenge Fund. The purpose of the Fund is to establish closer ties between the Chrysler Corporation and leading American universities, and to promote direct access to the advanced technologies being developed in universities. It also aims to increase interaction between the Chrysler engineering staff and university research personnel, and to increase undergraduate and graduate student awareness of the engineering opportunities available at the Chrysler Corporation.

The authors would like to thank Steve Goldstein for his considerable help in preparing switches, testing participants, and report preparation. They also wish to thank John Boreczky of the UMTRI Human Factors Division for his help with many aspects of this project, and Guy Gattis of UMTRI for technical editing suggestions. Photographs contained in this report were taken by Kathy Richards of UMTRI. The authors would also like to thank Ken Socks and Scott Baker of the Chrysler Corporation for serving as project liaisons.

INTRODUCTION

Background

This report concerns the design of secondary controls such as switches for the windshield wipers, headlights on/off, and so forth. Customers want those controls to be easy to use. To provide information engineers and designers need to achieve that goal, the Chrysler Corporation has supported a series of studies at the University of Michigan Transportation Research Institute concerning that topic. Specifically, this report examines the types of switches drivers want for secondary controls, where drivers want them, and how they want them to operate. It also examines the reasons for those preferences.

There were three reports in the previous initial effort. The first report (Turner and Green, 1987) reviews every document in the open literature (except for one recent discovery, Okada, Tsuda, and Kurata, 1985) concerning human factors and the design of secondary controls. Over 40 documents are examined in detail in that 306 page report. Topics covered include:

- What expectancies do drivers have for controls?
- What control designs do people prefer?
- What problems do drivers say they have with controls?
- What do the driver performance data show?
- How have human factors analyses been used to design controls?
- How should specific controls be designed?

Distributed throughout that report are several documents that concern preferences or expectancies for control operation. While those studies are briefly summarized in the section that follows, readers are encouraged to retrieve the Turner and Green (1987) review for additional details.

The second report in the series (Green, Ottens, and Adams, 1987) describes a survey of 1986 model year cars. A total of 236 cars were examined, representing 90% of the new car models sold in the United States for that model year. Switch types, locations, method of operation, and labelling were recorded for 31 secondary controls. Thus, this report catalogs contemporary design practice.

The third report in the series (Green, Kerst, Ottens, Goldstein, and Adams, 1987) identifies the results of an initial study concerning driver preferences for secondary controls. A total of 103 drivers sat in a mockup of a sports car with a "pod-like" Velcro® covered instrument panel. While a transmission shift lever was not provided, the configuration of the car led drivers to believe it would be mounted on the transmission hump.

Drivers designed instrument panels by placing switches they preferred for 24 functions in the locations they desired. There were 255 switch designs (stalk controls, pushbuttons, etc.) to choose among. Drivers also identified the motion

used to operate each control and provided comments. When the panel design was complete, drivers reached for each control while operating a driving simulator. The development of the test procedure, the "Potato Head" method, was a major contribution of this experiment. This name has been used because of the similarity of how children play with a toy (using parts representing eyes, ears, and so forth to construct a face on a potato) and adults build an instrument panel (by placing switches on a surface resembling a production car).

The results from the first preference study were grouped by control, each having four pages associated with it. The first page contained text describing preferences. Associated with the text and appearing on subsequent pages were figures showing the preferences for location, switch type, and method of operation. For each function, only the overall preferences for method of operation were given (e.g., for the front windshield washer, 45.6% thought the switch should be pushed into the instrument panel). However, the motion that is preferred very much depends on the type of switch chosen (e.g., rocker switch vs. stalk) and its location (on the panel face vs. its left side). Examining that question was not part of the charter for that project. A summary of the preferences follows.

Table 2. Summary of Preferences from the Previous Experiment

Function	Preferred Location
Auditory Horn	Steering wheel zones
Beam Select	Left stalk
Climate	Center console
Cruise switches	Steering wheel zones
Dome Light	Ceiling zones
	Below pods
Front Washer	Right stalk, left stalk, right pod
Front Wiper	Right stalk, left stalk, right pod, below pods
Hazard	Switch below pods
Headlights On/off	Left pod, left stalk, zones below pods
Ignition	Right side of column
Optical Horn	Zones below pods
Panel Brightness	Zones below pods, left pod
Power Door Lock	Driver's door armrest
Power Seat	Lower left side of driver's seat
Power Windows	Driver's door armrest
	Center console
Radio	Center Console
Rear Defrost	Upper portion of center console, right pod, below pods
Rear Washer	Upper sections of center console, right pod, below pods
Rear Wiper	Upper sections of center console, right pod, below pods
Steering Adjust	Dash below pods
	Steering wheel
Suspension Adjust	Below pods, low on center console
Turn Signal	Left stalk

Those preference data were examined in greater detail in Green and Goldstein (1989). In particular, Green, Kerst, Ottens, Goldstein, and Adams (1987) presented mostly univariate and bivariate statistics. (For example, for the wiper function, how often was a stalk control preferred?) Green and Goldstein take the

analysis one step further (e.g., For the wiper control, how often is each particular type of switch preferred as a function of location. For those switch /location combinations, what motions do drivers prefer to use to operate the switches?) Those questions were examined for nine secondary functions examined in the initial preference experiment for which there was not an overwhelming consensus: beam flash (optical horn), beam select, cruise on, cruise resume, cruise set, front wiper, front washer, headlights on/off, and panel brightness.

Research Issues

There are two shortcomings with the previous preference studies. First, they do not examine why particular switch types, locations, and methods of operation were preferred. Without that information, the automotive industry will be faced with supporting a never ending series of studies to identify driver preferences for controls for every possible instrument panel shape and package geometry. By providing reasons for preferences, some rules should emerge that will allow engineers and designers to generalize beyond the specific data collected.

The second shortcoming is that the effect of shift lever location was not considered. Because of the package geometry of the 1985 Chrysler Laser mockup in the initial preference experiment, it is believed that participants assumed the shift lever would be floor-mounted. There clearly was space available for it in that location but not on the column. The shift location issue was discussed while that experiment was being designed but the sponsor decided not to explore it at that time.

While both of these issues could have been explored at an earlier time, adding them in would have made the experiment so complex that it would have been difficult to manage. As a consequence, costs would have risen considerably.

The research described in this report was originally intended to answer two questions:

1. **How does the location of the shift lever affect driver preferences for controls and switch designs?**

2. **Why do drivers prefer particular switch designs and locations for controls?**

The original plan called for simply replacing the steering column from the previous study with one with a shift lever (for an automatic transmission car) and making no other changes to the mockup. However, the sponsor (Chrysler) later decided they were more interested in preferences for a conventional instrument panel found in a sedan. Therefore, it was decided to replace the bucket seat used previously with a bench seat, remove the pods used as mounting surfaces for controls, and remove the center console. With these changes is was no longer possible to explore the effect of shift lever location alone. Further, it was also decided to try to collect additional data on participants to see if it was possible to predict driver preferences for controls from a description of them. Hence, this study explores the following questions:

1. **Where do drivers want controls in sedans? What types of switches do they want? What methods of operation do they prefer?**

2. **What reasons do drivers give for their preferences?**

3. **How do the preferred locations and switches differ from the controls in participants' cars?**

4. **How do preferences differ for controls on pod-based versus conventional instrument panels?**

5. **How do driver characteristics (i.e. sex, age, stature, etc.) influence their preferences for locations and switches?**

TEST PLAN

Test Participants

A total of 54 licensed drivers, 27 men and 27 women, ranging in age from 19-77, participated in this experiment. Specifically, nine men and nine women were selected within each of the following three age groups: 18-29 years, 30-54 years, and 55-77 years. All completed the experiment satisfactorily and no data was deleted.

As requested by the sponsor, only people who drove a 1985-model year or later vehicle as their primary means of transportation were tested, though one person who drove a 1982-model car slipped through the screening process. (See Appendix A for a complete listing of the vehicles participants drove.) This makes the sample used in this study somewhat different from that in Green, Kerst, Ottens, Goldstein, and Adams (1987) and Green and Goldstein (1989). (In that study there were no constraints on their vehicles.)

Because the effect of body size was potentially thought to be related to control placement, an effort was made to select participants uniformly from ten height percentiles, each of which represents ten percent of the adult population. This was also a change from the previous research. (In fact, considerable anthropometric data, along with information concerning their experience with a wide variety of vehicles was recorded. It is summarized in Appendices B and C.)

Most drivers were recruited from lists generated by previous studies of the UMTRI Human Factors and Biosciences Divisions. Some were recruited from flyers handed out at the College of Engineering and by word of mouth, especially for the people in the youngest age group.

The majority of people participating in this study lived in the local Ann Arbor-Saline-Ypsilanti (Michigan) area. The combination represents a broad socio-economic mix of well-educated professionals, blue-collar factory workers, and farmers. The sample included a pharmacy worker, a free-lance artist, an automotive engineer, three teachers, a bus driver, a secretary, a photographer, a nurse, a printer, and one person who claimed to be a "retired housewife." The authors want to emphasize that while the experiment was conducted at the University and while there were a few students in the sample, the overwhelming majority of the sample were <u>not</u> students. As a result, this group should be considered a reasonable sample of the U.S. adult population.

Finally, participants were paid $15 for a session, which typically lasted an hour and a half. All subjects (except two-- #5 and #45) were videotaped during the portion of the experiment where they were seated in the mock-up. A person was videotaped only when he or she gave written consent. These tapes were useful records of each session's data collection. One participant (#45), whose entire session was videotaped was paid $20 since her session lasted approximately two hours. This full-length videotape was intended to be a record of a typical participant's experience.

Test Equipment and Materials

The general arrangement of the equipment used in this experiment is shown in Figure 1 and described below. There was a mockup of a sedan, a collection of nearly 1000 switches, a computer system for data acquisition, another computer system to run the driving simulator, two video cameras, a video recorder and monitor system, and other miscellaneous items.

1985 Chrysler Laser Mockup

All tests were conducted with the driver seated in an A to B pillar metal mockup of a 1985/86 Chrysler Laser, modified to represent a sedan Chrysler is designing. Figure 2 shows two pictures of the mockup. Figures 3 and 4 contain the dimensioned drawings.

The car had a finished interior which included a tilt-column steering wheel, an automatic transmission lever, and a bench seat. It should be noted the mockup was fitted with standard three-point restraint unit, a dome light, and two functional foot pedals. (In Green, Kerst, Ottens, Goldstein, and Adams, 1987, a non-tilt steering wheel was used instead of a tilt-column, bucket seats were used instead of a bench seat, and a floor-mounted shift lever was assumed. Furthermore, in the 1987 study, the lower portion of the center console was present. All of these modifications were made at Chrysler's request.)

One Sears model #3950 1/2" drill chuck was mounted on the left side of the column to accept and allow for movement of any size stalk control. A custom-designed bracket was used to allow for placement of a stalk control on the right hand side of the steering wheel. The steering wheel was linked by ropes to bungee cords, giving the system a spring-centered feel.

Switches

A collection of 245 different switches was painstakingly prepared for use as secondary controls in the initial preferences study (Green, Kerst, Ottens, Goldstein, Adams, 1987). Multiple copies of some switches were provided so that the same switch design could be used for several different functions. Most of these switches were taken from interesting designs uncovered in the survey of 1986 cars (Green, Ottens, and Adams, 1987), though several were unique prototypes. For example, a collection of push surface switches were created in various shapes (arrows, squares, the arc of a wiper sweep) to allow drivers to choose futuristic switches.

In order to guarantee adequate hand/finger clearance between the switches and to avoid inadvertent operation, most switches were mounted on plexiglass bases. Bases were sized so that switches would have hand/finger clearances between them recommended in Military Standard 1472C (1 inch between hand-operated controls (knobs), 1/2 inch between finger-operated controls (buttons and rocker switches). In each case it was assumed the clearance would be split between adjacent controls, so knobs had 1/2 inch skirts and buttons 1/4 inch skirts. The Velcro® backings were glued onto those skirts so the switches could be easily placed on the Velcro® surfaces within the vehicle mockup.

Most of the switches were identical to those used in the initial control preferences study (1987). Twelve switches originally used were deleted while two

new switches were added to the selection of switches used in the present experiment. Only 107 of the 245 styles of switches were actually selected and used by people in this experiment. Styles not selected are indicated in the complete switch listing which appears in Appendix D.

Four large boards were used to hold the switches. The boards were positioned in and around the vehicle so that the participant could reach the entire collection of approximately 1000 switches. (See Figure 5.) The largest switch board (Figure 6), located by the driver's door, had an extensive collection of rocker switches, thumbwheels, knobs, and stalks. A second switch board (Figure 7), positioned on the passenger seat and leaning against the passenger's door, contained a large collection of push surfaces, and push buttons. A third, smaller board, on the dashboard above the console (Figure 8), contained various forms of slide switches. Another smaller board, the fourth, located on the seat next to the driver, contained push-pull switches, toggle switches, paddle switches, and other miscellaneous switches. A fifth board containing the secondary control function labels, information about the questions to be answered about each function label, along with a one-page list of reasons to aid in defining vague responses, was located directly in front of the participant.

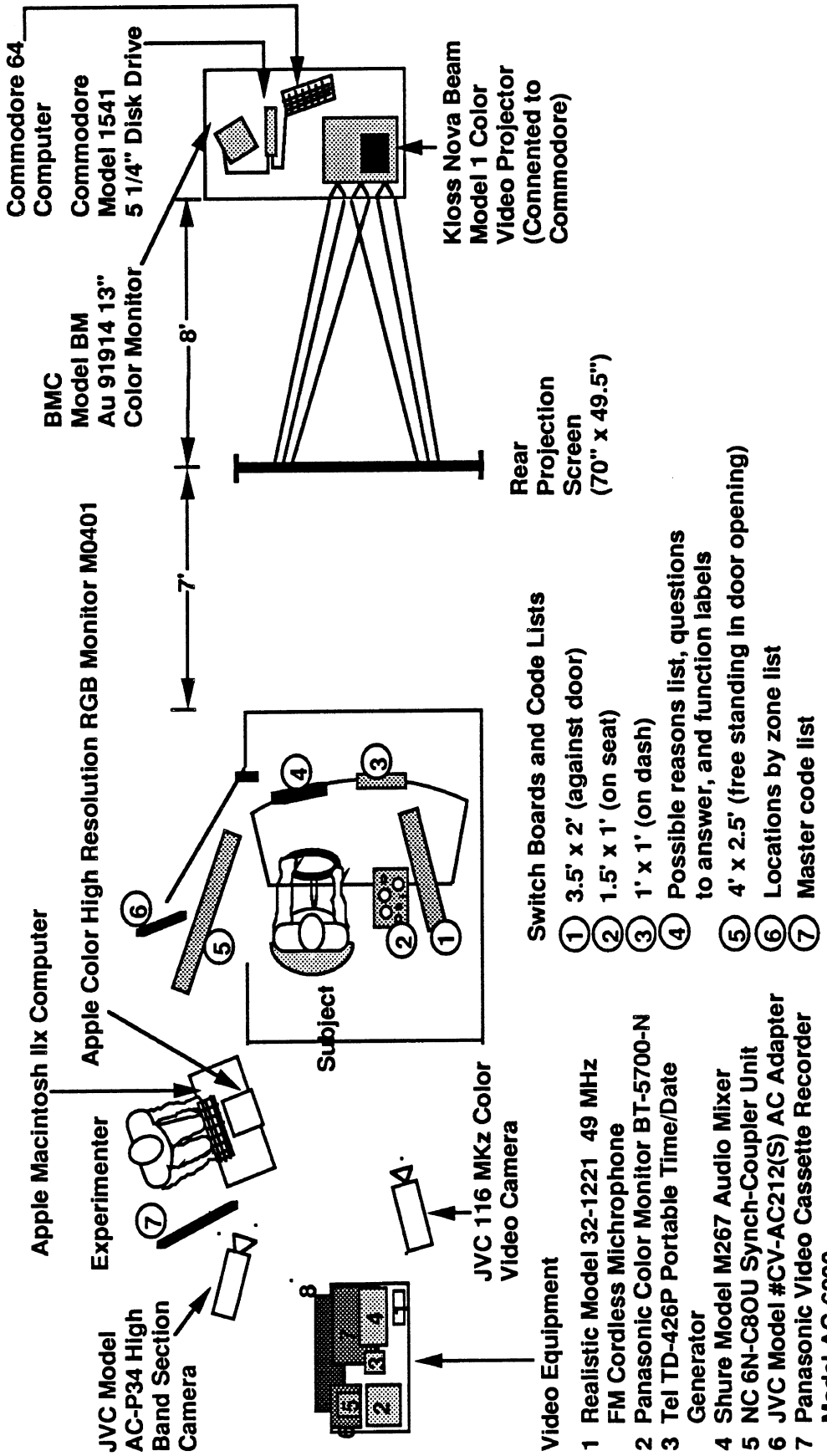


Figure 1. General Arrangement of the Test Equipment

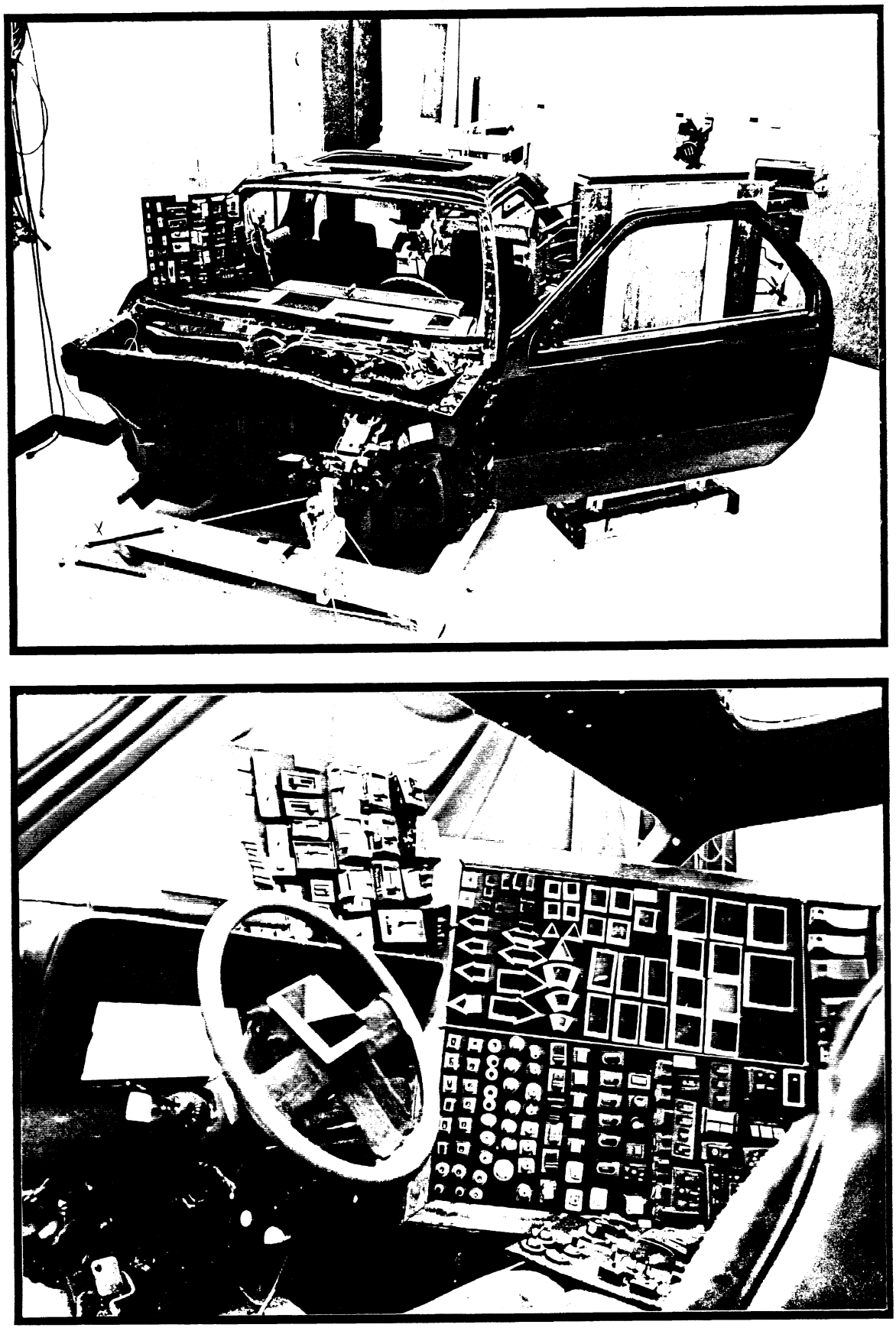


Figure 2. Pictures of the Chrysler Mock-up

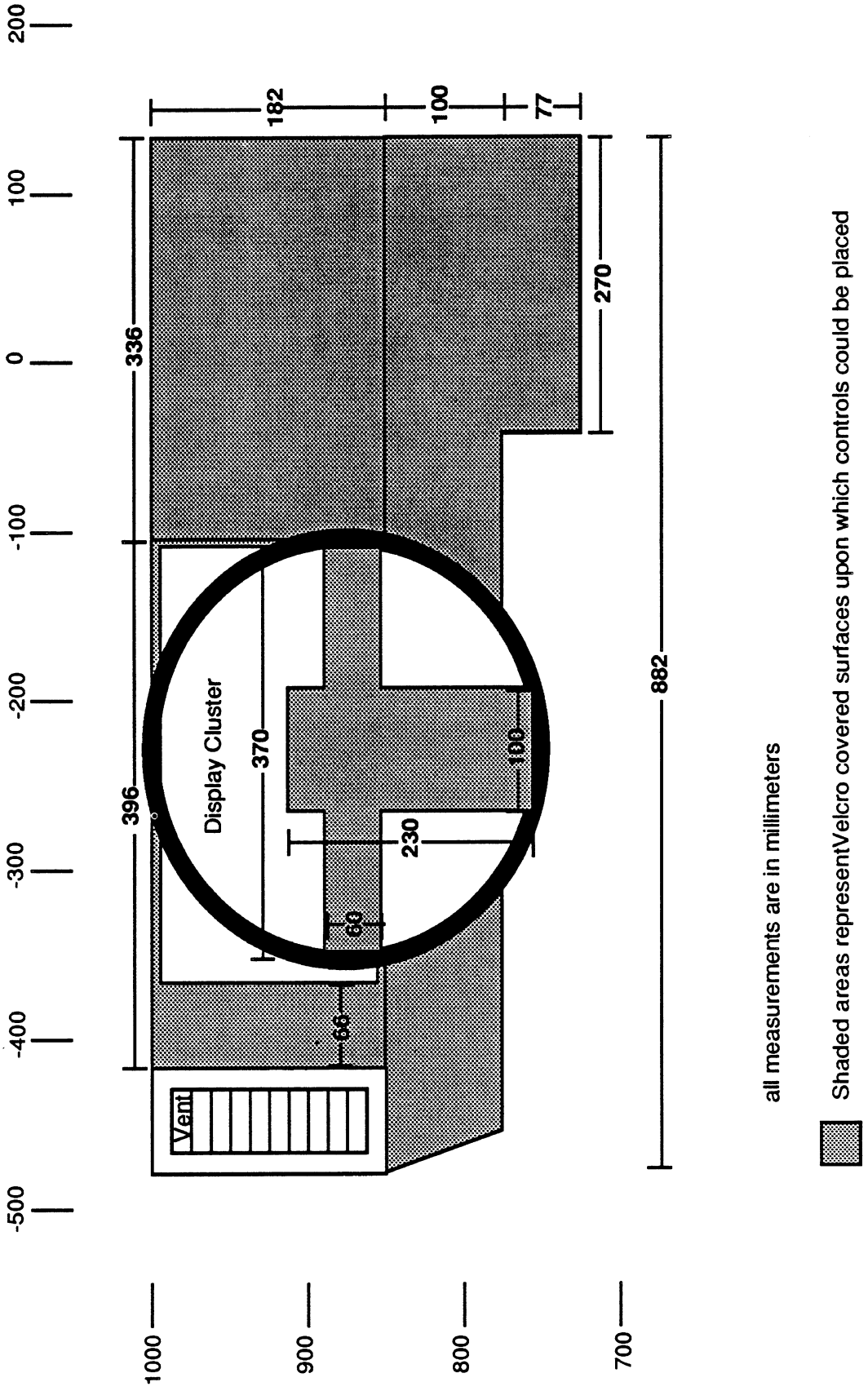


Figure 3. Front View of the Sedan Instrument Cluster

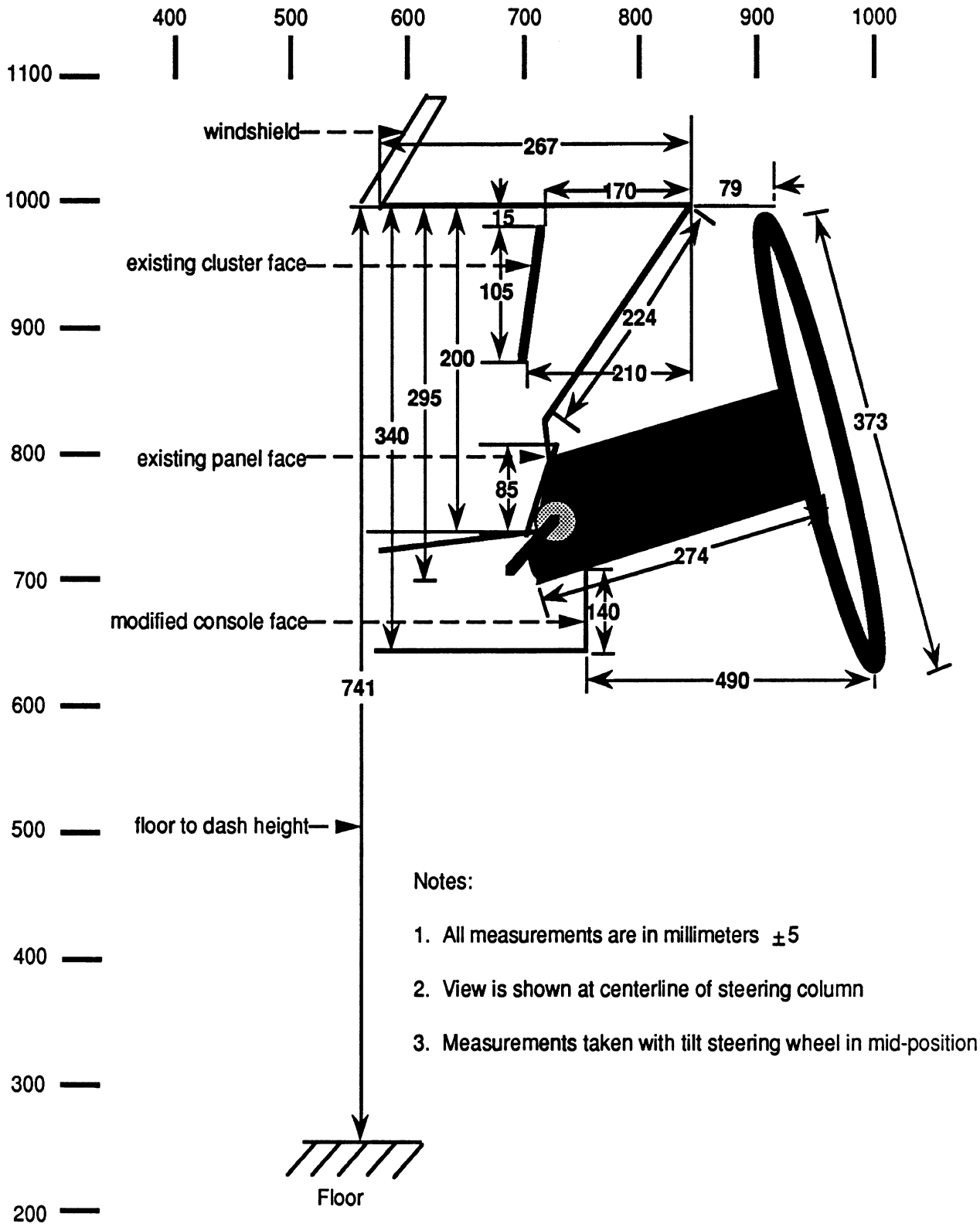


Figure 4. Side View of the Sedan Instrument Cluster

Figure 5. Driver Surrounded by Switches

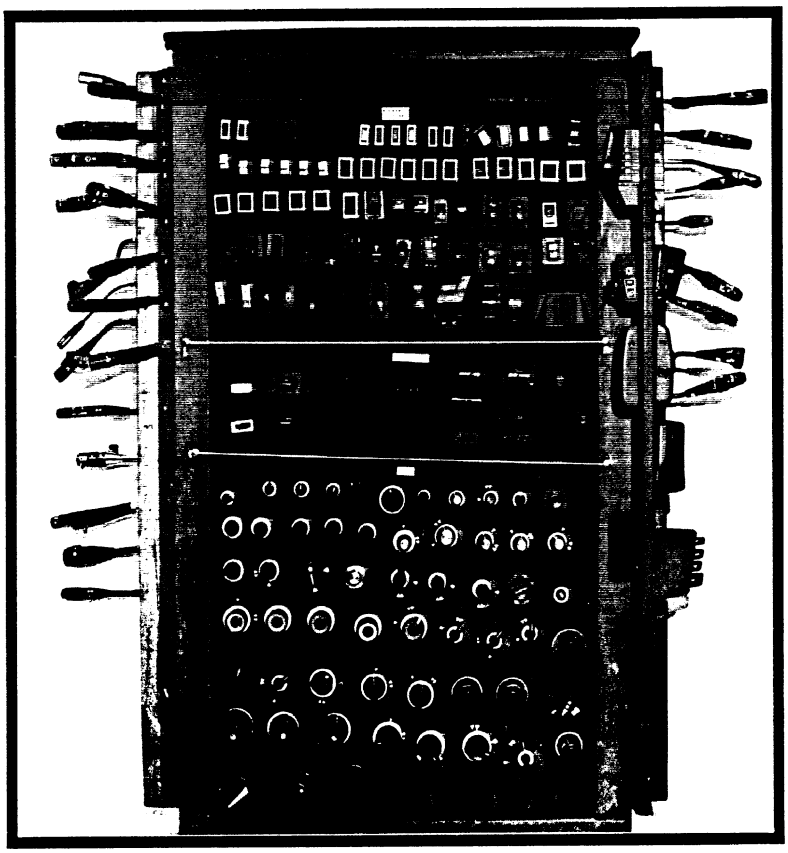


Figure 6. Large Switch Board

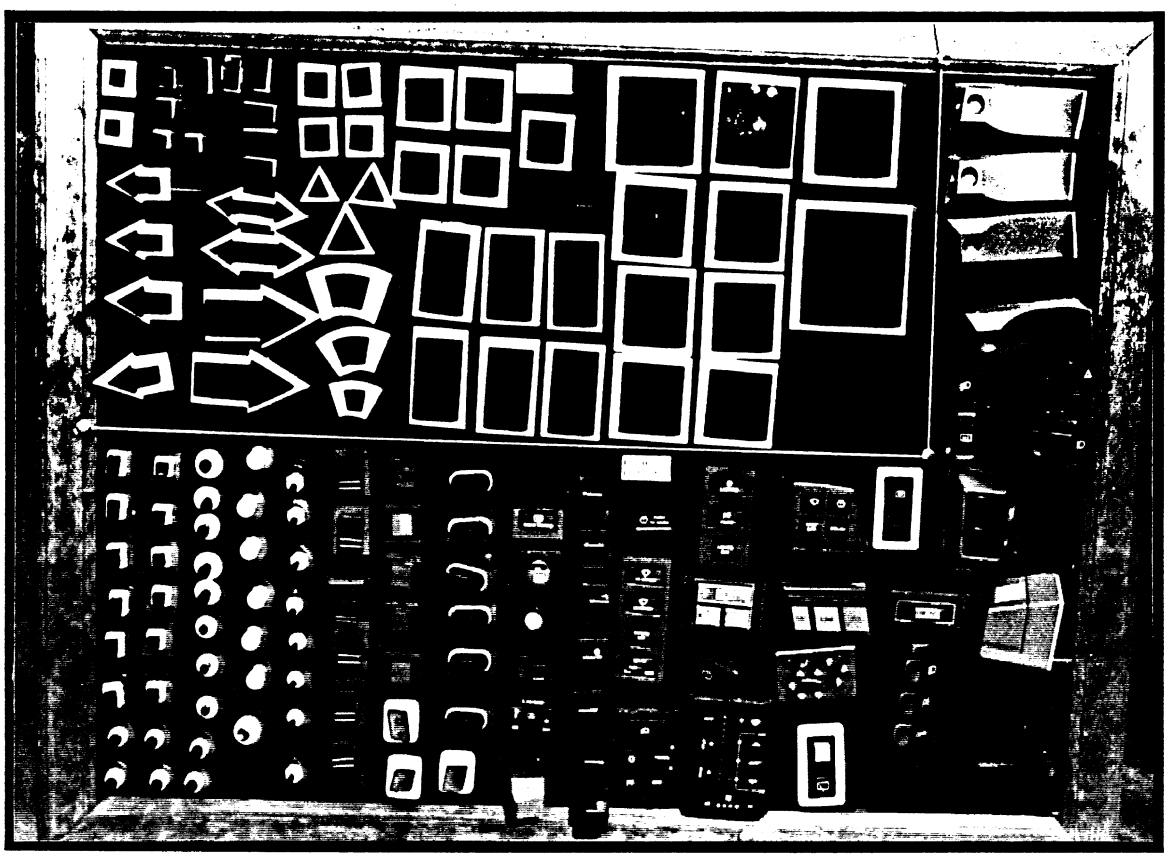


Figure 7. Medium Switch Board

Figure 8. Small Switch Board

Computer for Recording Preferences

The experimenter recorded the participant responses (preferences for each switch, its location, its method of operation, and the reasons for each) on a Macintosh SE computer for participants 1-3 and 5-8. Because the software ran too slowly on the SE, responses for other participants were recorded using a Macintosh IIx computer with an Apple color monitor. A custom routine written in HyperTalk for the HyperCard environment was used on both the Macintosh SE and IIx. Figure 9 shows a sample screen in which data for the Cruise Control On/Off function has been entered. In real time, the software caught many errors made by the experimenter (entering nonexistent zone numbers and method of operation codes, mismatches between switch type and number, etc.) This quality control procedure made the computer-assisted data collection considerably less error-prone than using a paper and pencil method. In addition, this software was much easier to use than the software for the initial experiment, and had additional error-checking.

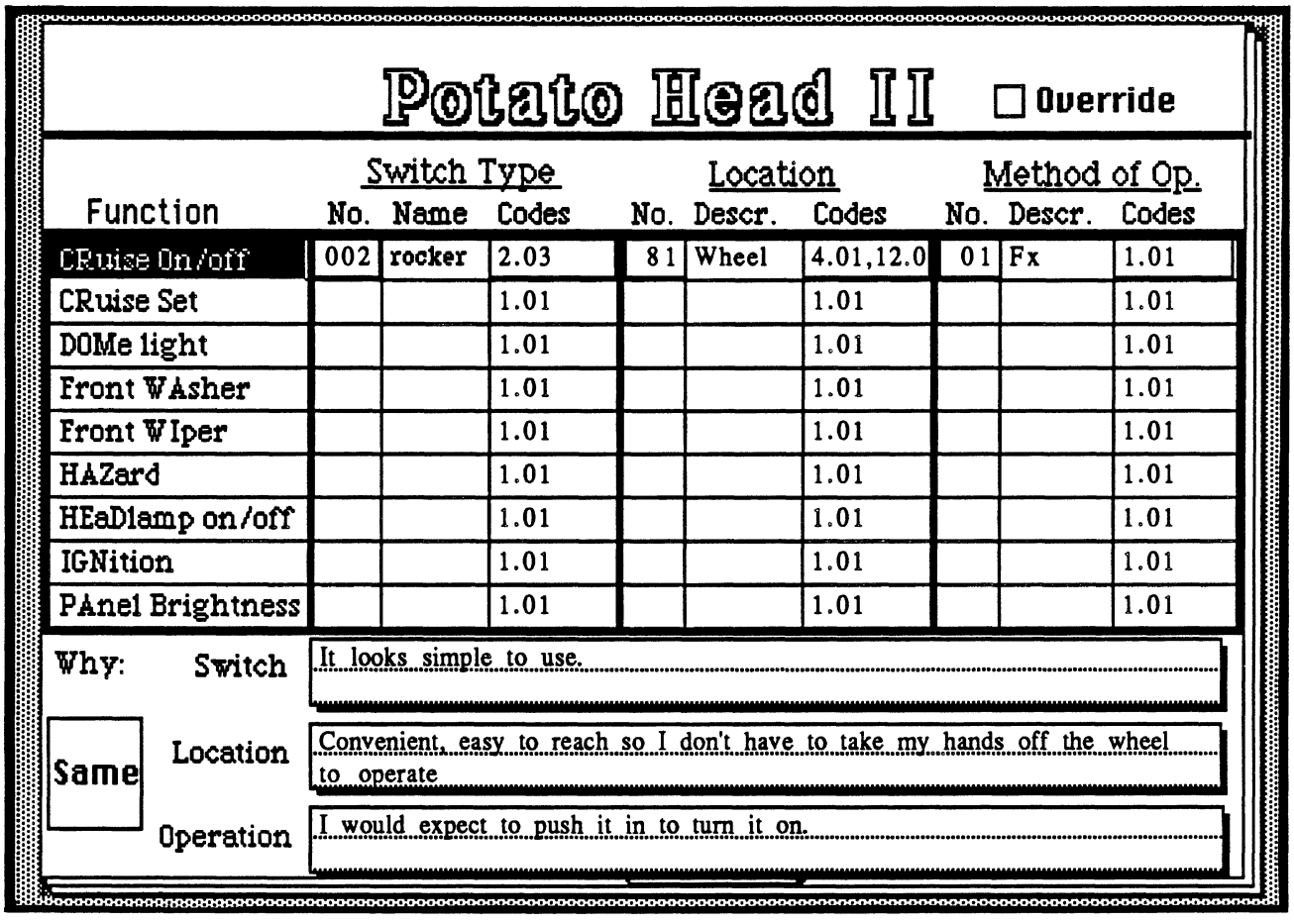


Figure 9. Sample Screen Used in Data Collection

Coding Forms

A Master Code List was placed next to the Macintosh computer to help in the data entry procedure. This Master Code List consisted of a Zone Diagram, a Method of Operation Table, and an Experimenter's List of Reasons.

To create the Zone Diagram (Figure 10) the interior of the mockup was partitioned into several regions, and each region was further partitioned into many zones. The partitioning followed a standard method adopted from Malone et al. (1972). The same basic scheme has subsequently been used by Anacapa Sciences (1976) and Friedman and Schmidtz (1981). These zones are also identical to those used in the survey of secondary controls of 1986 production cars (Green, Ottens, and Adams, 1987) and the initial study of driver preferences (Green, Kerst, Ottens, Goldstein, and Adams, 1987).

The primary regions included: left panels (locations 4, 5, 6) lower left panels (locations 7, 18, 19), right panels (locations 10, 11, 12), lower right panels (locations 9, 20), console (locations 31-36, 41-46), steering column (locations 24-27), ceiling surfaces (locations 61-78), stalks (locations 26, 27), and the steering wheel surfaces (locations 81-85). All locations were covered with Velcro® so that switches selected during the experiment could be mounted quickly and easily.

In this study, zones 1-3 and 13-17 were not used because they represented the side and underneath portions of a pod design, which was not present in the instrument panel for this study. Likewise, zones 47-53 were not used because there was no center console extension on which switches could be mounted. Also, the door panel and lower seat surfaces were not used by any participant as they were blocked by the large switch board.

The Method of Operation Table (Table 3) identified the direction of the force or torque participants used to operate a control. It should be noted that all directions were *relative to the vehicle* and not the specific surface on which a control was to be mounted. The Method of Operation Table (Table 3) and associated figure (Figure 11) were derived by applying the right-hand rule for a driver seated in the mockup.

The right hand rule was applied to twisting motions (typically knobs or stalk switches) through torques around the appropriate axes. This was determined by curving the fingers of the right hand in the direction of the motion desired. The resulting axis was that on which the right thumb pointed in accordance to the curving fingers. (e.g. twisting a stalk toward the front of the car would point the thumb to the left, corresponding to the y-axis in Table 3) This was recorded as a twist right/left (+/- Ty) motion since it was a torque around the right/left (y) axis.

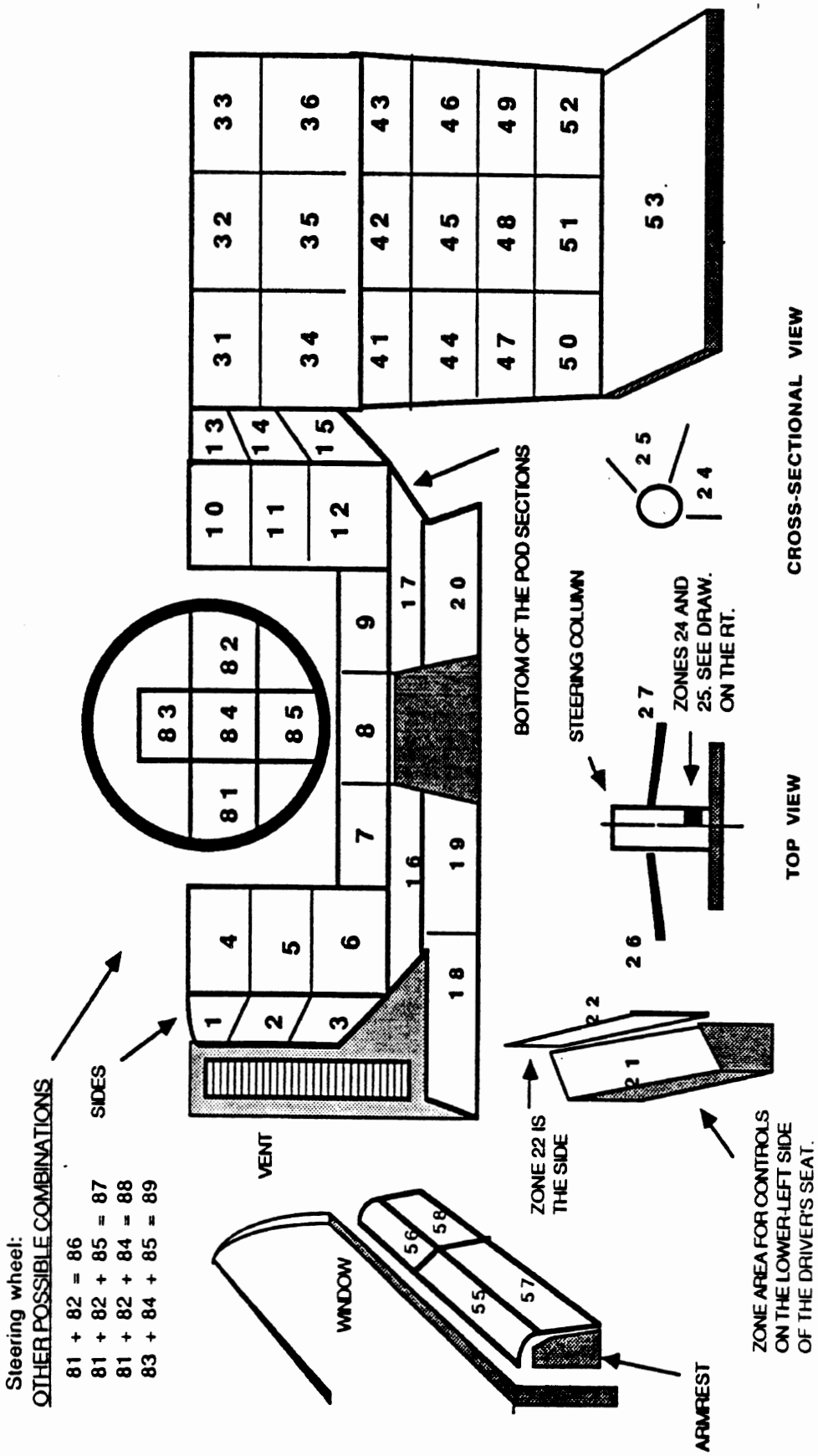
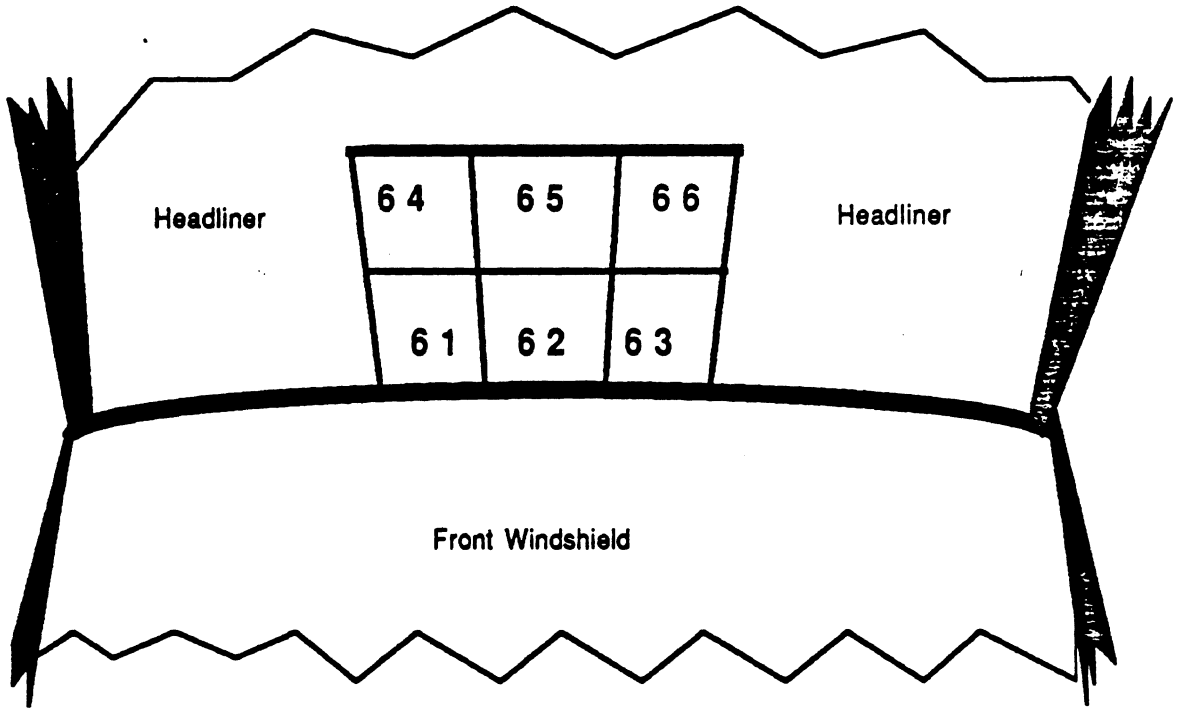


Figure 10. Locations Where Controls Could Be Mounted

The Front Dome Light Switch Locations



The Rear Dome Light Switch Locations

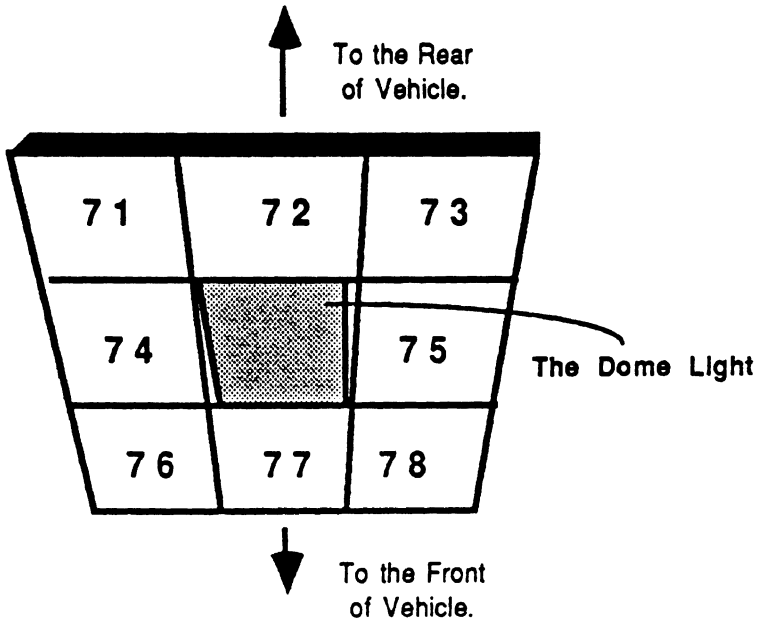


Figure 10 (continued). Locations Where Controls Could Be Mounted

Table 3. Method of Operation Codes

# Vector Motion Name	# Vector Motion Name
1 Fx push in	13 Tx twist in
2 Fy push right	14 Ty twist right
3 Fz push up	15 Tz twist up
4 -Fx pull out	16 -Tx twist out
5 -Fy push left	17 -Ty twist left
6 -Fz push down	18 -Tz twist down
7 +/-Fx push in/pull out	19 +/-Tx twist in/out
8 +/-Fy push right/left	20 +/-Ty twist right/left
9 +/-Fz push up/down	21 +/-Tz twist up/down
10 Fx&y push/pull in/out, left/rt.	22 Tx&y twist in/out, left/rt.
11 Fx&z push/pull in/out, up/down	23 Tx&z twist in/out, up/down
12 Fy&z push/pull left/rt., up/down	24 Ty&z twist left/rt.,up/down

25 force not along axis
26 torque not along axis
27 multiple (twist & push)
99 not fitted

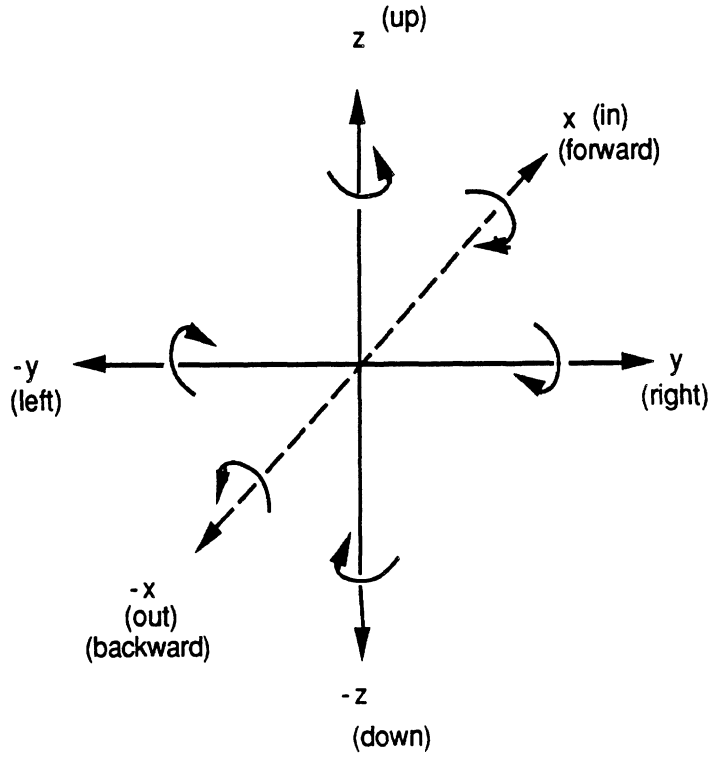


Figure 11. One Directional Operating Codes

List of Reasons

The original list of reasons was developed by experimenters, who were familiar with comments made by participants in the first UMTRI preference study ("Potato Head I"). The developers were also familiar with other literature on the subject. The list was compiled by asking several people to describe any reasons they could think of as to why a person would choose a particular switch/location/ method of operation. The list was modified based on data from several pilot subjects. Throughout the experiment, there was an "other" category to handle any responses considered unique and not represented on the list. The experimenters' list is shown in Table 4.

The participants were given a similar but abbreviated one-page list. (See Table 5.) This list helped participants express why they preferred particular switches, locations, and methods of operation. The need for a list and what form it should take was explored in pilot studies. When no list was provided, people were vague in their initial responses ("I like it", "It's simple", "It's easy to use") These responses were too general to be useful. It was evident from the discussions with participants that they had more specific reasons in mind ("I want to operate the switch with my right hand without removing my hand from the steering wheel.") but had trouble in expressing them. When the full list (the experimenter's list) was provided, participants found it to be overwhelming. Experience showed that providing the abbreviated list but not pushing participants to use it helped stimulate thinking without leading them too much.

Table 4. Experimenters' List of Reasons

1. **Familiarity/Expectation**
   - .01 That's the way it is in my car
   - .02 I saw it in a friend's car
   - .03 I would expect it to look like this/be here
   - .04 I expect up/right/clockwise to be "ON"
   - .05 Convenient *****note why or other reasons*****
   - .06 I have a similar switch in my home/office/other like that
   - .07 It's usually like that although it's not what I expect
   - .08 Everyone knows how to use it
   - .09 That's an industry standard
   - .10 Common/Typical in a foreign country
   - .11 It's a "Car Company" (e.g.Chrysler,Ford) Standard
2. **Aesthetics**
   - .01 I like the way it looks**note why or other reasons*
   - .02 It looks different/hi-tech/fancy/modern/nice design
   - .03 It looks simple/straight forward to use
   - .04 I like a simple layout
   - .05 The instrument panel looks balanced
   - .06 Other areas too cluttered with other controls
3. **Partiality/General Preference**
   - .01 I like that type of switch/location/method of operation *****note why or other reasons*****
   - .02 I don't like any of these switches but this would be the best
   - .03 I like multi-function switches
   - .04 I like ___ switch for ____ application (ie. knob vs. slide for temp. control, etc.) *****note why or other reasons*****

PERSON-PHYSICAL

4. **Body Restrictions**
   - .01 It is an easy motion to make
   - .02 I have a physical handicap which prevents me from operating other types of switches
   - .03 I can't see well, but I know how to operate this/find it there.
   - .04 I have short arms, but I can reach it there
   - .05 Hard to push or turn the other switches that far

PERSON'S OPINION ON SWITCH PROPERTIES

5. **Safety**
   - .01 This is the safest type of switch/location/method of operation.
   - .02 I wouldn't want ___ because I or someone else might be hurt in an accident
   - .03 Those other switches are dangerous
6. **Avoiding accidental use/Inadvertent operation**
   - .01 I don't want to accidentally turn it on/set it off
   - .02 It shouldn't be able to be operated without thinking
   - .03 When I use it, it's important not to make a mistake
7. **Feedback**
   - .01 I should be able to sense when its activated/operated--needs to give good feedback
   - .02 I don't need to know when its activated/operated
   - .03 It should give feedback for intermediate positions
   - .04 It doesn't need to give feedback for intermediate positions

SWITCH

8. **Labelling/Illumination**
   .01 Switch labelling matches proposed function
   .02 It is easy to see/read
   .03 It is well illuminated
   .04 It is easily illuminated
9. **Durability**
   .01 It looks well-built
   .02 These types of switches don't break
   .03 These switches never fail
   .04 It should last because it is so simple
10. **Properties of operation**
   .01 The type of switch/method of operation is a good representation of the actual function
   .02 It should move easily (with little effort)
   .03 It shouldn't be too easy to move
   .04 It is easier to use than ____
   .05 It feels right when you move it
   .06 It should shut itself off
11. **Grasping/Touching**
   .01 I can use it while wearing gloves/mittens

   SURFACE
   .02 The surface is smooth
   .03 The surface is rough
   .04 The surface is rough enough to prevent hand slippage

   SIZE
   .05 It is big enough to easily grasp while driving
   .06 It is big enough to easily locate while driving
   .07 The other switches available are too small
   .08 The other switches available are too big

SWITCH RELATION TO OTHER SWITCHES

12. **Relation to other controls**
   .01 I need to operate it while keeping my hand on the steering wheel
   .02 I don't want to confuse it with _____ control
13. **Part of system** (e.g. radio/windshield washer-wiper)
   .01 and should be same type of switch/location/method of operation
   .02 and should be different than other switches/locations/methods of operation
14. **Sequence of use**
   .01 This other control is used right before/after/simultaneously

PANEL SPACE CONSIDERATIONS

15. **Space Restrictions**
   .01 It's the only place left to put a switch
   .02 It won't stick out and get in the way (due to location/size)
   .03 It fits in the space available
   04 I would have picked a _____ but you don't have one.
   .05 I would have put it somewhere else but I can't do that for this experiment

16. **Handedness/balance of use**
    .01 I can operate/reach it with my right hand
    .02 I can operate/reach it with my left hand
    .03 I can operate/reach it with either hand
    .04 Too many controls being used by the left hand
    .05 Too many controls being used by the right hand
17. **Surface-Orientation Characteristics**
    .01 I want it on a flat surface
    .02 I want it on a vertical surface
    .03 I want it in this general area
18. **Field of view**
    .01 It's easy to see in that location
    .02 I have to see it to use it
    .03 I don't have to see it to use it
    .04 It will stand out and be seen

PROPERTIES OF FUNCTION CONTROLLED

19. **Frequency of use**
    .01 I use that control often
    .02 I don't use that control often
    .03 It's the most commonly used control of a system
20. **Imperativeness of use**
    .01 I use this control in emergencies
    .02 I use this control only when not moving/driving
21. **Time Requirements**
    .01 I need to find it quickly
    .02 I need to operate it quickly
    .03 I need to operate it without thinking

MISCELLANEOUS

22. **No reason/Arbitrary/I don't know**
    .01 Not sure
    .02 Picked it at random

Added during the experiment to the list:

23. Other
    .01 I want a passenger to be able to reach/use it.
    .02 I don't want a passenger to reach it.
    .03 I can feel it in the dark.(category 11)
    .04 The shape lets me know what it is/does.(category 11)
    .05 I'll be able to see the keys if I drop from there.
    .06 It's accessible from outside the car.
    .07 It's a different method of operation than a nearby switch (12.02/13.02)
    .08 It's easy to reach (4.01)
    .09 Gives good precision/accuracy when adjusting (7.01/7.03)
    .10 Don't want to activate the wrong control.(12.02)

Table 5. Participants' List of Reasons

GENERAL REASONS	1. FAMILIARITY	I'm familiar with that. I expect it to be like that. It's convenient
	2. APPEARANCE	I like the way it looks. (simple, modern, fancy, hi-tech)
	3. GENERAL PREFERENCE	I like that switch/location/method of operation. I don't like any of these but this is the best.
BODY RESTRICTIONS	4. MOVEMENT RESTRICTION	It's an easy motion to make. I have trouble with other locations/operating other switches. (because of physical handicap/sight loss)
SWITCH PROPERTIES	5. SAFETY	This switch/location/method of operation is the safest type. I wouldn't want ___ because someone might get hurt.
	6. AVOIDING ACCIDENTAL USE	I don't want to accidentally set it off. It's important not to make a mistake. It shouldn't be able to be operated without thinking.
	7. FEEDBACK	I need to know/don't need to know if it's been actvated. I need/don't need feedback for intermediate positions.
SWITCH CHARACTERISTICS	8. LABELS/ILLUMINATION	It's easy to see/read/illuminate. Switch labelling matches proposed function.
	9. DURABILTY	This switch is durable/won't break. It should last because it's so simple.
	10. SWITCH OPERATION	This type of switch/method of operation represents the control well. It moves easily. It shouldn't be too easy to move.
	11. GRASPING/TOUCHING SURFACE SIZE	I can use it while wearing gloves/mittens. I like the feel of the surface. It's big enough to grasp/locate easily.
RELATION TO OTHER CONTROLS	12. OTHER CONTROLS	I don't want to confuse it with the _____ control. I need to operate it while keeping my hand on the steering wheel.
	13. PART OF A SYSTEM	Therefore, switch/location/method of operation should be the same. Therefore, switch/location/operation should be different.
	14. SEQUENCE OF USE	This other control is used right before/after/simultaneously.
CAR INTERIOR	15. SPACE RESTRICTIONS	It's the only place left to put a switch. It won't stick out and get in the way. It fits in the space available. I would have picked ____ but you don't have one.
	16. HANDEDNESS/BALANCE	I can operate/reach it with my left/right/either hand. Too many controls for the left/right hand.
	17. SURFACE ORIENTATION	I want it on a flat/vertical surface. I want it in this general area.
	18. FIELD OF VIEW	I do/don't have to see it to use it. This type of switch/location will stand out and be seen there.
WHAT THE SWITCH CONTROLS	19. FREQUENCY OF USE	I use that control often. I don't use that control often. It's the most commonly used control of the system.
	20. IMPORTANCE OF USE	I use this control only in emergencies or only when not driving.
	21. TIME REQUIREMENTS	I need to be able to find/operate it quickly or without thinking.
MISCELLANEOUS	22. I DON'T KNOW	Not sure, picked it at random

Driving Simulator

A Commodore 64 computer was connected to a color video projector to generate the simulated road scene. An UMTRI-developed proprietary assembly language program loaded by a BASIC language I/O program generated the road image. A color monitor used with the Commodore computer displayed a duplicate copy of the road scene to the experimenter. Figure 12 shows this arrangement. Those interested in a further description of the software should see Green and Clack, 1988. From the driver's perspective, the simulator was similar to that employed in the previous controls preference experiment. However, a number of changes were made to the user interface to make it easier to operate.

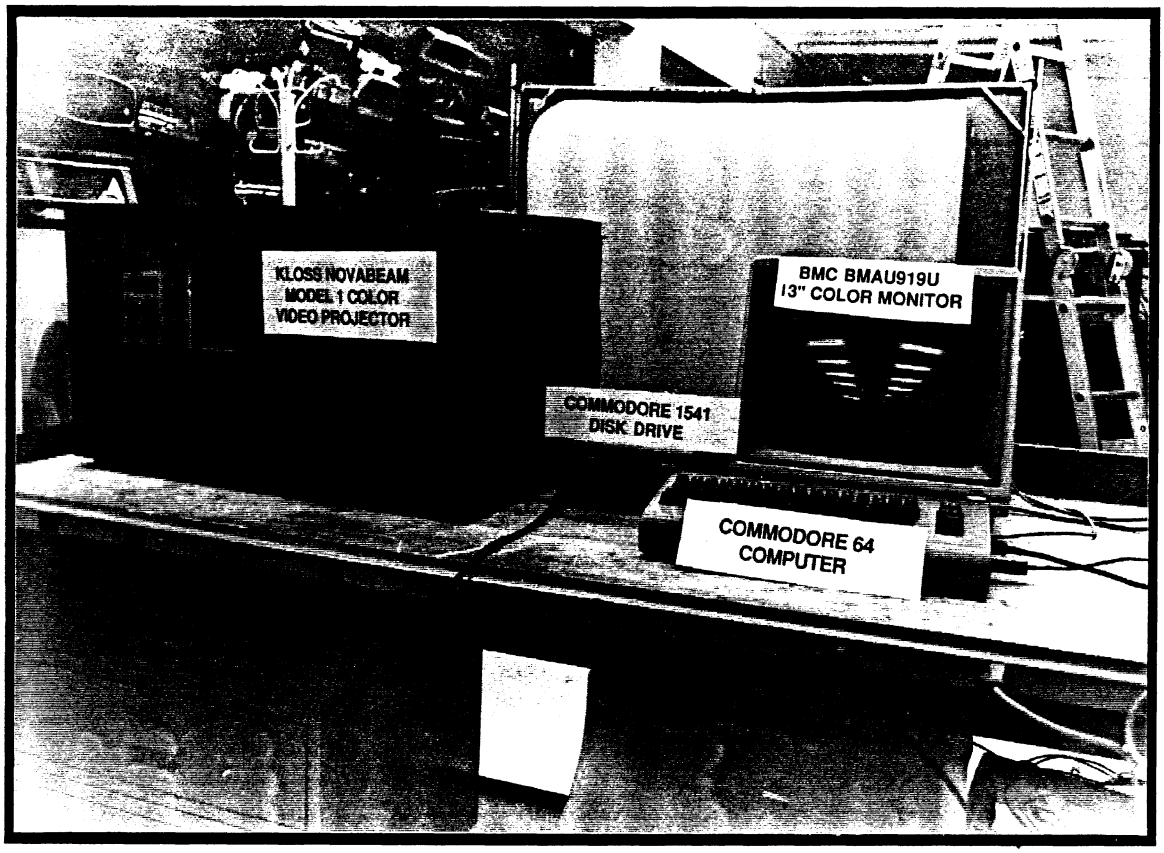


Figure 12. Driving Simulator

The road scene was projected onto a 4 by 6 foot screen in front of the vehicle. Six pairs of rectangles simulated road edge markers for a single-lane road as it would appear at night. (See Figure 13.) A 6 x 9 inch black paper rectangle was attached to the lower center of the screen to eliminate confusion regarding steering of the simulator. This symbolized the car which the driver was steering, making the driving simulator easier for drivers to understand and operate.

The driving simulator portion of the experiment was conducted in a windowless room with the lights off to simulate night driving. Some illumination was provided by a desk lamp with a 25 watt bulb located behind the driver's right shoulder (to provide simulated panel illumination). The experimenter's worklight located behind the screen, and the scatter from the projection video display also provided some lighting.

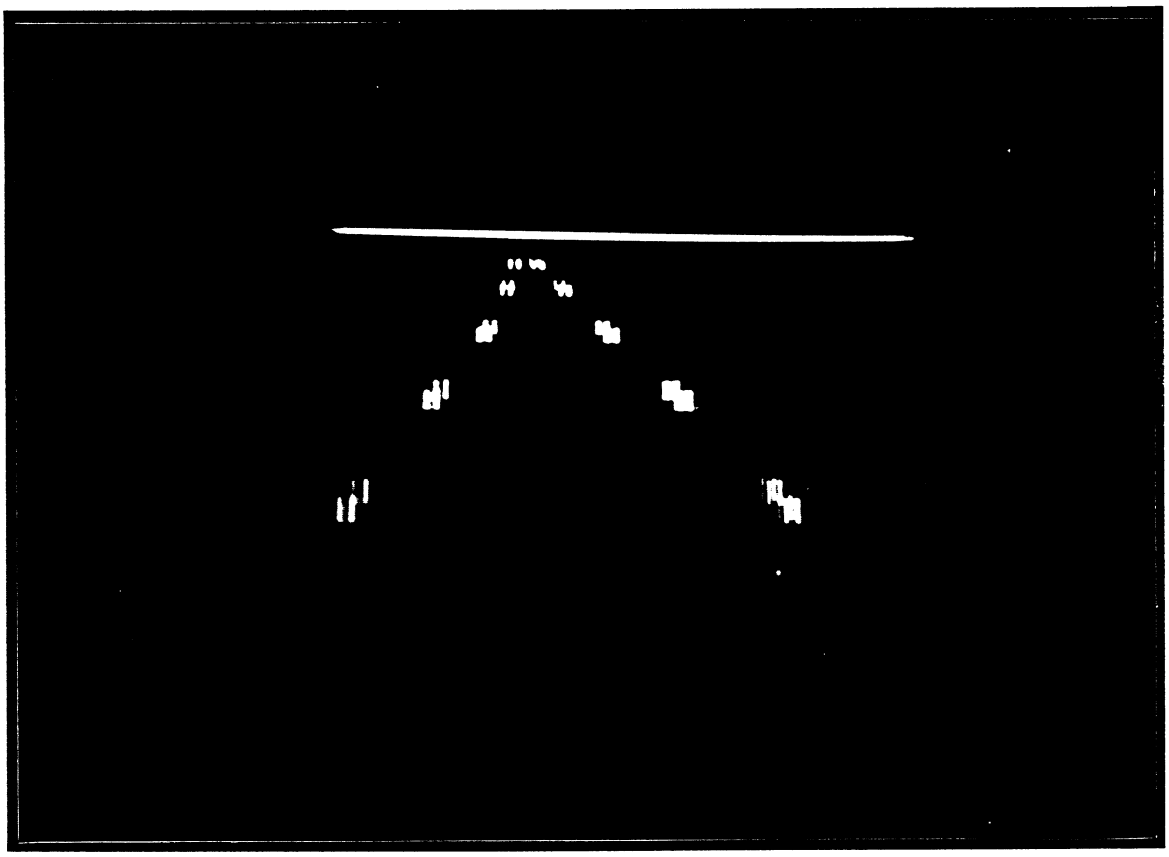


Figure 13. Picture of a Simulated Road

Miscellaneous

The subject was videotaped throughout the portion of the experiment conducted in the mock-up car. A Special Effects Generator enabled a split-screen using two video cameras linked to a synch-coupler unit and powered by an AC adapter. The image was monitored via a color monitor and recorded by a video cassette recorder. A time/date generator showed the time elapsed at the bottom of the screen. Audio was picked up by a cordless microphone on the experimenter and a microphone secured to the dashboard of the mock-up for the participant, both connected to an audio mixer. The equipment (excluding cameras) was mounted on a cart and is identified in Figure 14.

Test activities completed outside the mock-up car began with a vision test conducted on a Titmus Vision Tester (Model OV-7M Orthorater). A near point (14") test was given in which the participant's score represented the finest detail he/she could identify in symbols of decreasing size. The test was performed following the product instructions and equated to a Snellen ratio.

Anthropometric measurements listed in Table 6 were taken for each person using an anthropometer from a GPM Anthropometric Tool Kit. The measurements taken are listed in Table 4. People were weighed using a doctor's scale (Continental Scale Health-O-Meter).

Table 6. List of Anthropometric Measurements

1. Standing Head Height
2. Seated Head Height
3. Seated Eye Height
4. Shoulder-Elbow Length
5. Elbow-Wrist Length
6. Hand Length
7. Index Finger Width
8. Weight
9. Visual Acuity

Test Activities and Their Sequence

Each driver was recruited either by phone or in person using the instructions in Appendix E. One test session was conducted for each driver. Test sessions lasted about an hour and a half. Experimenters were provided with a complete set of written instructions to assure the test procedure was consistent. The instructions described both what the experimenter was to do and say. A copy of these instructions appears in Appendix F.

The experimenter began the session by outlining the experimental procedure, at which time the participant was asked to sign a consent form required by the University. A copy can be found in Appendix G. The participant then provided the background information requested on the form found in Appendix H. This information was useful in identifying the participant's driving experience, types of secondary controls used in other types of vehicles, whether corrective lenses were worn while driving, and whether they had any physical restrictions which would interfere with using controls.

The participant then entered the mockup and positioned the seat as would be comfortable for driving. The seat position was recorded from a ruler attached to the door well. (The position with the seat all the way forward was called zero.) The driver then grasped the steering wheel as they normally would while driving and the clock positions of their hands was recorded.

Next, the experimenter explained the purpose of the experiment and what would be required of the participant during the experiment. Then, the experimenter described the 9 functions selected by Chrysler (Table 7), giving examples of how each control was used if requested.

Table 7. Secondary Controls Tested

1. Cruise Control On/Off
2. Cruise Control Set
3. Dome Light
4. Front Washer
5. Front Windshield Wiper
6. Hazard Lights
7. Headlights
8. Ignition
9. Panel Brightness

The basic procedure used here was identical to that used by Green, Kerst, Ottens, Goldstein, and Adams (1987). In this procedure drivers selected the switches they preferred for instrument panel functions from a large collection of switches and placed them on a Velcro®-covered instrument panel at locations they prefer. This procedure is commonly referred to as the "Potato Head Method" because of the similarity between how children construct faces from parts (eyes, ears, noses, etc.) using a children's toy called Mr. Potato Head (made by Playskool®) and how drivers develop instrument panel designs when given a collection of switches.

While the cost of fabricating a collection of switches and a mockup for "Potato Head" method studies is considerable, the data collection process is extremely straightforward, and participants have no problems in understanding what they are to do. Further, the procedure provides them with an opportunity to exercise their creative energies, which they enjoy, and often identifies control designs, which may be marketable, that no one had ever thought of before. Many participants commented they wished they could do this when buying a new car. For additional discussion of this method, see Green, Kerst, Ottens, Goldstein, and Adams (1987).

In the initial study of driver preferences, drivers were very consistent in identifying where the horn, turn signals, beam select, and beam flashing controls should be located and how they should operate. Since they were unlikely to be affected by shift lever location or other differences between this and the previous study, those preferences were used here. (The horn was a large touch surface in the center of the steering wheel. The other three controls were on the left stalk. These were all clearly labelled so the participant would not forget.) However, participants were told they could combine these functions on another switch or stalk if they wanted. (A generic black stick with a label was all that was provided initially on the left stalk. They were allowed to change it to a different stalk.)

The experimenter identified the various switches available, both verbally and by demonstration. Participants were instructed not to feel restricted to select certain switches due to switch labelling or color (i.e. a red switch labeled "hazard") but to select switches based on their shape and functionality (i.e., a round pushbutton) and that any desired alterations in switch appearance or operation should be reported to the experimenter. Additionally, multiple switches were allowed for one function (i.e., one switch to turn a control on and one to turn it off) and multiple functions could be assigned to one switch.

A list of six questions regarding the selection of each function's location, switch, and method of operation (Table 8) was presented and explained to the participant. Also provided at this time was a list of possible reasons (Table 3) to stimulate responses to the six questions. The participant read the list to become familiar with the ideas. In response to the questions, the driver was asked to first state whatever came to mind, and then refer to the list if necessary. The purpose of the list was to trigger specific reasons behind often general or vague answers (i.e. "It's convenient", "I like it that way"). Both the list of questions, and the list of possible reasons remained in front of the participant throughout the experiment.

Table 8. Six Questions Asked for Each Control

==========

FOR EACH OF THESE FUNCTIONS ON YOUR RIGHT
YOU WILL BE ASKED THE FOLLOWING QUESTIONS:

1. WHICH SWITCH DID YOU CHOOSE FOR THAT FUNCTION?
2. WHY DID YOU CHOOSE THAT SWITCH?
3. WHERE DO YOU WANT TO PUT THE SWITCH?
4. WHY DO YOU WANT TO PUT IT THERE?
5. HOW DO YOU WANT THE SWITCH TO OPERATE?
6. WHY DO YOU WANT THE SWITCH TO OPERATE IN THAT MANNER?

==========

The driver was reminded that the controls being selected were for use in a vehicle to be produced in the 1990's. It was stressed that selections for each function should be made with this perspective in mind. The participant was then encouraged to ask any questions he or she may have before beginning the task.

With these preliminary steps completed, the participant selected switches for the nine function labels in any order and place them on the Velcro® surfaces within the mockup. For each function, the same procedure was followed. The participant was asked to announce the function that he or she intended to work on. Information about that function was collected in the following order, unless the subject preferred otherwise. (A few people chose to follow a different order.)

First, the switch number was entered into the Macintosh. The participant was then asked why he/she selected that particular switch. As they responded, the

experimenter entered the verbal response followed by the associated code from the full list of reasons (Table 4).

The participant placed the switch onto the Velcro®-covered panel where he/she preferred. The location of the switch was identified based on the zone chart, and entered accordingly. The driver's reasoning behind selecting a particular location was recorded in the same manner as that for switch selection.

The method of operation was discussed, including how the driver would turn the switch on or off, and any intermediate positions desired. Using the Method of Operations Table, the experimenter recorded the specified method. A description of the method of operation and orientation of the switch was also recorded. The driver's reasoning for method of operation was entered in the same manner as for switch type and location.

In the next portion of the experiment, the UMTRI driving simulator was used. The participant was given one-minute practice runs until feeling comfortable with the simulator operation. During this time, the experimenter gave the driver feedback regarding steering. When participants had difficulty, the experimenter stood next to the car and told the participant which way to turn the wheel.

Once the participant understood the simulator operation and was comfortable driving, the experimenter asked the participant to operate the controls one at a time. ("Now turn on the windshield wiper.") This was done while driving the simulator. The experimenter waited five seconds after the driver finished operating one control before presenting the next one. The order in which these controls were operated appears in the instructions in Appendix F. Although there was no formal error collection, the experimenter made note of any difficulties the participant may have had operating or locating the switches.

Operating the selected controls while driving was a critical step. It emphasized to drivers that aesthetically pleasing designs may not be easy to use. Further, one can't always make a good judgement about a design's ease-of-use without first using it in a representative situation, such as simulated driving. This was supported by the data. Many people made changes in their designs after the simulated drive.

After the driving session, participants were encouraged to discuss any problems they experienced while using the controls. The experimenter prompted the discussion with comments on observed difficulties with the driving task, which often led to modification of the original dashboard design. Changes were usually made because some controls were hard to reach, awkward to operate, confused with other switches, or drivers had forgotten where the controls were located. All changes were recorded by the experimenter using the software running on the Macintosh IIx (or SE) computer. Since the basic design was typically very similar, no driving session was conducted using the new configuration.

Once the participant was satisfied that his/her instrument panel was set up the right way, the experimenter asked him/her to step out of the car. The participant was then seated at a Titmus Vision Tester. The instructions read to the participant can be found in Appendix F. Results were recorded as a Snellen Ratio. This test determined the participant's near vision, relative to being able to see and read switches in a car.

Several anthropometric measures were then recorded following the standard procedures described in Lohman, Roche, and Martorell, 1988. The participant removed his or her shoes and their height (in cm) and weight (in lbs) were measured. The person put their shoes back on and sat on a flat wooden table, which allowed their feet to dangle freely. Measurements of seated head and eye height were taken. Details concerning the anatomical landmarks used appear in the instructions (Appendix F). The length of the arm from the shoulder to the elbow and from the elbow to the wrist were measured and recorded, as well as the hand length and the index finger width at the knuckle closest to the finger nail. All length and width measurements were taken were taken with the anthropometer. Weight was measured with the doctor's scale.

The last part of data collection took place in the participant's vehicle. For the nine functions studied, the type of switch, location, and method of operation were recorded as they appeared in his or her car. The make, model, and year of the car was also noted. Forms for recording this information appear in Appendix H. The information and reference materials were similar to those used in the UMTRI survey of 1986-model cars (Green, Ottens, and Adams, 1987).

Upon completion of the test session, the driver was paid and thanked for their contribution to the research. Also, each driver's design was photographed with a 35mm camera. Rear view, right side, and left side shots were taken with a driver nameplate (name, subject number, and date) in clear view to identify the design. Photos for two typical and two unusual designs appear in the Appendix I.

After the conclusion of the data collection, some inconsistencies were discovered in the coding of data, particularly for the first eight subjects. In order to correct these inconsistencies, the videotapes and photographs for all 54 subjects were examined to verify and re-code (if necessary) the location and switch coding for every function. The reasons drivers gave for their preferences were re-coded as required using the text saved with the data. This re-coding was done by one individual after conferring with the other experimenters. A consistent coding scheme emerged from these efforts. If this type of experiment is done in the future, a longer experimenter training period is recommended, and modifying the coding scheme should be considered.

RESULTS AND DISCUSSION

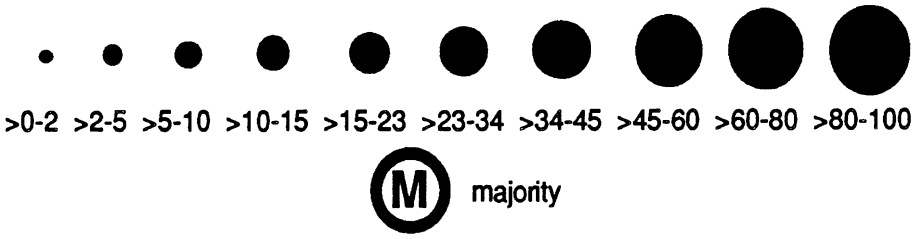
Examined here are driver preferences for controls and a wide variety of factors which may influence them. This unit is divided into five sections. The first is a summary of driver preferences for location, switch, and method of operation aggregated across all functions, except ignition. Ignition was excluded because there was interest only in the location of the switch, which varied little. Including ignition data with the other eight functions would be misleading. The reasons drivers stated for choosing overall locations and switches are also discussed. Second, driver preferences for locations, switches and methods of operation are examined for each specific function studied (except ignition), with attention given to why drivers said they preferred locations and switches. Third is a discussion of the preferred locations and switches for specific functions versus those in the drivers' current cars. The fourth section compares the control preferences reported here (for a conventional instrument panel-sedan) with a pod-based design (for a sports car) examined in the previous driver preference study (Green et al, 1987). The fifth section discusses how driver characteristics may have influenced location and switch preferences.

Driver Preferences and Reasons For All Functions

This section provides a general overview of the locations, switches, and methods of operation preferred for all of the functions studied, except ignition. The driver preferences are described on two pages of text followed by two pages of diagrams (one showing general preferences, one showing switch/motion preferences by pooled zones). The original location coding sheet (Figure 10 in the Test Plan) was reorganized into pooled zone locations to aid in data analysis. The pooled zones are a sensible approach because driver performance in operating controls degrades when a control is more than six inches from where it is expected (Turner and Green, 1987), or, of course, on a different plane. The pooled zones are areas that fit that dimensional constraint. Figure 14 shows the instrument panel locations (pooled zones 1-8), Figure 15 shows the Stalk Control and Steering Column zones (pooled zones 9-11), and Figure 16 describes the ceiling panels (pooled zones 12 & 13).

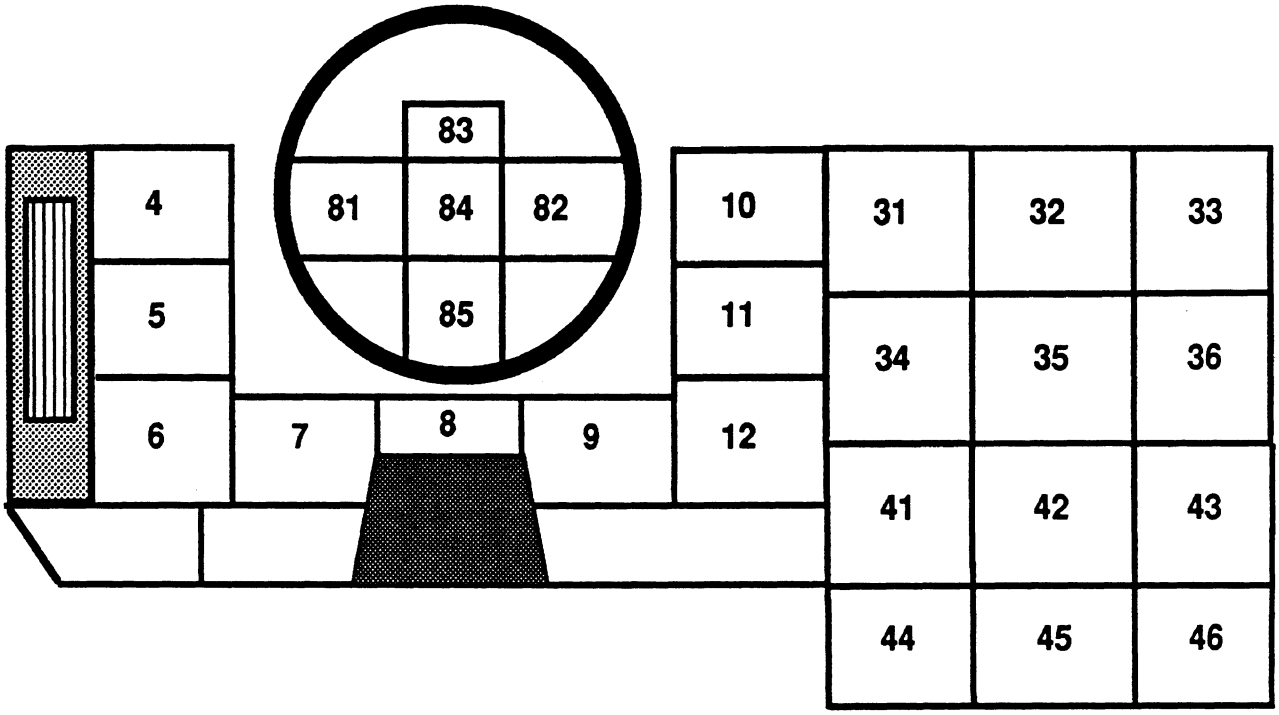
The following coding scheme was used on the first diagram (general preferences) to show the popularity of specific locations. As indicated, larger dots represented a larger consensus of overall preferences. The scale for the dots is slightly different from that in Green et al, 1987. The low end of the range of the scale has been expanded since most responses are in that portion. The most preferred location and method of operation were each indicated by a circled "M" (as in Most).

The overall reasons drivers gave for preferring locations and switches are also included in this section, with the information about location appearing first. The text explains trends and interesting points found, followed by three pages graphically representing the common responses.



Key to preference percentage coding

Individual zones on instrument panel



Pooled zone instument panel locations

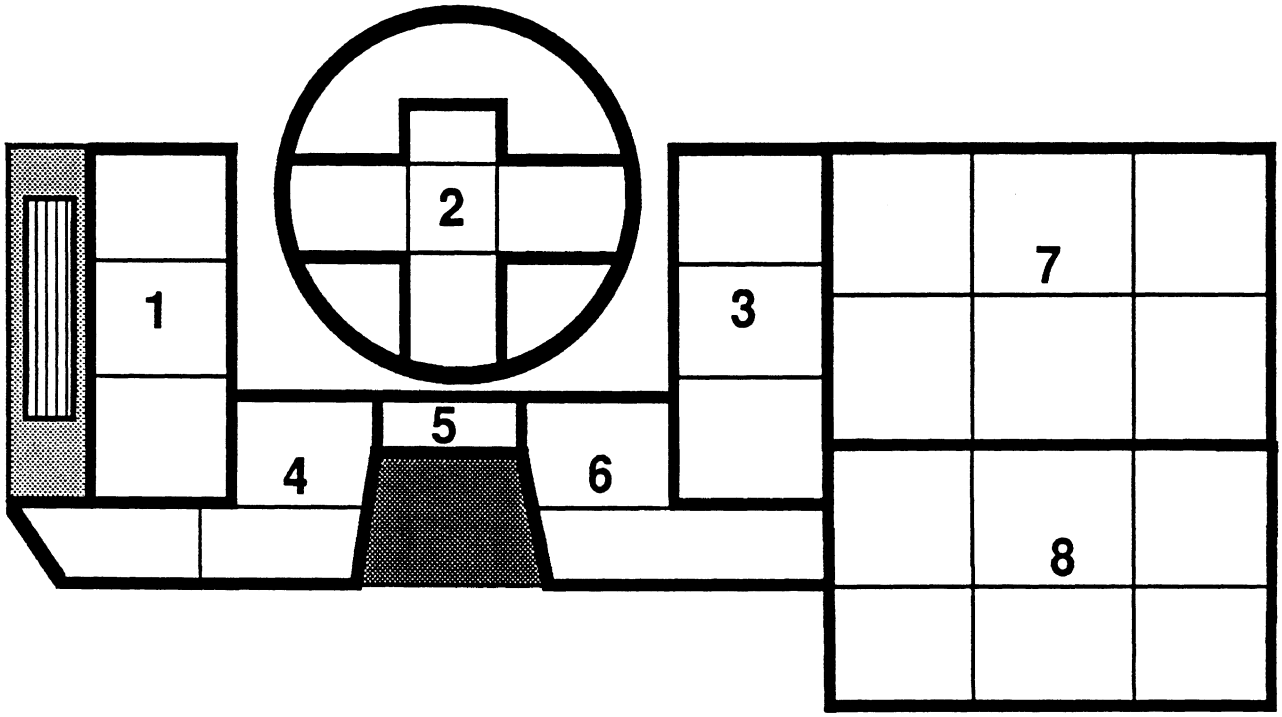
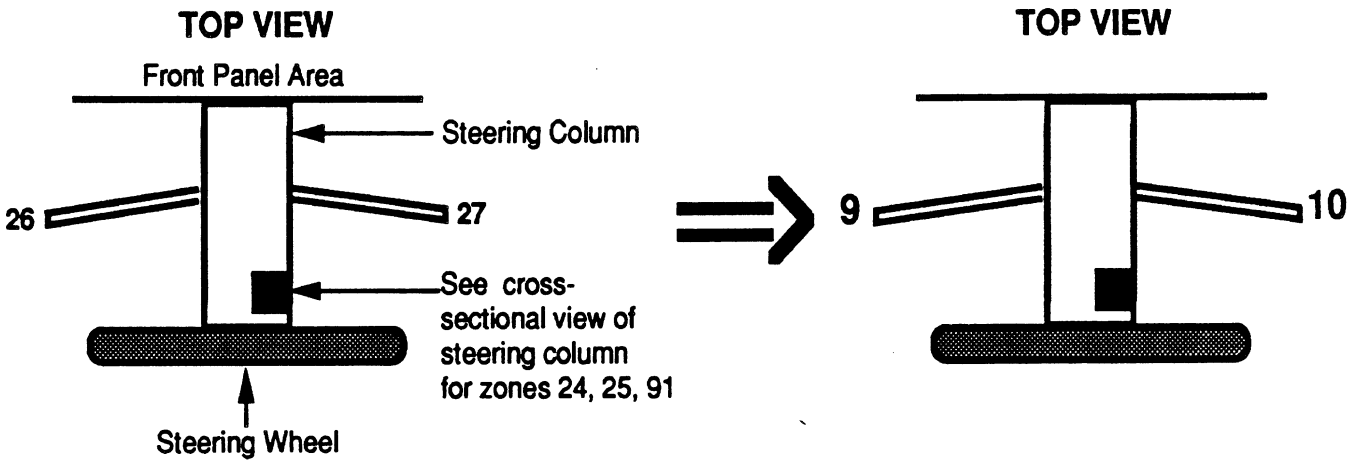


Figure 14. Instrument Panels, Consoles, and Steering Wheel Pooled Zones

Stalk Locations

Individual Zones

Pooled Zones



Steering Column Locations

Individual Zones

Pooled Zone

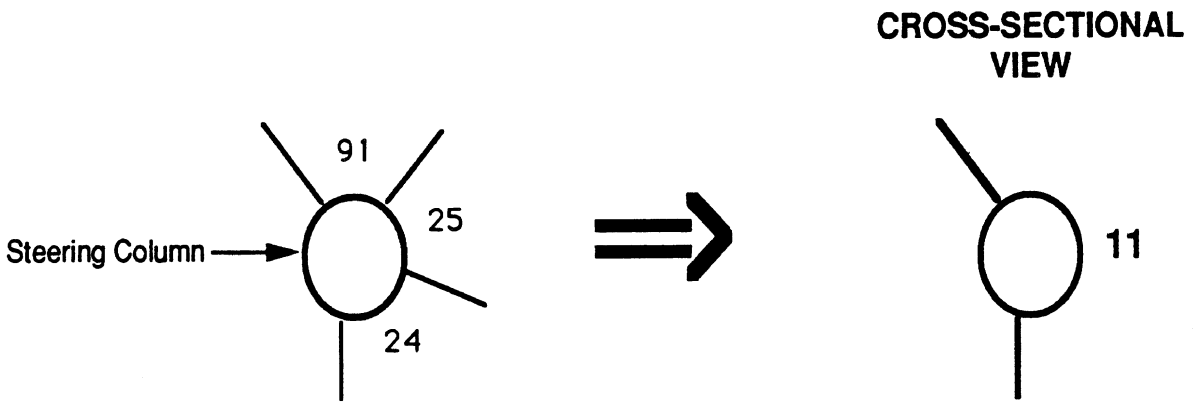
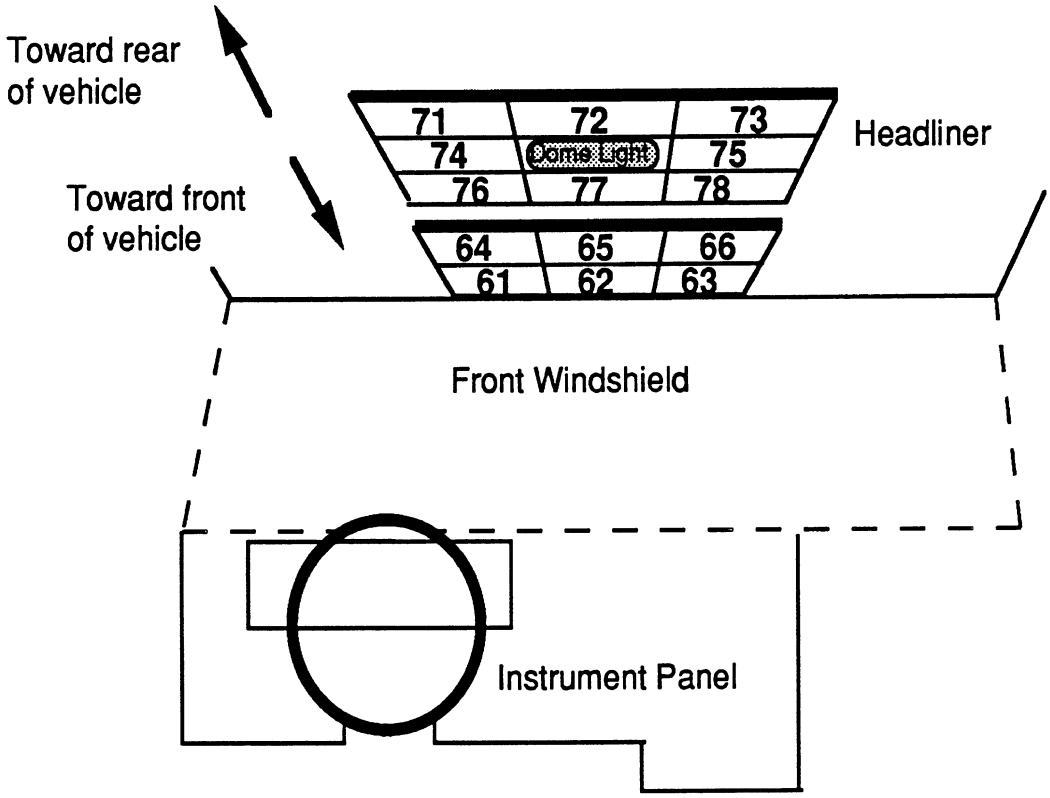


Figure 15. Stalk Control and Steering Column Pooled Zones



Pooled ceiling zones

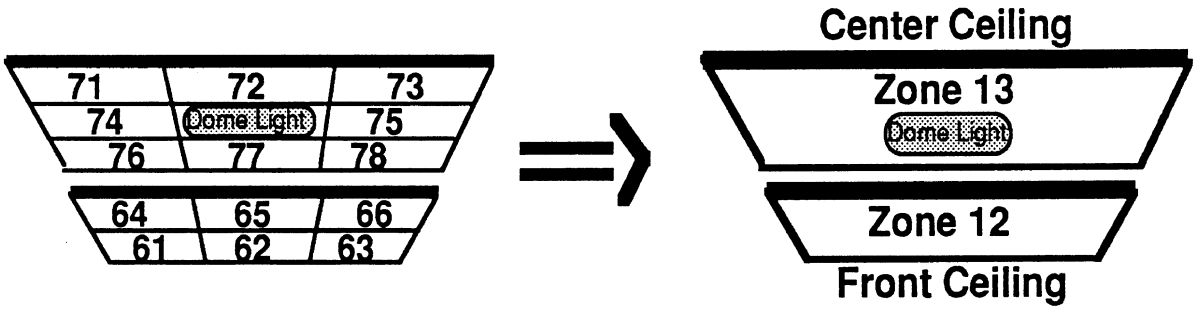


Figure 16. Ceiling Panel Pooled Zones

This section provides a general overview of the preferences over all of the functions. It is hoped that this information will be used as a general idea of secondary control preferences and may provide insights for controls not tested. Also, it contains the aggregate data on which the overall reasons for control selections were based. For insight into the specific controls tested, use the information for each individual control found in the next section of this report, not this general overview.

Location Preferences

The following two pages show the combined preferences for all functions studied, except ignition. The preferred overall location was the lower left corner of the instrument panel (selected by 16% as shown by the circled block 'M' on the next page. This specific location was part of the lower left panel area (pooled zone 4) which was most preferred (24%) of the 13 pooled zones, as shown in the second drawing. The steering wheel spoke locations (pooled zone 2) were also popular for all of the combined functions (16.7%). Drivers also selected stalk locations often, preferring the left stalk more than the right (14.2% vs. 9.7%). Interestingly, this is opposite the trend of the steering wheel, where the right spoke was preferred over the left, perhaps showing the drivers' need to balance the driving task load.

The driver's left side of the instrument panel was favored over the right side (32% vs. 17%), even though there were twice as many right side panel zones. Therefore, the preferred instrument panel design would be unbalanced with a greater number of controls to the left of the driver. Regarding ceiling locations, drivers equally preferred the front (pooled zone 12) and center (pooled zone 13) locations. These pooled zones were used for one function, dome light.

Switch Preferences

The overall switch preferred was the stalk control (25%) since this switch was required for both of the stalk locations, which, as mentioned above, were often selected. The rocker switch was also commonly preferred (23%), and could be used in almost all of the locations. It was the preferred switch for every panel zone (pooled zones 1, 2, 3, 4, 6 & 8) except the upper console (pooled zone 7) which itself was not a commonly preferred zone. Pushbuttons (12%) and the similar push surfaces (7%) were often selected, and were typically the second choice to rocker switches for use on the instrument panel. (Many drivers misinterpreted push surfaces to be pushbuttons, therefore the values should be considered accordingly.) Push-pull switches were chosen one-tenth of the time, especially for the lower left panel (preferred location). Another regionally preferred switch was the combination switch (8%) which was often placed on the panel and console locations to the right of the driver.

Method of Operation Preferences

The overall preferred method of operation was definitely a push in (forward) motion (42%). This resulted primarily because of the popularity of the rocker switch and pushbutton/surfaces, which required this motion when placed on the instrument panel and console locations. The second-most popular method of operation, a twisting motion around the horizontal (+/- y) axis (11%) was typically used with stalk controls. Twisting around the +/- x axis (6%) was often used for knobs or the knob-like portion of push-pull switches, which also favored a push in-pull out method (6%) depending on the function for which it was used. A push right-left (8%) or push up-down (7%) motion was also somewhat common overall, especially for thumbwheels and slide switches.

Combined Preferences

A push in motion was highly favored for the pooled zones 1-8, as this region was the predominant location for rocker, pushbuttons, push surfaces, combination and other switches requiring this motion. The preferred location, switch and method of operation were therefore often dependent upon one another. For instance, a rocker switch positioned directly in front of the driver (pooled zones 1-8) required a push in motion, whereas the same switch located on the steering column (pooled zone 11) used a push left or push down motion, depending on its specific location on the column. If located on the ceiling panels (pooled zones 12 & 13), the same rocker switch would imply a push up motion. Therefore, the drivers' preference for method of operation was basically a default which depended upon the preferred location and switch.

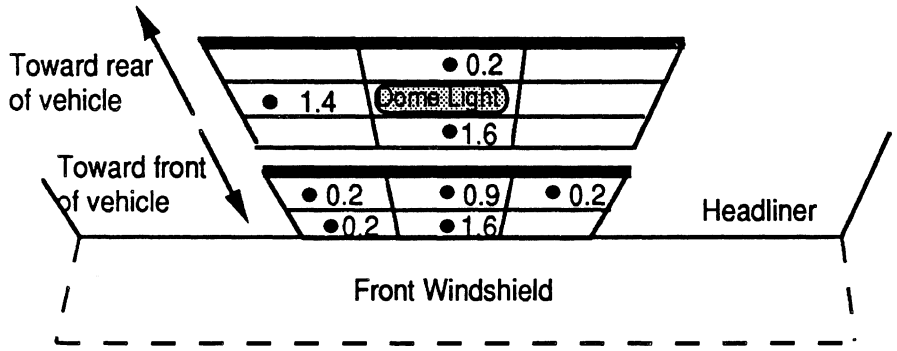
- Results and Discussion -

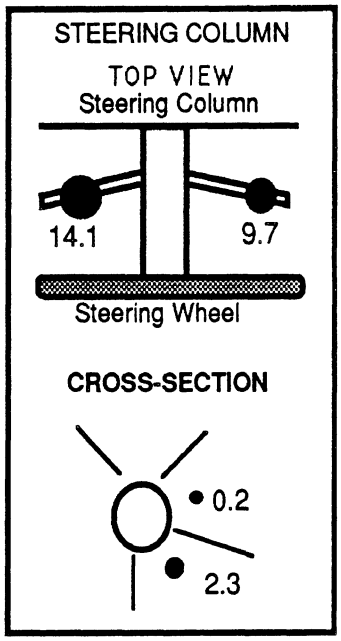
All Functions•

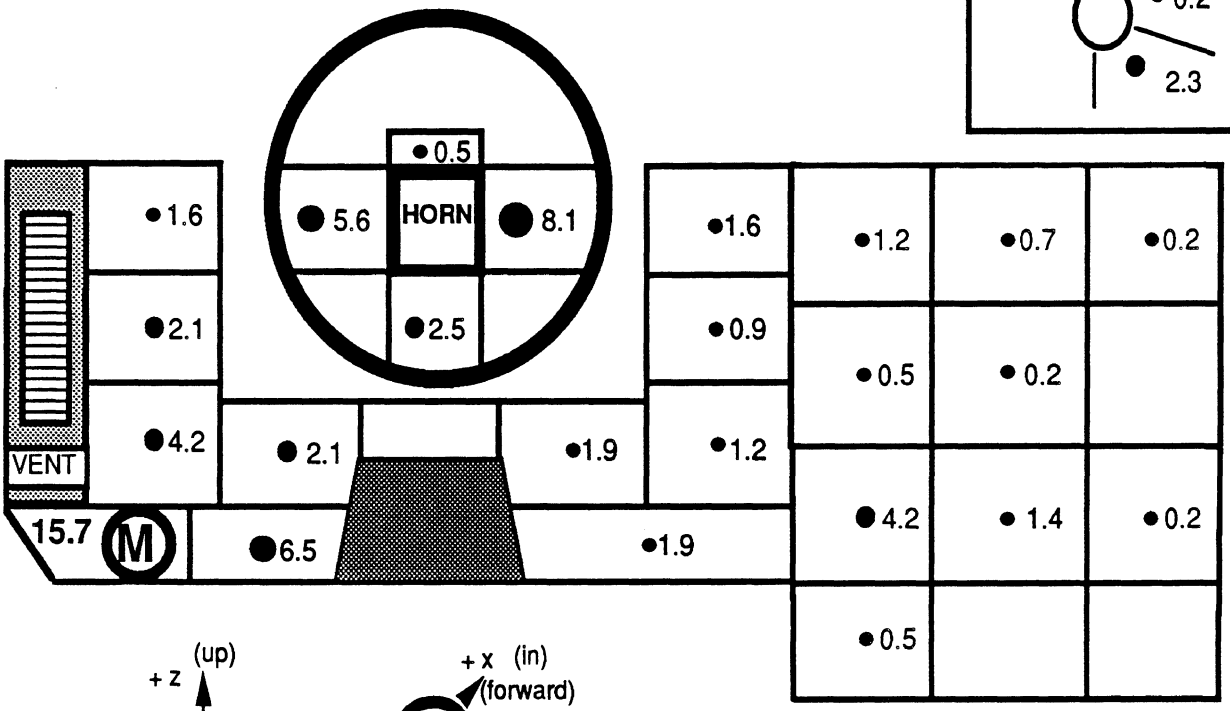
preferred locations, switches and methods of operation
(n = 431 total observations)

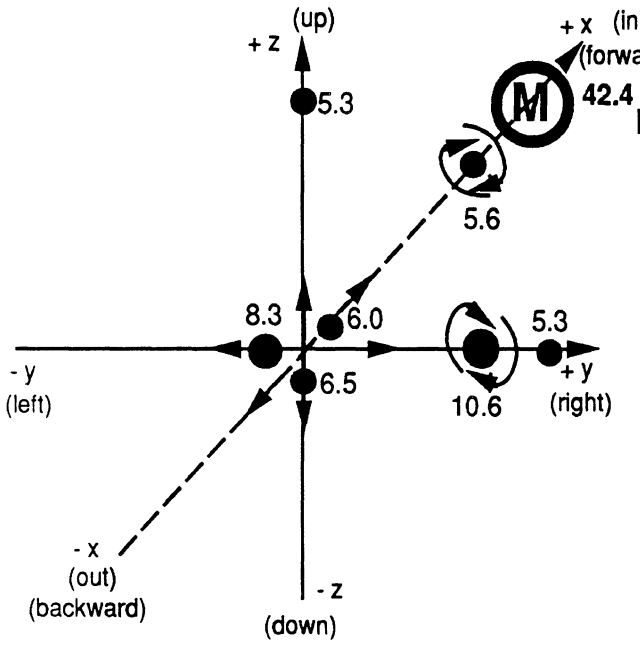
Locations Preferred

% of switches in each zone









Methods of Operation Preferred

(axes relative to the driver)

Method of Operation	%
push in	42.4
twist +/- y	10.6
push right-left	8.3
push up-down	6.5
push in-pull out	6.0
twist +/- x	5.6
push right	5.3
push up	5.3

Switches Preferred

Switch	%
stalk	24.6
rocker	22.5
pushbutton	12.1
push-pull	10.0
combination	7.9
push surface	7.2
slide	4.9
knob	4.4
thumbwheel	3.9

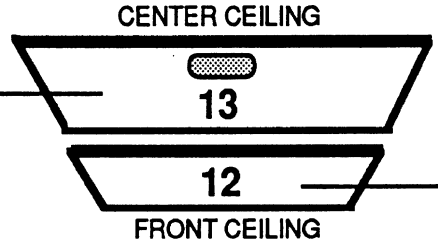
• represents all functions tested except ignition

*Note: Drivers may have confused push surfaces with pushbuttons.

All Functions*

Overall Switch / Motion Preferences by Pooled Zones

(n = 431 total observations)

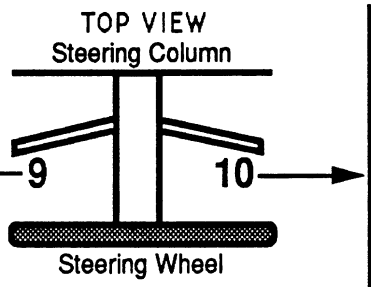


Zone: 13 n = 14 (3.2%)

Switch	Motion	%
rocker	push up	1.4
slide	push in & out	0.7
slide	push r & l	0.7
other (less than 0.5% each)		0.4

Zone: 12 n = 14 (3.2%)

Switch	Motion	%
pushbutton	push up	1.2
rocker	push up	0.9
push surface*	push up	0.7
other (less than 0.5% each)		0.4



Zone: 9 n = 61 (14.2%)

Switch	Motion	%
stalk	twist +/- y	6.3
stalk	push right	6.0
stalk	pull out	0.7
other (less than 0.5% each)		1.2

Zone: 10 n = 42 (9.7%)

Switch	Motion	%
stalk	twist +/- y	4.2
stalk	push left	1.9
stalk	pull out	1.6
stalk	push up-dn	1.2
other (less than 0.5% each)		0.8

Zone: 1 n = 34 (7.9%)

Switch	Motion	%
rocker	push in	1.4
thumbwheel	push r-l	0.9
combination	push in	0.9
combination	push up-dn	0.7
other (less than 0.5% each)		4.0

Zone: 2 n = 72 (16.7%)

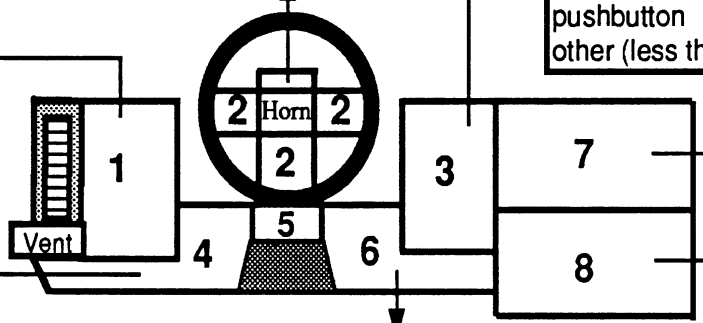
Switch	Motion	%
rocker	push in	5.6
pushbutton	push in	4.2
push surface*	push in	3.9
combination	push in	1.2
paddle	push in	0.7
other (less than 0.5% each)		1.1

Zone: 3 n = 16 (3.7%)

Switch	Motion	%
rocker	push in	0.9
combination	push in	0.9
other (less than 0.5% each)		1.9

Zone: 7 n = 12 (2.8%)

Switch	Motion	%
combination	push in	1.2
pushbutton	push in	0.7
other (less than 0.5% each)		0.9



Zone: 4 n = 105 (24.4%)

Switch	Motion	%
rocker	push in	5.3
pushbutton	push in	4.2
push-pull	push in-out	2.8
push-pull	twist +/- x	2.6
knob	twist +/- x	2.1
thumbwheel	push up-dn	0.7
push-pull	twist - x	0.7
knob	push in	0.7
push surface*	push in	0.7
other (less than 0.5% each)		4.6

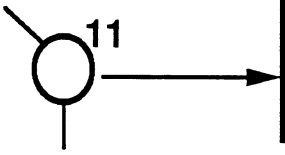
Zone: 6 n = 16 (3.7%)

Switch	Motion	%
rocker	push in	2.3
other (less than 0.5% each)		1.4

Zone: 8 n = 27 (6.3%)

Switch	Motion	%
rocker	push in	2.1
combination	push in	0.9
thumbwheel	push r-l	0.7
other (less than 0.5% each)		2.6

STEEIRING COLUMN
CROSS-SECTION



Zone: 11 n = 18 (4.2%)

Switch	Motion	%
rocker	push down	0.9
rocker	push left	0.7
push-pull	push r-l	0.7
other (less than 0.5% each)		1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Why Locations Were Preferred

The following three pages summarize drivers' reasons for choosing locations over all of the functions tested except ignition, which was located almost entirely due to expectation. Familiarity/expectation most influenced drivers' location preferences for instrument panel controls (17%). In general, people wanted controls to be placed in locations similar to their current vehicles, and often commented that this made the controls easier to find and use. This was particularly true for the lower left panel, stalks, steering column and front ceiling (pooled zones 4, 9, 10, 11 & 12) which accounted for two-thirds of the overall responses.

Body restrictions, implying an easy motion to make, was the second-most common reason (14%) for overall location choice. This reason was often cited for the left panel, right panel, and center ceiling locations (pooled zones 1, 3 & 12), and was of some importance for every location. Many people also considered handedness (which hand should operate the control-11%) in location selection. Depending on the function, some drivers preferred using either their left or right hand. Related to this was the idea of enabling the hand that operated the control to be kept on or near the steering wheel, which involved the relation to other controls (9%). At times it was difficult to determine with which of these two categories (handedness or relation to other controls) driver responses should be associated.

The frequency with which a control was used also helped determine the preferred location (9%). This reason was cited for less common locations, primarily those to the right of the driver, such as the lower right panel, upper and lower console, steering column, and center ceiling (pooled zones 6, 7, 8, 11 & 13) where less frequently used controls (hazard, dome light) were preferred. The field of view reason was also cited when positioning controls (7%). First, many drivers chose locations in which the control would be easy to see. This supported all panel and console areas (pooled zones 1, 3, 4, 6, 7 & 8), and was also important for the hazard function, so it could be easily located in an emergency. In contrast, controls used regularly (cruise control, windshield washer/wipers) were often located on stalks and the steering wheel (pooled zones 9, 10 & 2) because drivers felt they didn't need to see the controls in order to use them. Another reason affecting the cruise control, windshield wiper/washer, and lighting controls was the tendency to view individual functions as part of a system (7%) locating them together, often on the same switch.

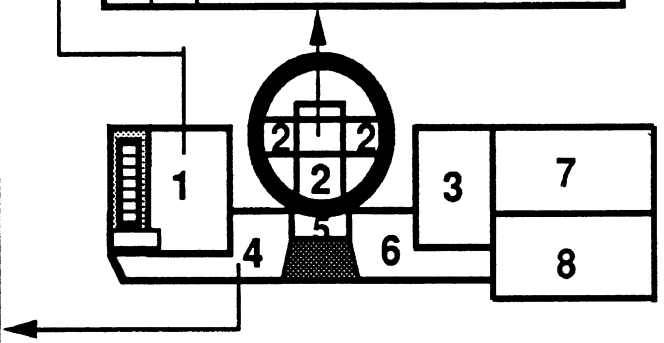
Left Panels and Steering Wheel

Reasons for choosing pooled zones 1, 2, & 4 as locations for all functions
(n = 949 total observations, of which 425 are in the shown regions)

Zone 1: Left Panel (n=69)		
n		Reason
12		**Body restrictions**
		Easy motion to make
11		**Part of system**
		Same location as rest of system
9		**Field of view**
	5	Easy to see in that location
	3	Don't need to see it to use it
	1	Need to see it to use it
8		**Handedness/Balance of use**
		Can operate with left hand
6		**Frequency of use**
		Control not often used
6		**Aesthetics**
	4	Instrument panel looks balanced
	2	Other areas too cluttered
17		**Other**

Zone 2: Steering Wheel (n=149)		
n		Reason
33		**Relation to other controls**
		Keep hand on wheel when using
23		**Body restrictions**
		Easy motion to make
20		**Handedness/Balance of use**
	13	Can operate using right hand
	4	Can operate using either hand
	3	Can operate using left hand
17		**Familiarity/Expectation**
	8	Similar to subject's car
	6	Convenient
	2	Car manufacturer standard
	1	Expects control to be there
12		**Field of view**
	7	Don't need to see it to use it
	5	Easy to see in that location
10		**Time requirements**
	4	Need to find it quickly
	4	Need to operate it quickly
	2	Need to operate without thinking
9		**Frequency of use**
	7	Control used often
	2	Control not often used
25		**Other**

Zone 4: Lower Left Panel (n=207)		
n		Reason
38		**Familiarity/Expectation**
	12	Similar to subject's car
	11	Expects control to be there
	8	Feels it's an industry standard
	5	Convenient
	2	Similar to a friend's car
26		**Handedness/Balance of use**
	21	Can operate with left hand
	3	Can operate with either hand
	1	Too many controls for left hand
	1	Too many controls for right hand
24		**Frequency of use**
	23	Control not often used
	1	Used the most in that system
17		**Body restrictions**
		Easy motion to make
16		**Part of system**
	14	Same location as rest of system
	2	Different location than rest
14		**Field of view**
	11	Easy to see in that location
	2	Don't need to see it to use it
	1	Need to see it to use it
12		**Space restrictions**
	10	Won't stick out or get in way
	2	Unable to put it where preferred
60		**Other**



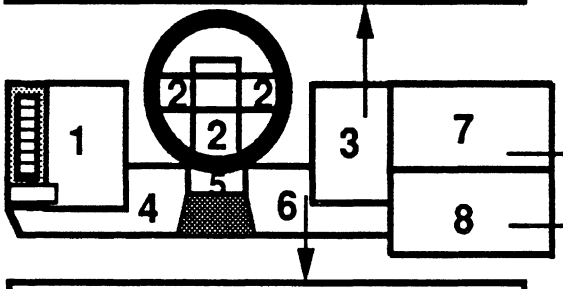
Overall reasons for location preference	n	%
Familiarity/Expectation	161	17.0
Body restrictions	130	13.7
Handedness	106	11.2
Relation to other controls	82	8.6
Frequency of use	81	8.5

Right Panels, Consoles, and Ceiling

Reasons for choosing pooled zones 3, 6, 7, 8, 12, & 13 as locations for all functions
(n=949 total observations, 224 observations in the shown regions)

Zone 3 Right Panel n=34		
n		Reason
13		**Body restricitons**
	8	Easy motion to make
	2	Eyesight limitations
	2	Can reach it with short arms
	1	Physical handicap limitations
5		**Field of view**
	4	Easy to see in that location
	1	Need to see it to use it
16		**Other**

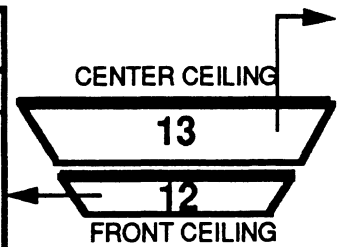
Zone 7 Upper Console n=24		
n		Reason
5		**Body restricitons**
		Easy motion to make
3		**Part of system**
		Same location as rest of system
3		**Frequency of use**
	2	Control used often
	1	Control not often used
13		**Other**



Zone 8 Lower Console n=61		
n		Reason
10		**Body restrictions**
		Easy motion to make
10		**Field of view**
	8	Easy to see in that location
	2	Don't need to see it to use it
9		**Handedness/Balance of use**
		Can operate with right hand
9		**Part of system**
	5	Different location than rest
	4	Same location as rest of system
7		**Frequency of use**
	5	Control not often used
	2	Control used often
3		**Sequence of use**
		Used in sequence with others
13		**Other**

Zone 6 Lower Left Panel n=58		
n		Reason
8		**Field of view**
		Easy to see in that location
7		**Body restrictions**
		Easy motion to make
7		**Frequency of use**
		Control not often used
4		**Properties of operation**
		Easier to use than others
4		**Space restrictions**
		Won't stick out or get in way
4		**Part of system**
	3	Same location as rest of system
	1	Different location than rest
4		**Time requirements**
	3	Need to find it quickly
	1	Need to operate it quickly
20		**Other**

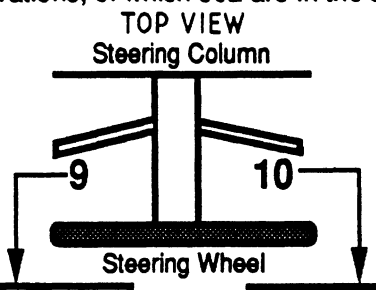
Zone 12: Front Ceiling (n=23)		
n		Reason
8		**Familiarity/Expectation**
	3	Similar to subject's car
	3	Expects switch to be there
	2	Convenient
3		**Body restrictions**
		Easy motion to make
2		**Handedness/Balance of use**
		Too many controls for left hand
10		**Other**



Zone 13: Center Ceiling (n=24)		
n		Reason
5		**Body restrictions**
		Easy motion to make
5		**Other**
		Passengers can reach it also
4		**Frequency of use**
		Control not often used
4		**Familiarity/Expectation**
	3	Expects control to be there
	1	Convenient
3		**Part of system**
		Same location as rest of system
3		**Other**

Stalks and Steering Column

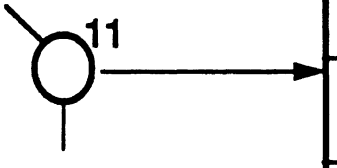
Reasons for choosing locations for all functions by pooled zones 9, 10, 11
(n = 949 total observations, of which 302 are in the shown regions)



Zone 9: Left Stalk (n=114)		
n		Reason
31		**Familiarity/Expectation**
	19	Similar to subject's car
	7	Feels it's an industry standard
	3	Convenient
	2	Expects control to be there
21		**Handedness/Balance of use**
	20	Can operate with left hand
	1	Can operate with either hand
16		**Body restrictions**
		Easy motion to make
15		**Relation to other controls**
	11	Keep hands on wheel when using
	4	Won't confuse with other controls
10		**Field of view**
	6	Don't need to see it to use it
	3	Easy to see in that location
	1	Need to see it to use it
8		**Part of system**
		Same location as rest of system
13		**Other**

Zone 10: Right Stalk (n=78)		
n		Reason
21		**Familiarity/Expectation**
	14	Similar to subject's car
	7	Expects control to be there
15		**Relation to other controls**
		Keep hands on wheel when using
12		**Handedness/Balance of use**
	10	Can operate using right hand
	2	Too many controls for left hand
5		**Aesthetics**
		Instrument panel looks balanced
5		**Body restrictions**
		Easy motion to make
5		**Field of view**
		Don't need to see it to use it
15		**Other**

STEERING COLUMN
CROSS-SECTION



Zone 11: Steering Column (n=110)		
n		Reason
33		**Familiarity/Expectation**
	13	Feels it's an industry standard
	8	Similar to subject's car
	7	Convenient
	3	Expects control to be there
	1	Similar to a friend's car
	1	Everyone knows how to use it
14		**Body restrictions**
	13	Easy motion to make
	1	Can reach it with short arms
11		**Frequency of use**
	9	Control not often used
	2	Control used often
8		**Space restrictions**
	6	Won't stick out or get in way
	1	Only place left to put a switch
	1	Unable to put it where preferred
7		**Properties of operation**
		Easier to use than other areas
6		**Avoiding accidental use**
		Don't want to accidentally use
5		**Handedness/Balance of use**
		Can operate with right hand
26		**Other**

Why Switch Types Were Preferred

The following three pages show the most common reasons why drivers preferred various types of switches for all functions, except the ignition. For ignition, a key switch was always selected due to driver expectancies and industry standardization. As with location preference, drivers sometimes selected switches that resembled those in their current vehicles--that is, switches that were familiar or expected (15%). This was especially true for the stalk control (most preferred overall) and push-pull switches. Affecting both location and switch choice was body restrictions (7%), cited for switch preferences where drivers wanted an easy motion to make.

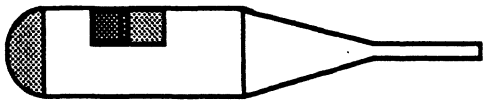
Many of the physical characteristics of switches were considered by drivers in making their selection. Aesthetics were commonly mentioned (14%), where people chose switches that looked simple to use, or those for which they liked the overall appearance. References were also made to the labelling/illumination qualities of the switch (12%) despite specific instructions from the experimenter to ignore labelling. Aesthetics and labelling influenced the selection of rocker switches, pushbuttons, and push surfaces, which represented over a third of the switch responses. Combination and slide switch selection was also highly attributed to labelling qualities. How often labelling was cited depended upon the function. Switches for the hazard, windshield washer, and windshield wiper were selected due to labelling much more often than for the cruise control or other functions.

About 10% of the reasons given for switch preferences were attributed to switch properties of operation. For on/off controls, a switch requiring a deliberate movement was often preferred (rocker, push-pull), while controls used for setting or adjusting (panel brightness, windshield wiper) were better suited by switches for continuous adjustment (thumbwheel) or multiple discrete positions (stalk). Another physical characteristic highly recognized was grasping/touching. Drivers usually wanted switches that were big enough to easily grasp. This issue was especially important to older drivers with arthritis. The need to use controls while wearing gloves or mittens was also acknowledged by some drivers, as was the benefit of textured contact surfaces to avoid slipping.

Overall, drivers tended to view switch and location preferences together. For example, when asked why a particular switch was chosen, they typically gave a response which led to or included their intended location. The connection between switch and location was unavoidable in stalk control/stalk location selection. However, other locations were also linked with certain switch types or vice versa. People selecting the steering wheel spoke locations typically assumed rocker switches and pushbutton/surfaces to operate the control.

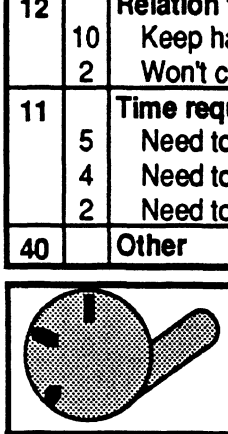
Stalk Control; Rocker & Paddle Switches

Reasons for choosing types of switches for all functions
(n = 913 total observations, of which 449 are shown)



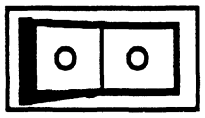
Stalk Control (n = 244)

n		Reason
60		**Familiarity/Expectation**
	31	Similar to subject's car
	10	Expects switch to look like this
	8	Convenient
	6	Similar to a friend's car
	5	Feels it's an industry standard
25		**Labelling/Illumination**
	17	Switch labelling matches function
	8	Switch is easy to see/read
25		**Properties of operation**
	8	Switch represents function well
	8	It feels right when you move it
	6	Switch should move easily
	3	Easier to use than others
23		**Body restrictions**
		Easy motion to make
18		**Aesthetics**
	9	Switch looks simple to use
	7	Subject likes the way it looks
	2	Instrument panel looks balanced
17		**Grasping/Touching**
	8	Rough surface prevents slipping
	5	Big enough to easily grasp
	3	Can use while wearing gloves
	1	Switch surface is rough
13		**Part of system**
		Same switch as rest of system
12		**Relation to other controls**
	10	Keep hands on wheel when using
	2	Won't confuse with other controls
11		**Time requirements**
	5	Need to operate it quickly
	4	Need to operate without thinking
	2	Need to find it quickly
40		**Other**



Paddle Switch (n = 5)

n		Reason
2		**Body restrictions**
		Easy motion to make
2		**Relation to other controls**
		Keep hands on wheel when using
1		**Other**



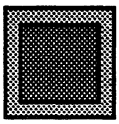
Rocker Switch (n = 200)

n		Reason
30		**Aesthetics**
	17	Switch looks simple to use
	9	Subject likes the way it looks
	4	Nice design/looks unique
30		**Labelling/Illumination**
	18	Labelling matches function
	5	Switch is easy to see/read
	4	Switch is easily illuminated
	3	Switch is well illuminated
19		**Properties of operation**
	4	Switch represents function well
	4	Switch should move easily
	4	It shouldn't be too easy to move
	4	Easier to use than others
	3	It feels right when you move it
18		**Familiarity/Expectation**
	6	Similar to subject's car
	4	Expects switch to look like this
	2	Similar to a friend's car
	2	Convenient
	2	Have similar switches elsewhere
	1	Everyone knows how to use it
	1	Car manufacturer's standard
17		**Feedback**
		Should sense when activated
15		**Grasping/Touching**
	5	Big enough to easily locate
	4	Big enough to easily grasp
	4	Switch surface is smooth
	1	Switch surface is rough
	1	Rough enough to prevent slipping
12		**Body restrictions**
		Easy motion to make
11		**Partiality/General preference**
	9	Subject likes rocker switches
	2	Doesn't like it, but feels it's best
10		**Part of system**
		Same switch as rest of system
38		**Other**

Overall reasons for switch preference	n	%
Familiarity/Expectation	133	14.6
Aesthetics	130	14.2
Labelling/Illumination	107	11.7
Properties of operation	95	10.4
Grasping/Touching	85	9.3

Push Surface, Thumbwheel, Knob, Toggle Switch, & Lever

Reasons for choosing types of switches for all functions
(n = 913 total observations, of which 151 are shown on this page)

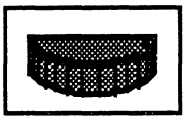


Push Surface* (n = 66)

n		Reason
11		**Aesthetics**
	4	Subject likes the way it looks
	3	Switch looks simple to use
	2	Other areas too cluttered
	1	Subject likes a simple layout
	1	Instrument panel looks balanced
10		**Familiarity/Expectation**
	5	Similar to subject's car
	3	Convenient
	2	Have similar switches elsewhere
10		**Grasping/Touching**
	4	Big enough to easily grasp
	3	Other switches are too big
	2	Other switches are too small
	1	Can be used while wearing gloves
5		**Body restrictions**
		Easy motion to make
5		**Relation to other controls**
		Keep hands on wheel while using
5		**Safety**
	3	Safest type of switch available
	2	Other switches may hurt
5		**Properties of operation**
	2	Switch represents function well
	2	Switch should move easily
	1	Switch surface is rough

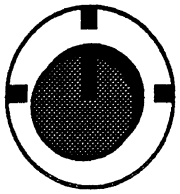
Toggle Switch (n = 12)

n		Reason
3		**Aesthetics**
		Switch looks simple to use
2		**Body restrictions**
	1	Physical limitations on others
	1	Other switches hard to use
2		**Grasping/Touching**
	1	Can use while wearing gloves
	1	Big enough to easily grasp



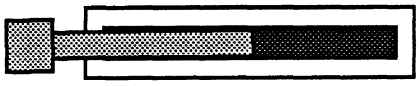
Thumbwheel (n = 26)

n		Reason
8		**Properties of operation**
	4	Switch represents function well
	3	Switch should move easily
	1	Easier to use than others
5		**Aesthetics**
	3	Nice design/Looks unique
	1	Subject likes a simple layout
	1	Other ares too cluttered
4		**Body restrictions**
		Easy motion to make
4		**Grasping/Touching**
	2	Can use while wearing gloves
	2	Big enough to easily grasp



Knob (n = 42)

n		Reason
16		**Grasping/Touching**
	6	Big enough to easily grasp
	4	Can use while wearing gloves
	4	Big enough to easily locate
	1	Rough surface prevents slipping
	1	Other switches are too big
9		**Properties of operation**
		Switch represents function well
5		**Familiarity/Expectation**
	3	Similar to subject's car
	1	Similar to a friend's car
	1	Expects it to look like this



Lever (n = 5)

n		Reason
2		**Space restrictions**
		Unable to put where desired
2		**Field of view**
		Switch will stand out and be seen

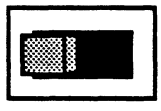
*Note: Drivers may have confused push surfaces with pushbuttons.

Pushbutton, Push Pull, Combination, and Slide Switches

Reasons for choosing types of switches for all functions
(n = 913 total observations, of which 313 are shown on this page)

Pushbutton (n = 105)

n		Reason
24		**Aesthetics**
	12	Switch looks simple to use
	9	Subject likes the way it looks
	2	Nice design/looks unique
	1	Instrument panel looks balanced
16		**Labelling/Illumination**
	10	Labelling matches function
	5	Switch is easy to see/read
	1	Switch is well illuminated
13		**Relation to other controls**
	11	Keep hands on wheel when using
	2	Won't confuse with other controls
10		**Familiarity/Expectation**
	4	Similar to subject's car
	4	Expect switch to be like this
	1	Convenient
	1	Have similar switches elsewhere
8		**Properties of operation**
	5	Switch represents function well
	2	Easier to use than others
	1	Switch should move easily
8		**Field of view**
	4	Easy to see in that location
	3	Switch will stand out and be seen
	1	Don't need to see it to use it

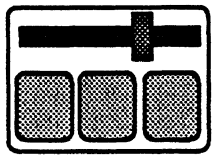


Slide Switch (n = 46)

n		Reason
15		**Labelling/Illumination**
	6	Labelling matches function
	5	Switch is easy to see/read
	2	Switch is well illuminated
	2	Switch is easily illuminated
5		**Aesthetics**
		Switch looks simple to use
5		**Properties of operation**
	2	Switch represents function well
	2	Switch should move easily
	1	Easier to use than others

Push Pull Switch (n = 91)

n		Reason
16		**Familiarity/Expectation**
	10	Similar to subject's car
	3	Expects switch to be like this
	2	Feels it's an industry standard
	1	Convenient
15		**Aesthetics**
		Switch looks simple to use
12		**Grasping/Touching**
	7	Can use while wearing gloves
	3	Big enough to easily grasp
	1	Switch surface is smooth
	1	Big enough to easily locate
11		**Properties of operation**
	4	Switch represents function well
	4	Easier to use than others
	3	Switch should move easily
9		**Part of system**
		Same switch as rest of system



Combination Switch (n = 71)

n		Reason
15		**Labelling/Illumination**
	8	Labelling matches function
	7	Switch is easy to see/read
14		**Aesthetics**
	6	Subject likes the way it looks
	4	Instrument panel looks balanced
	2	Nice design/looks unique
	2	Switch looks simple to use
10		**Familiarity/Expectation**
	8	Similar to subject's car
	2	Have similar switches elsewhere
6		**Body restrictions**
		Easy motion to make
6		**Properties of operation**
	4	Switch should move easily
	2	Switch represents function well

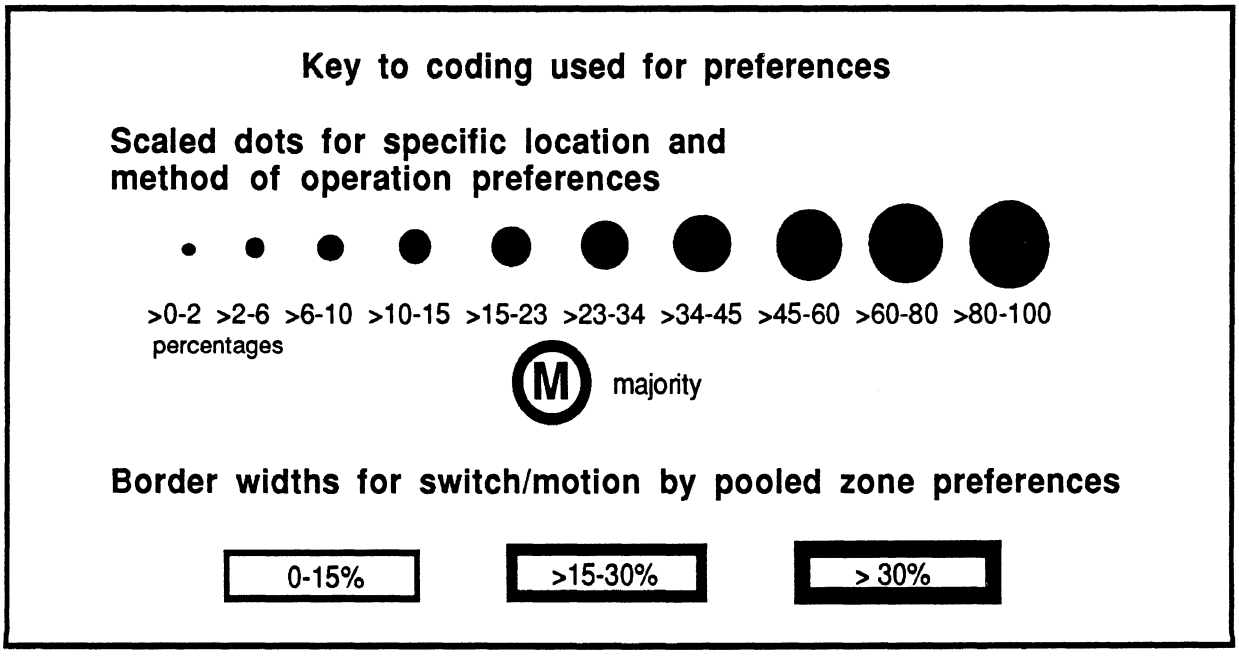
Driver Preferences and Reasons for Individual Functions

The locations, switches, and methods of operation preferred for each of the functions studied are examined in this section in alphabetic order. Reasons drivers gave for their preferences are also summarized. This information is displayed individually by function using the following eight page format:

Pages 1-2. These two pages of text highlight the overall preferences for locations, switches, and methods of operation. A summary of preferences is provided at the end of the text.

Pages 3-4. These figures show driver preferences described on the previous two pages. To keep things simple, they are not numbered. (In fact, none of the figures in this section are.) The left page shows the locations where drivers placed controls. Scaled dots were placed on each location to show the percentage of preferences in that area. The most preferred area was marked by a circled block "M" (majority). A key to dot size is given below. The switches were ranked in order of preference, and the most preferred was boxed and the typeface set to bold. The preferred methods of operation were both listed and shown on the direction of motion axes used throughout the experiment.

The right page gives switch and method of operation preferences based on pooled zone locations (See Figures 10-12 for location-pooled zone relationships). The combinations are ranked by preference, and contained in boxes corresponding to their represented zone. The width of the borders of the boxes represents the percentage of responses for each location shown. Border widths are shown below. Note that due to round off errors, the percentage given in the top of each box may not equal the sum of the percentages for responses contained within the box.



Pages 5-6. These two pages of text describe why people said they preferred certain locations and switch types, supported by direct quotes from participants. A summary of reasons for preferences is provided at the end of the text.

Pages 7-8 These two pages graphically represent the most commonly stated reasons for driver preferences: The left page contains reasons for location selection, using the pooled zones for reference. The right page shows why certain switch types were preferred. The format of these diagrams is similar, with the most common locations/switches shown in boxes of increasing border width based on the number of responses for that location/switch . The reason shown in bold (i.e. Familiarity/Expectation, Aesthetics, etc.) is the general category from the experimenter's coding sheet shown in Table 4. The left-most bold number shows how many responses from that category supported the particular location/switch. The plain text reason (indented) is the specific reason stated by the driver (i.e. Similar to subject's car, Looks simple to use, etc.) which was given by the plain-text number associated with it. Overall reasons are summarized on both pages. These numbers represent all of the participant responses and may not equal the sum of the individual switch or location responses shown on each page, as the individual responses are shown only for the most common reasons.

Cruise Control On/Off

Location Preferences

As shown on the following two pages, the preferred location for cruise control on/off (indicated by the "M" on the following left page) was on the right steering wheel spoke. This location was chosen by 24% of the respondents. Almost as many preferred the left spoke (20%). Jointly these two locations account for over 44% of the 54 responses. In addition, as shown in the pooled zone table on the right-hand page, there were a few people who wanted the switch on the bottom spoke. Hub mounting, (pooled zone 2) as indicated by the thick border around the text on the following right page, was preferred over the second (lower left panel, pooled zone 4) and third choices (left stalk, pooled zone 9) by 3 to 1 margins. Given the nature of responses in these experiments, this is a fairly high level of agreement.

Switch Preferences

No single switch type was preferred by a majority of the participants, though rocker switches were preferred by 41% of them. A similar switch, the pushbutton, was the second choice (20.4%), and a push surface was also commonly selected (14.8%). However, when push surfaces were selected, they were generally quite small (1cm x 1cm), and for all practical purposes were identical to pushbuttons in both functionality and physical appearance. According to comments made throughout the study, most participants intended the push surfaces to be small pushbuttons flush to the steering hub surface. Therefore, the values for push surfaces and pushbuttons should be pooled for the cruise control functions, increasing pushbutton preference to 35%.

Method of Operation Preferences

There was an extremely strong preference (81.5% of those responding) for pushing the switch in (forward) to operate it. Although method of operation preferences tended to have higher percentage rates (compared to preferences for switch or location), this value was the largest in this experiment. All switches selected by drivers for the cruise control on/off, except stalk controls, utilized this push in motion.

Combined Preferences

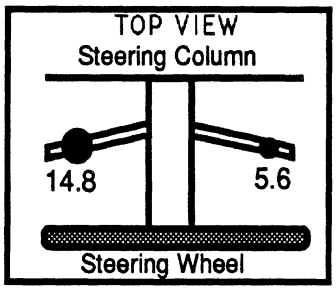
As noted in the pooled zone figure (the right page), a pushbutton switch mounted on the steering wheel spokes (pooled zone 2) was preferred by 24% of those responding. Almost equally common in this location was a rocker switch (22%) which used a similar push in motion. Rocker switches were also the primary switch selected for the lower panels (pooled zones 4 and 6). The push in method of operation was preferred for all switches and locations except the stalks.

Summary of Preferences

Location:	• **steering wheel spokes,** • **right side preferred over left**
Switch:	• **no dominantly preferred switch** • **rockers slightly more than pushbuttons**
Method of Operation:	• **push in**

Cruise Control On/Off

(n = 54 total observations)

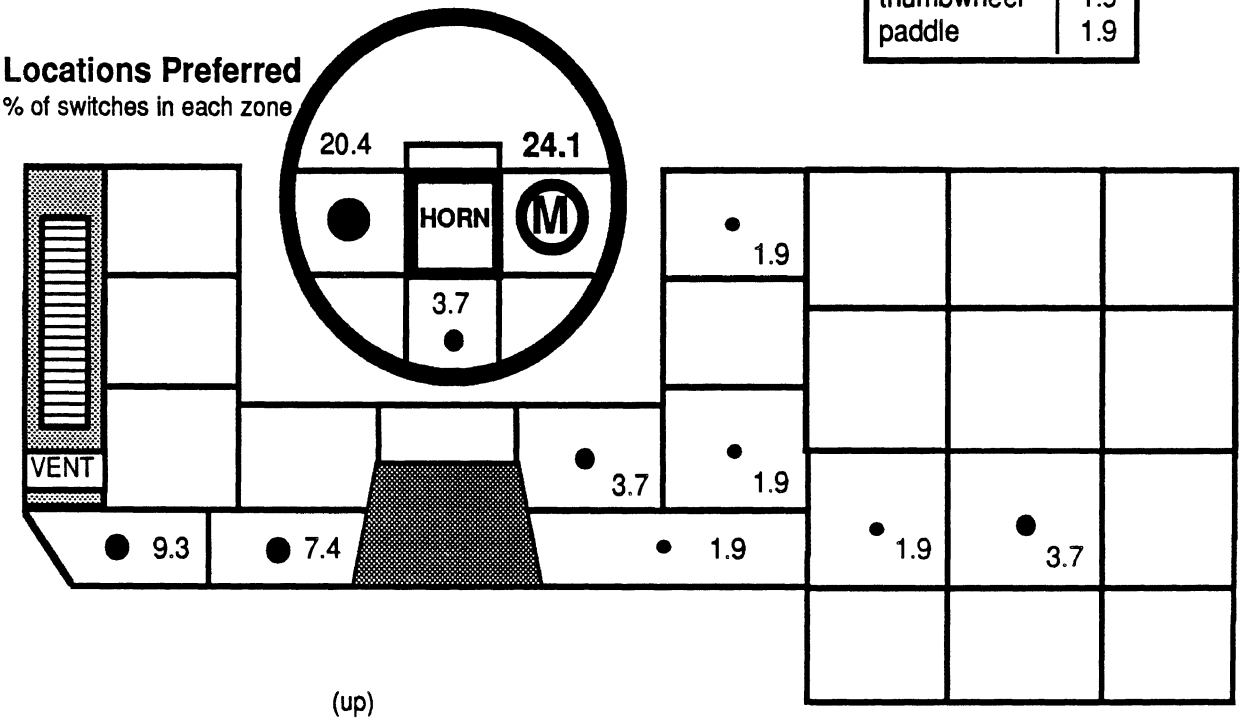


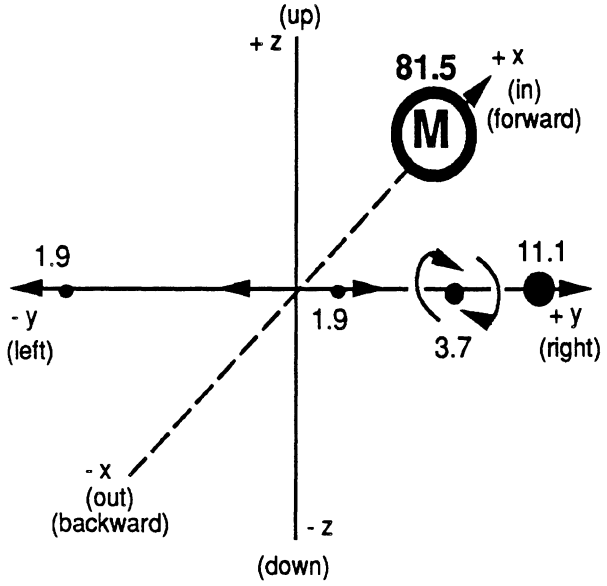
Switches Preferred

Switch	%
rocker	40.7
pushbutton or push surface*	35.2
stalk	20.4
thumbwheel	1.9
paddle	1.9

Locations Preferred

% of switches in each zone





Methods of Operation Preferred

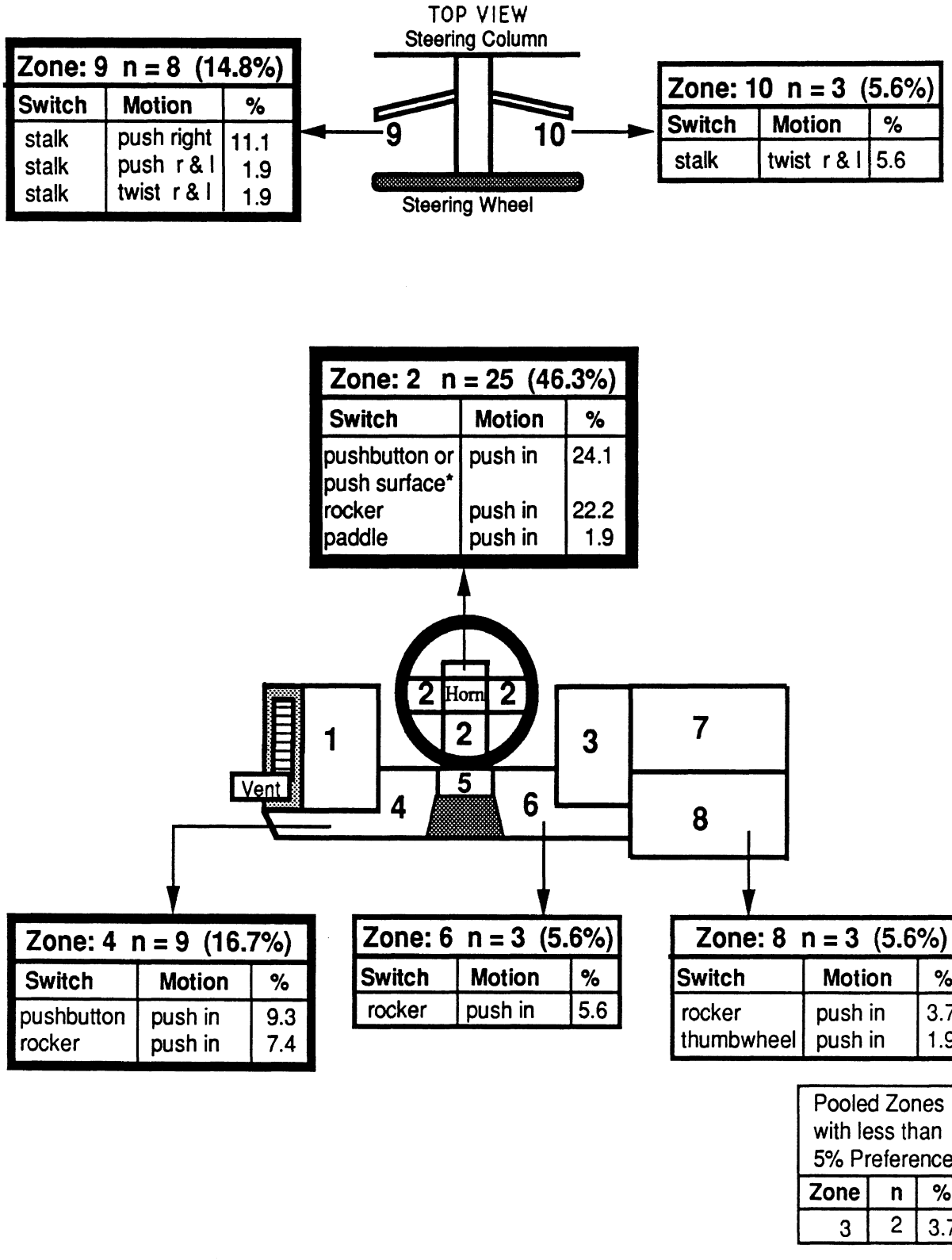
(axes relative to the driver)

Method of Operation		%
	push in	81.5
	push right	11.1
+y / - y	twist + & - y	3.7
	push right & left	1.9
	push left	1.9

*Note: Most drivers misinterpreted the push surface to be a flush-mounted pushbutton.

Cruise Control On/Off

Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)



Zone: 9 n = 8 (14.8%)

Switch	Motion	%
stalk	push right	11.1
stalk	push r & l	1.9
stalk	twist r & l	1.9

Zone: 10 n = 3 (5.6%)

Switch	Motion	%
stalk	twist r & l	5.6

Zone: 2 n = 25 (46.3%)

Switch	Motion	%
pushbutton or push surface*	push in	24.1
rocker	push in	22.2
paddle	push in	1.9

Zone: 4 n = 9 (16.7%)

Switch	Motion	%
pushbutton	push in	9.3
rocker	push in	7.4

Zone: 6 n = 3 (5.6%)

Switch	Motion	%
rocker	push in	5.6

Zone: 8 n = 3 (5.6%)

Switch	Motion	%
rocker	push in	3.7
thumbwheel	push in	1.9

Pooled Zones with less than 5% Preference

Zone	n	%
3	2	3.7

*Note: Most drivers misinterpreted the push surface to be a flush-mounted pushbutton.

Why Locations Were Preferred

The following two pages of graphics show why drivers wanted the cruise on/off control in various locations and preferred various types of switches. Readers are reminded that the total number of responses can exceed 54 because there was no limit as to how many reasons each participant could offer as to why a particular location, switch, or motion was preferred. As noted earlier, data on method of operation is not presented because once the switch and location (in particular the mounting plane) were selected, the method of operation was highly constrained. Further, comments about method of operation tended to be uninformative. In describing why particular locations and switches were preferred, the two types of responses were often intertwined for the cruise on/off function.

There was no single dominant reason why particular locations were favored. The most commonly chosen reason (18% of the participants) was the desire to keep one's hands on the steering wheel while driving (see the following left page). As one participant commented, "It's easy to reach without taking my hands off the wheel." This reason was given for locating the switch on the steering wheel hub. Related to that were nine people who cited handedness as a reason for selecting spoke-mounting. One driver explained, ". . .it seems convenient to use with the left hand; I want to keep my right hand on the steering wheel." Comments about handedness were also mentioned with regards to stalk controls. Finally, people were rather consistent in commenting that familiarity or expectation influenced their preferences (17%). "It always seems to be there, I'm used to it and I think that's a good place for it," stated one driver.

Why Switch Types Were Preferred

Concerning switch type, shown on the right page, aesthetics ("I like the way it looks") was a key reason, though it did not dominate the responses. For the rocker switch, 10 of the 52 reasons given were associated with this. It was also the most common reason selected for pushbuttons. In both cases, drivers stressed the simplicity of the switch they selected. One person chose a switch because, "Its simple procedure makes it easy to use." Another commonly offered reason was associated with expectation or familiarity. In several cases, participants chose a switch similar to that in their own vehicle. Having familiarity in mind, they subsequently chose the same location as in their own vehicle. This was one of the instances where people gave reasons for switch selection which incorporated the intended location. For example, a driver selected a rocker based partly on familiarity, and explained her selection with regard to its upcoming location, "It's like that in my car and I like it: it's easy to reach and I don't have to fumble to set it."

Finally, there were several instances where participants chose a particular switch because of its labelling. As one driver stated, "I like the green coloring and how it's clearly labelled." This was in spite of instructions that said to ignore labels. Therefore, in future studies, labels identifying switch functions (e.g., "cruise on/off") should be removed and possibly labels for switch position (e.g., "on," "off") as well.

Summary of Reasons Why

Preferred Location:

- **no dominant reason**

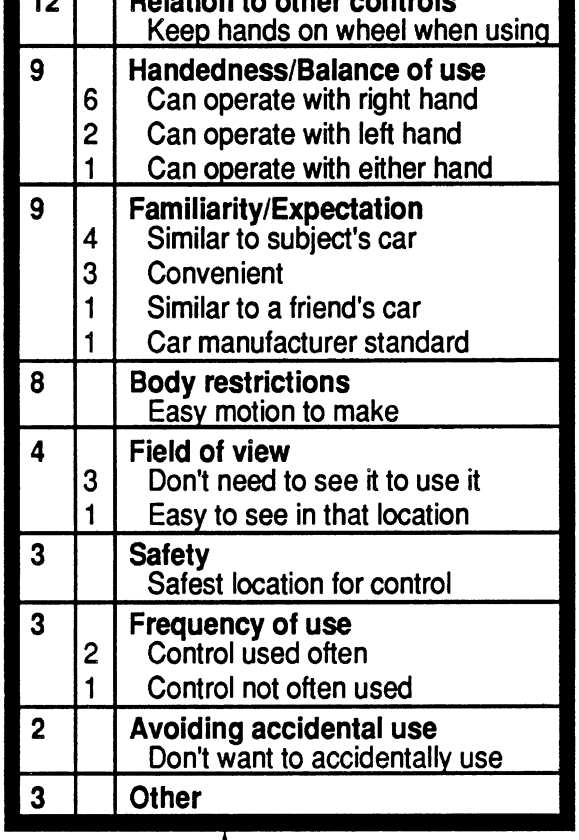
Preferred Switch:

- **aesthetics was most commonly cited for rocker switch (preferred design)**
- **familiarity/expectation and labelling were also important (drivers wanted designs similar to their own vehicle)**

Cruise Control On/Off

Reasons for choosing locations for specific functions by pooled zones
(n = 104 total observations)

Zone 2: Steering Wheel (n=53)		
n		Reason
12		**Relation to other controls** Keep hands on wheel when using
9		**Handedness/Balance of use**
	6	Can operate with right hand
	2	Can operate with left hand
	1	Can operate with either hand
9		**Familiarity/Expectation**
	4	Similar to subject's car
	3	Convenient
	1	Similar to a friend's car
	1	Car manufacturer standard
8		**Body restrictions** Easy motion to make
4		**Field of view**
	3	Don't need to see it to use it
	1	Easy to see in that location
3		**Safety** Safest location for control
3		**Frequency of use**
	2	Control used often
	1	Control not often used
2		**Avoiding accidental use** Don't want to accidentally use
3		**Other**



Zone 9: Left Stalk (n=15)		
n		Reason
7		**Familiarity/Expectation**
	4	Similar to subject's car
	2	Feels it's an industry standard
	1	Expects switch to be there
3		**Handedness/Balance of use** Can operate with left hand
5		**Other**

Zone 6: Lower Right Panel (n=7)		
n		Reason
2		**Part of system** Same location as rest of system
2		**Sequence of use** Used in sequence with others
3		**Other**

Zone 4: Lower Left Panel (n=15)		
n		Reason
4		**Frequency of use** Control not often used
3		**Handedness/Balance of use** Can operate with left hand
8		**Other**

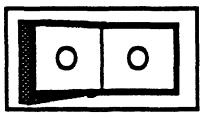
Overall reasons for location preference†	n	%
Handedness/Balance of use	19	18.3
Familiarity/Expectation	18	17.3
Relation to other controls	16	15.4
Body restrictions	10	9.6
Frequency of use	9	8.7

†Overall reasons represent the total of frequent reasons (shown) plus infrequent reasons (not shown)

Cruise Control On/Off

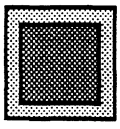
Reasons for choosing types of switches for specific functions

(n = 116 total observations)



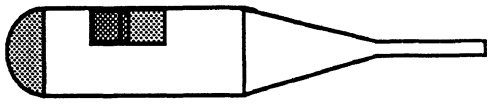
Rocker Switch (n = 52)

n		Reason
10		**Aesthetics**
	6	Looks simple to use
	4	Like the way it looks
6		**Properties of operation**
	3	Shouldn't be too easy to move
	1	Represents function well
	1	Should move easily
	1	Easier to use than others
5		**Feedback**
		Should sense when activated
4		**Body restrictions**
		Easy motion to make
4		**Familiarity/Expectation**
	1	Similar to subject's car
	1	Similar to a firend's car
	1	Expects switch to look like this
	1	Convenient
3		**Avoiding accidental use**
		Don't want to accidentally use
3		**Field of view**
		Don't have to see it to use it
3		**Partiality/General preference**
	2	Subject likes this type of switch
	1	Doesn't like, but feels it's best
14		**Other**



Push Surface* (n = 18)

n		Reason
4		**Familiarity/Expectation**
	3	Similar to subject's car
	1	Convenient
4		**Grasping/Touching**
	2	Big enough to easily grasp
	1	Other switches are too small
	1	Other switches are too big
2		**Body restrictions**
		Easy motion to make
2		**Relation to other controls**
		Keep hands on wheel when using
6		**Other**



Stalk Control (n = 22)

n		Reason
4		**Familiarity/Expectation**
	2	Similar to subject's car
	1	Expects switch to look like this
	1	Convenient
3		**Labelling/Illumination**
	2	Easy to see/read
	1	Labelling matches function
2		**Body restrictions**
		Easy motion to make
2		**Avoiding accidental use**
		Don't want to accidentally use
2		**Space restrictions**
		Won't stick out or get in way
9		**Other**

Pushbutton (n = 21)

n		Reason
6		**Aesthetics**
	3	Looks simple to use
	2	Subject likes the way it looks
	1	Nice design/looks unique
3		**Labelling/Illumination**
	2	Labelling matches function
	1	Easy to see/read
2		**Familiarity/Expectation**
		Similar to subject's car
2		**Body restrictions**
		Easy motion to make
2		**Field of view**
		Will stand out and be seen
6		**Other**

Overall reasons for switch preferences:†	n	%
Aesthetics	19	16.4
Familiarity/Expectation	14	12.1
Body Restrictions	12	10.3
Labelling/Illumination	10	8.6

*Note: Most drivers misinterpreted the push surface to be a flush-mounted pushbutton.

† Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Cruise Control Set

Location Preferences

The preferred location for cruise control set (as shown on the following left page) was the right spoke of the steering wheel (37%). The left (13%), lower (4%) and upper (4%) spokes were also selected by drivers making the steering wheel (pooled zone 2 on the following right page) the most preferred location (selected by 57% of the participants.) This represented an unusually large consensus since the preferred location for a function was usually selected by only about 30% of those responding. Other common locations included both the left (15%) and right (13%) stalks.

Switch Preferences

As mentioned earlier, participants misinterpreted the push surface to be a flush-mounted pushbutton and often chose it instead of the pushbutton. Therefore, the pushbutton and push surface values have been combined for this function, making the pushbutton the preferred choice (43%). This choice is also evident for the steering wheel hubs (zone 2), where 64%* of the responses for that pooled zone were for pushbuttons. The rocker switch was also common (24%), and was used on the steering hub as well. Finally, the stalk control was chosen for areas where stalks would normally be located (pooled zones 9 and 10).

It is interesting to note that the rocker switch was preferred more for the cruise control on/off, whereas the pushbutton dominated the cruise control set. This supports good human factors practice, in that adjacent controls (drivers typically placed the on/off and set buttons near each other) should be of different types. This helps avoid errors or accidental use when reaching for the control, since the cruise control is often used by drivers without looking, allowing them to distinguish functions by physical differences between the controls.

Method of Operation Preferences

Drivers overwhelmingly preferred (70%) a forward motion of pushing a switch inward to use it. This method was adopted for all locations with the exception of the stalk controls, for which the method of operation depended upon the design of the stalk. The left stalks utilized a push left motion (toward the steering column) while most of the right stalks used a twisting motion around the horizontal axis.

Combined Preferences

Not only did people in general want to push in a switch to operate the cruise set, but they were in unanimous agreement to do so when the switch was on the steering wheel spokes, the favored location. Further, the switches preferred for that location (pushbutton and rocker) can only be operated by pushing in.

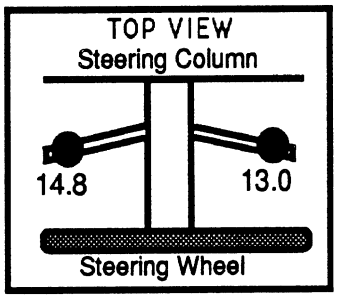
Summary of Preferences

Location:	• **steering wheel spokes** • **right side preferred over left**
Switch:	• **pushbutton**
Method of Operation:	• **push in (toward front of vehicle)**

* from switch motion preference by pooled zone figure (following right page):
35.2% chose pushbuttons in zone 2. Zone 2 was selected by 57.4%, therefore 35.2%/57.4% = 64.4% of the steering wheel responses preferred pushbuttons.

Cruise Control Set

(n = 54 total observations)

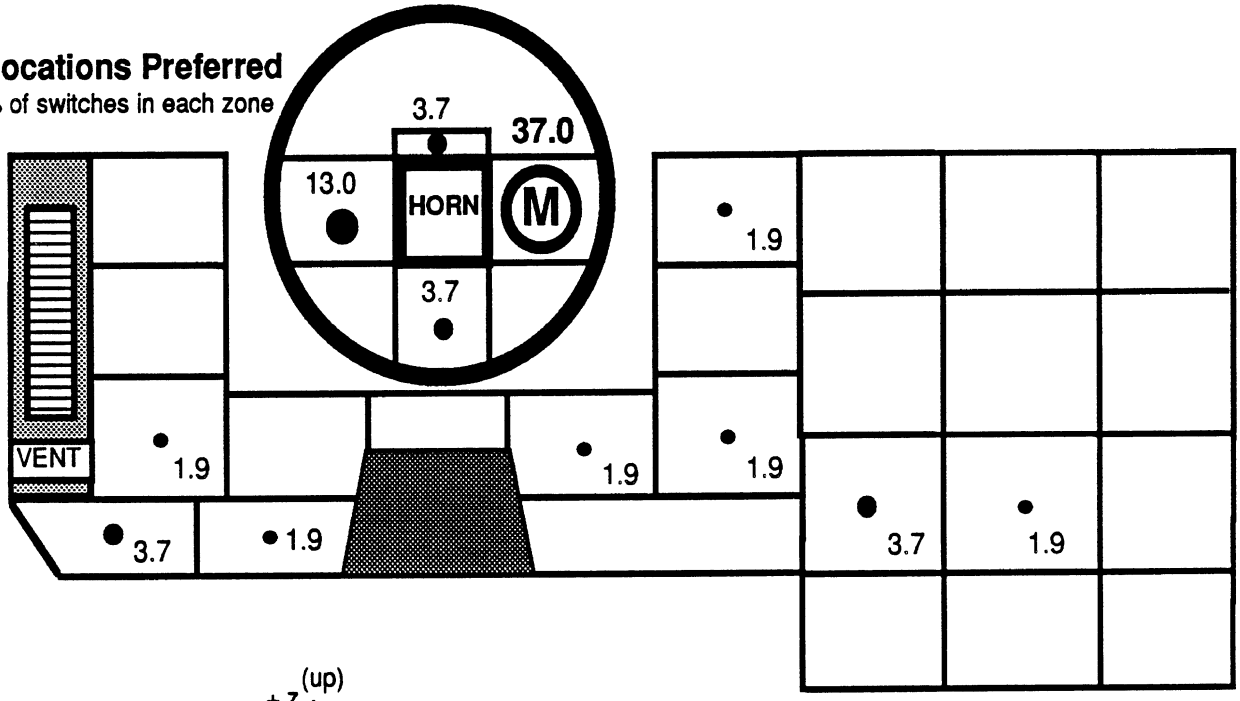


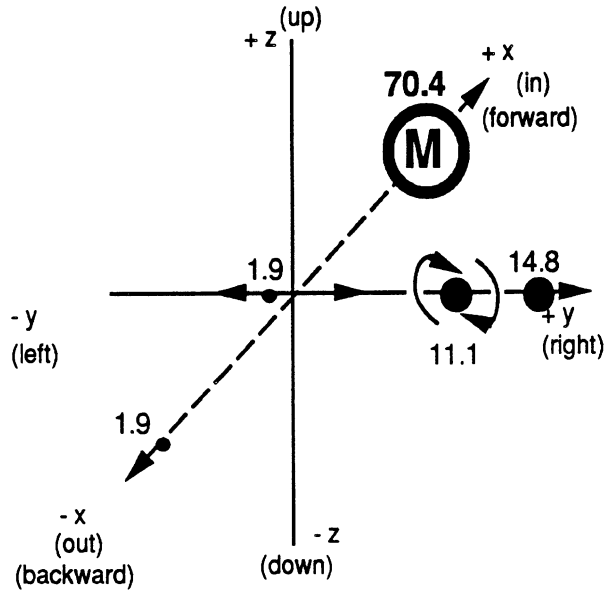
Switches Preferred

Switch	%
pushbutton or push surface*	42.6
stalk	27.8
rocker	24.1
paddle	3.7
slide	1.9

Locations Preferred

% of switches in each zone





Methods of Operation Preferred

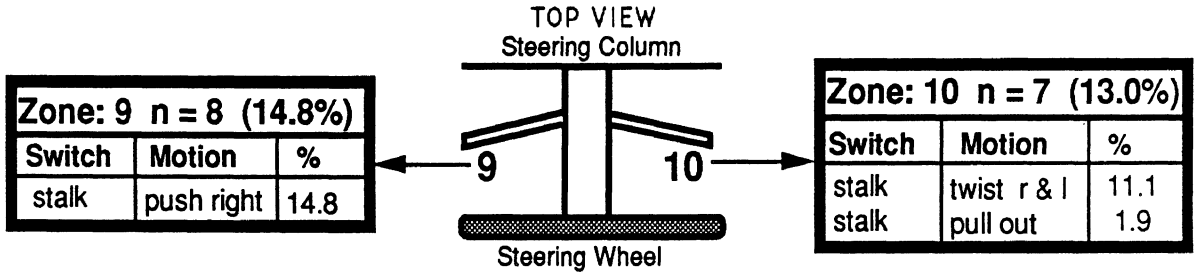
(axes relative to the driver)

Method of Operation		%
	push in	70.4
	push right	14.8
+y / - y	twist + & - y	11.1
	push right & left	1.9
	pull out	1.9

*Note: Most drivers misinterpreted the push surface to be a flush-mounted pushbutton.

Cruise Control Set

Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)



Zone: 9 n = 8 (14.8%)

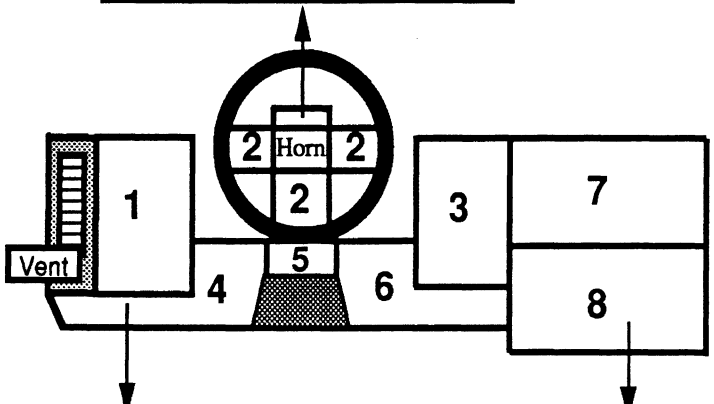
Switch	Motion	%
stalk	push right	14.8

Zone: 10 n = 7 (13.0%)

Switch	Motion	%
stalk	twist r & l	11.1
stalk	pull out	1.9

Zone: 2 n = 31 (57.4%)

Switch	Motion	%
pushbutton or push surface*	push in	35.2
rocker	push in	18.5
paddle	push in	3.7



Zone: 4 n = 3 (5.6%)

Switch	Motion	%
pushbutton or push surface*	push in	5.6

Zone: 8 n = 3 (5.6%)

Switch	Motion	%
rocker	push in	3.7
pushbutton	push in	1.9

Pooled Zones with less than 5% Preference

Zone	n	%
1	1	1.9
6	1	1.9

*Note: Most drivers misinterpreted the push surface to be a flush-mounted pushbutton

Why Locations Were Preferred

The following two pages explain why people selected the locations and switches for cruise control set which were just described. Although no single reason predominated, drivers tended to select a location based on three ideas. Over all locations, the relation to other controls was considered by 19% of the drivers, stressing the need to operate the switch while keeping both hands on the steering wheel. One person explained, "I can reach it easily with either hand quickly, without taking my hands off the wheel." A similar issue, handedness, was mentioned by 17% of the drivers regarding location selection. In support of the right spoke of the steering wheel (most preferred location), one person stated, "I'm right handed and I'm used to having it on the right side." This comment also refers to the issue of familiarity or expectation which influenced location choice (18%).

The importance of being able to operate the control while keeping either one or both hands on the wheel supported the preferred location of the steering wheel spokes. This pair of reasons was specified in 40% of the responses. It should be noted that many participants who stated handedness as their reasoning for location selection implied the concept of keeping both hands on the steering wheel. Although "handedness" and "relation to other controls" were two separate categories, their relationship implies that drivers showed a predominant concern in keeping both hands on the steering wheel.

Why Switch Types Were Preferred

There were no dominant reasons for switch type preference for the cruise control set function. Aesthetics was mentioned overall by 12%, and was prevalent in pushbutton selection, on which 21% of the responses were based. Drivers were mainly interested in a simple-looking control, as one stated, "I like the way it looks--simple and easy to use." Familiarity/expectation also played a role (13% overall) in switch type preference. Drivers tended to select switches that were similar to those in their current cars. This continued a trend in which drivers based both switch and location preferences on those of their own vehicles.

The properties of operation of the switch were also a factor (10%) in switch preference. This idea encompassed the ease with which the switch moved, and primarily, how well the switch represented the function. One driver explained his stalk control selection with "The design is good for the [cruise control] function." Once again, drivers admitted to selecting switches based on labelling (7%), despite the experimenter's instructions to ignore such characteristics of the switch.

Summary of Reasons Why

Preferred Location:

- **drivers wanted to operate the control while keeping one or both hands on the steering wheel**

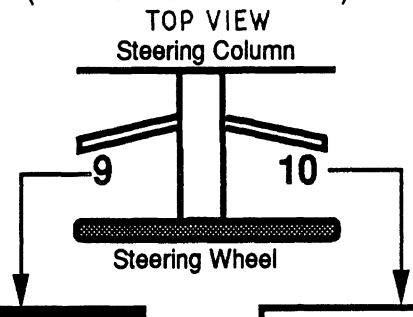
Preferred Switch:

- **no dominant reason**
- **pushbuttons and rockers were often selected for aesthetic reasons by drivers wanting simple looking controls**
- **some drivers based both location and switch preferences on familiarity**

- Results and Discussion -

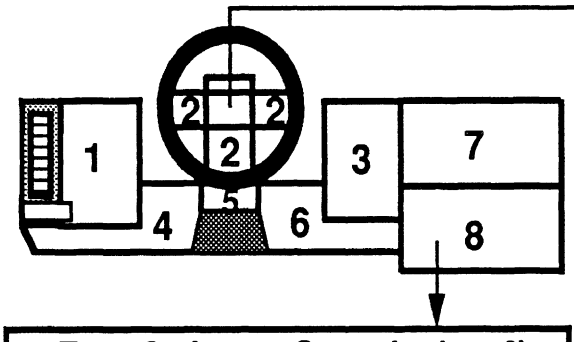
Cruise Control Set

Reasons for choosing locations of specific functions by pooled zones
(n = 106 total observations)



Zone 9: Left Stalk (n=16)		
n		Reason
9		**Familiarity/Expectation**
	4	Similar to subject's car
	3	Feels it's an industry standard
	1	Expects switch to be there
	1	Convenient
3		**Handedness/Balance of use**
		Can operate with left hand
2		**Relation to other controls**
	1	Keep hands on wheel when using
	1	Won't confuse with other controls
2		**Other**

Zone 10: Right Stalk (n=12)		
n		Reason
3		**Relation to other controls**
		Keep hands on wheel when using
2		**Familiarity/Expectation**
		Expects switch to be there
2		**Handedness/Balance of use**
		Can operate with right hand
5		**Other**



Zone 2: Steering Wheel (n=64)		
n		Reason
15		**Relation to other controls**
		Keep hands on wheel when using
10		**Handedness**
	7	Can operate with right hand
	2	Can operate with either hand
	1	Can operate with left hand
9		**Body Restrictions**
		Easy motion to make
8		**Familiarity/Expectation**
	4	Similar to subject's car
	3	Convenient
	1	Car mufacturer standard
6		**Frequency of use**
	5	Control used often
	1	Control not often used
5		**Field of view**
	4	Don't need to see it to use it
	1	Easy to see in that location
3		**Safety**
		Safest location for control
3		**Time requirements**
	2	Need to operate control quickly
	1	Need to operate it without thinking
5		**Other**

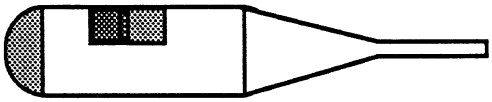
Zone 8: Lower Console (n = 6)		
n		Reason
2		**Handedness/Balance of use**
		Can operate with right hand
4		**Other**

Overall reasons for location preference†	n	%
Relation to other controls	20	18.9
Familiarity/Expectation	19	17.9
Handedness	18	17.0
Body restrictions	11	10.4
Field of view	9	8.5

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

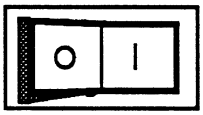
Cruise Control Set

Reasons for choosing types of switches for specific functions
(n = 107 total observations)



Stalk Control (n = 29)

n		Reason
4		**Labelling/Illumination**
	2	Labelling matches function
	2	Easy to see/read
4		**Familiarity/Expectation**
	2	Similar to subject's car
	1	Expects it to look like this
	1	Convenient
3		**Body restrictions**
		Easy motion to make
3		**Avoiding accidental use**
		Don't want to accidentally use
3		**Relation to other controls**
	2	Keep hands on wheel when using
	1	Won't confuse with other controls
3		**Properties of operation**
	1	Switch represents function well
	1	Should move easily
	1	Feels right when you move it
9		**Other**

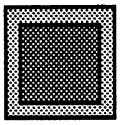


Rocker Switch (n = 28)

n		Reason
4		**Field of view**
	3	Don't need to see it to use it
	1	Need to see it to use it
4		**Familiarity/Expectation**
	2	Similar to subject's car
	1	Similar to a friend's car
	1	Expects switch to look like this
3		**Body restrictions**
		Easy motion to make
3		**Aesthetics**
	2	Switch looks simple to use
	1	Subject likes the way it looks
3		**Properties of operation**
	1	Switch represents function well
	1	Should move easily
	1	Shouldn't be too easy to move
11		**Other**

Pushbutton (n = 28)

n		Reason
6		**Aesthetics**
	3	Looks simple to use
	2	Subject likes the way it looks
	1	Nice design/Looks unique
4		**Properties of operation**
	2	Switch represents function well
	1	Should move easily
	1	Easier to use than others
3		**Labelling/Illumination**
	2	Easy to see/read
	1	Labelling matches function
3		**Partiality/General preferences**
	1	Subject likes that type of switch
	1	Doesn't like, but feels it's best
	1	Likes pushbutton for Cruise Set
12		**Other**



Push Surface* (n = 17)

n		Reason
3		**Relation to other controls**
		Keep hands on wheel when using
3		**Familiarity/Expectation**
	2	Similar to subject's car
	1	Convenient
3		**Aesthetics**
	2	Switch looks simple to use
	1	Other areas too cluttered
8		**Other**

Overall reasons for switch preference†	n	%
Familiarity/Expectation	14	13.1
Aesthetics	13	12.1
Body restrictions	13	12.1
Properties of operation	11	10.3
Relation to other controls	10	9.3

*Note: Most drivers misinterpreted the push surface to be a flush-mounted pushbutton.
†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Dome Light

Location Preferences

Drivers preferred the outboard corner of the lower left panel (19%) for the dome light control, as shown on the following left page. In this case the dome light switch was usually integrated with the headlights on/off switch and thus, in the same location. Both the front and center ceiling panels were also commonly selected. This was the only function for which the ceiling locations were used. Regarding pooled zones, the front (pooled zone 12) and center (pooled zone 13) ceiling areas were equally preferred (26% each). Both were more popular than the lower left panel (pooled zone 4, 24%), and the upper left panel (pooled zone 1, 11%). There was more variability than usual among drivers for choosing the location of the dome light control, as shown on the following right page by the variety of locations and pooled zones selected. In particular, note that there was no single preferred pooled zone, 3 zones each represented about 25% of the responses, while 5 zones represented less than 5% each.

Switch Preferences

The rocker switch was preferred overall for the dome light by one third of all respondents, as shown on the following left page. This is not a strong preference. However the rocker was the first or second-most preferred switch for all pooled zones, except the lower left panel (zone 4). For the lower left panel, (shown on right page) drivers preferred a push-pull switch, which claimed 15% of the overall preferences, and over half of the responses for the lower left panel zone. The slide switch was also selected by 15% overall. Its use was limited to the ceiling area (pooled zones 12 and 13), where it was especially popular on the center ceiling panel (zone 13). A variety of other switch types were also selected by drivers. Of slight significance were thumbwheels (9%), and push surfaces (7%). Three other switch types were chosen by less than 5% of the participants.

Method of Operation Preferences

The dome light control was unique in its scope of preferred locations and methods of operation. The tendency to place the control on the ceiling (52% combining the front and center zones) led to the preference of a push up motion (37%). This method was used with all rocker switches, pushbuttons, and push surfaces located on the ceiling, noting the influence of switch location on method of operation. The preferred method for a slide switch (also located on the ceiling) depended upon the orientation of the switch. Switches placed horizontally to the driver required a push right-left motion (found only on the center ceiling panel), while slide switches placed in the forward plane used a push in-out (toward front-back of vehicle) motion.

Even more varied was the method preferred for the push-pull switch. Although the location and orientation were similar for all push-pull switches, drivers preferred four different methods of operation on the lower left panel (pooled zone 2). The common factor was that all methods used a twisting motion around the x axis.

(See left page for axes orientation.) However, people were inconsistent in deciding whether that motion should follow a clockwise or counter-clockwise rotation.

Combined Preferences

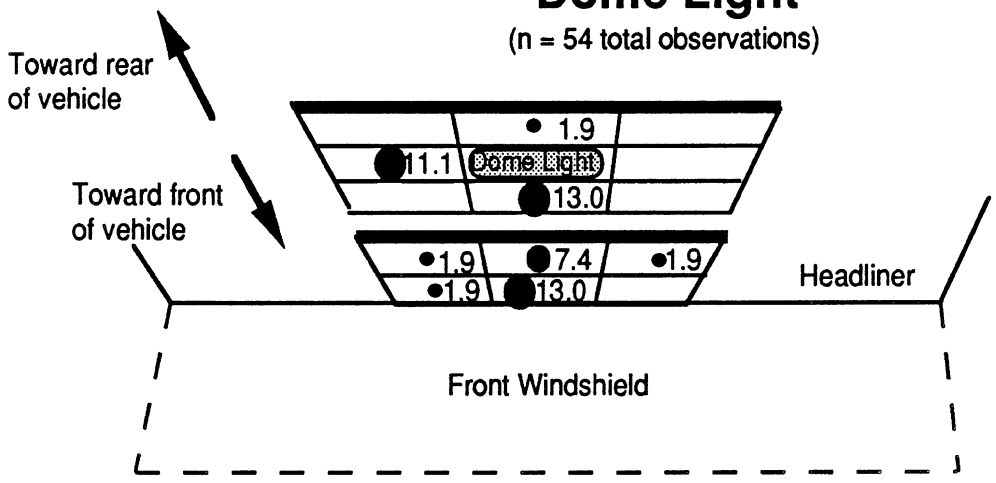
As previously mentioned, many factors influenced the operation of the dome light control. The method of operation was heavily influenced by the location and orientation of the switch for this function, since the ceiling locations (a different plane than the instrument panel) were often used. Another interesting characteristic of the dome light was the tendency to integrate the function with the headlights on/off function. This was particularly the case with the push-pull switch, where one switch controlled multiple functions through different methods of operation.

Summary of Preferences

Switch:	• **rocker**
Location:	• **ceiling area (52% total)** **front ceiling (26%), center ceiling (26%)**
	• **lower left panel (24%)**
Method of Operation:	• **push up (toward roof, for ceiling mounting)**
	• **push-pull - twist x (lower left panel)**

Dome Light

(n = 54 total observations)

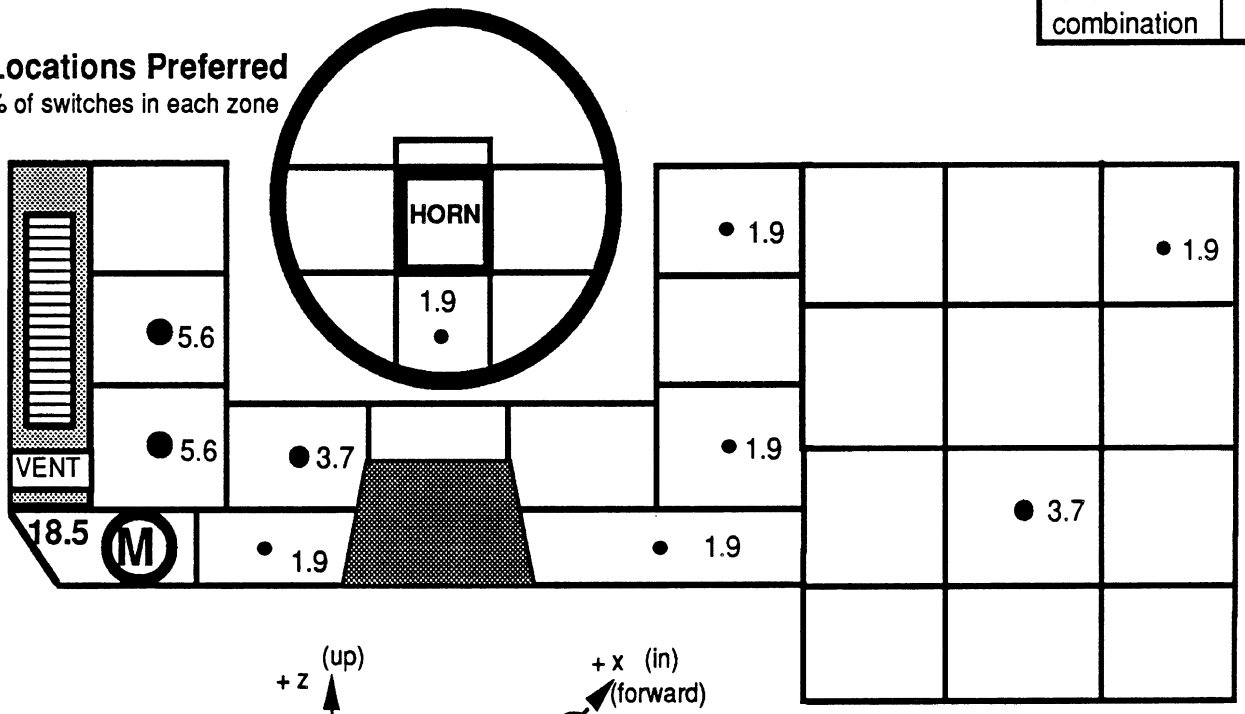


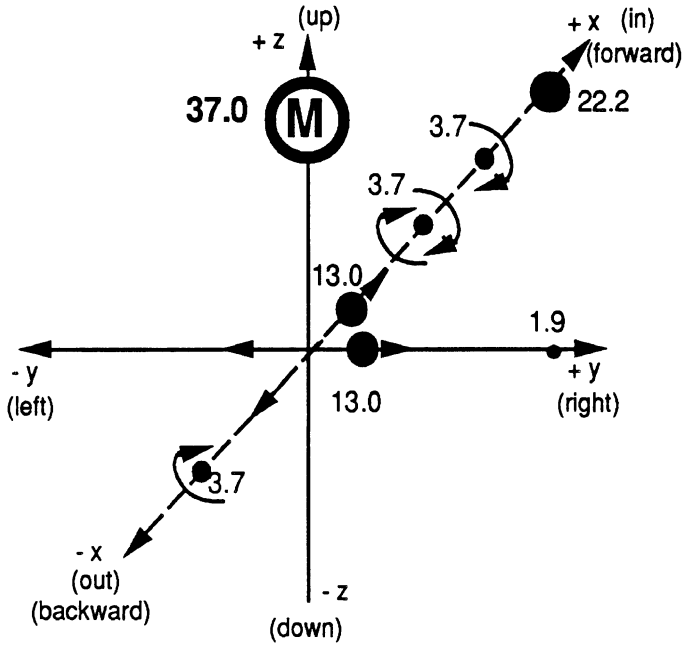
Switches Preferred

Switch	%
rocker	33.3
push-pull	14.8
slide	14.8
pushbutton	13.0
thumbwheel	9.3
push surface*	7.4
toggle	3.7
lever	1.9
combination	1.9

Locations Preferred

% of switches in each zone





Methods of Operation Preferred

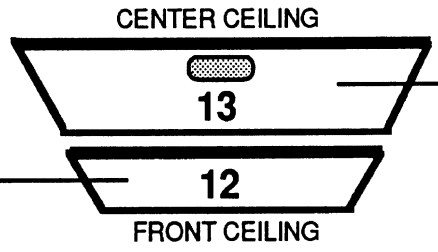
(axes relative to the driver)

Method of Operation		%
	push up	37.0
	push in	22.2
	push in & out	13.0
	push right & left	13.0
+ x	twist +x	3.7
	twist -x	3.7
- x	twist + & - x	3.7
	push right	1.9
	multi -way t & p	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Dome Light

Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)



Zone: 12 n = 14 (25.9%)

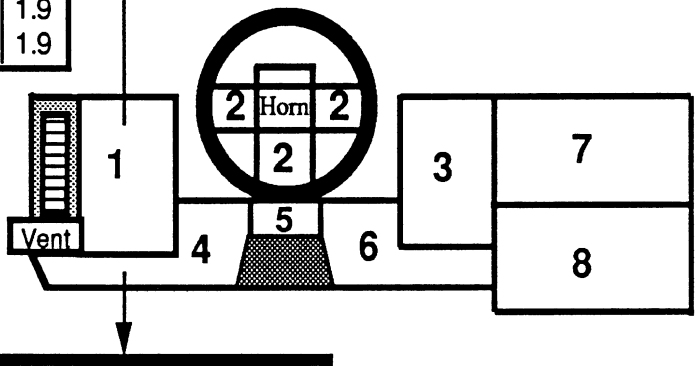
Switch	Motion	%
pushbutton	push up	9.3
rocker	push up	7.4
push surface*	push up	5.6
slide	push in & out	1.9
thumbwheel	push r & l	1.9

Zone: 13 n = 14 (25.9%)

Switch	Motion	%
rocker	push up	11.1
slide	push in & out	5.6
slide	push r & l	5.6
toggle	push in & out	1.9
lever	push in & out	1.9

Zone: 1 n = 6 (11.1%)

Switch	Motion	%
rocker	push in	3.7
push-pull	twist + x	1.9
pushbutton	push in	1.9
combination	push in	1.9
thumbwheel	push r & l	1.9



Zone: 4 n = 13 (24.1%)

Switch	Motion	%
rocker	push in	5.6
push-pull	twist + x	3.7
push-pull	twist - x	3.7
push-pull	twist +&- x	3.7
push-pull	multi-way t&p	1.9
thumbwheel	push up	1.9
thumbwheel	push right	1.9
pushbutton	push in	1.9

Pooled Zones with less than 5% Preference

Zone	n	%
2	1	1.9
3	2	3.7
6	1	1.9
7	1	1.9
8	2	3.7

*Note: Drivers may have confused push surfaces with pushbuttons.

Why Locations Were Preferred

Location preferences for the dome light control were based primarily on familiarity/expectation (19%). Two areas, the front ceiling (zone 12) and lower left panel (zone 4), were especially affected by familiarity/expectation, as shown on the following left page. Within this general response category, drivers based their decision on where the switch was in their own vehicle, where they expected the switch to be, or where they felt the switch was most convenient. A driver explained his preference for the front ceiling: "It's convenient for the passenger to reach, and where I expect it to be."

Body restrictions (16%) were also considered in deciding switch location. The ceiling locations tended to favor an easy motion, as one participant stated, "It's easy for the driver to use while reading a map or other tasks that take light." This reasoning demonstrates a good human factors principle of identifying the user's task before product design. Also related to the task, was the issue of frequency of use (13%), as a driver explained, "It's not used often, so it won't get mixed up with the other controls. It is right next to the dome light which makes it easy to remember."

Why Switch Types Were Preferred

Physical characteristics were very important to drivers when selecting switches for the dome light control. The grasping/touching characteristics were often mentioned in switch selection (12%), especially for the push-pull and slide switches, as a driver choosing a slide switch explained, "It's small enough not to get in the way, but large enough that it is easily grasped." Aesthetics (19%) were highly considered in switch choice, where drivers preferred switches that looked simple to use. The properties of operation of a switch were also somewhat influential (11%), as drivers wanted switches that represented the function, or felt right when used. Feedback was an issue favoring rocker switch selection (the most preferred switch), because drivers were concerned with being able to sense when activated. One participant supported her rocker switch selection by both properties of the switch's operation, and its feedback qualities, "It's easy to turn on and off, also it's easy to tell when it's on or off."

Familiarity/expectation again played a role in switch preference (13%), with drivers choosing switches similar to their own vehicles. The labelling of a switch still had some influence (8%) although not as extreme as some of the other functions. There was no dominant reason why people chose particular switch types for the dome light function, many factors were occasionally cited as shown on the following right page.

Summary of Reasons Why

Preferred Location:

- **familiarity/expectation drivers chose locations similar to their current vehicles**

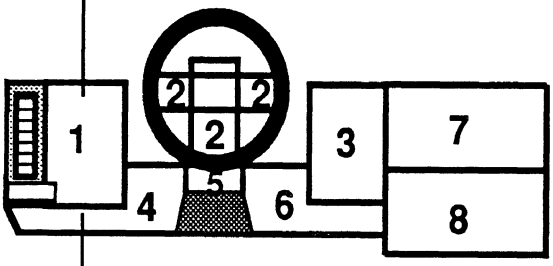
Preferred Switch:

- **no dominant reason**
- **grasping/touching characteristics were mentioned more than usual**

Dome Light

Reasons for choosing locations of specific functions by pooled zones
(n = 95 total observations)

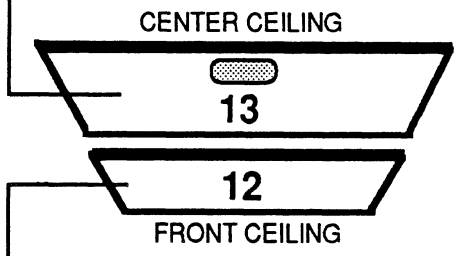
Zone 1: Left Panel (n=10)		
n		Reason
3		**Part of system** Same location as rest of system
2		**Body restrictions** Easy motion to make
5		**Other**



Zone 4: Lower Left Panel (n=28)		
n		Reason
6		**Familiarity/Expectation**
	2	Similar to subject's car
	2	Expects switch to be there
	1	Similar to a friend's car
	1	Convenient
4		**Frequency of use**
	3	Control not often used
	1	Control most commonly used
3		**Part of system** Same location as rest of system
2		**Body restrictions** Easy motion to make
2		**Space restrictions** Won't stick out or get in way
11		**Other**

Overall reasons for switch preference†	n	%
Familiarity/Expectation	18	18.9
Body restrictions	15	15.8
Part of system	14	14.7
Frequency of use	12	12.6
Additional	11	11.6

Zone 13: Center Ceiling (n=24)		
n		Reason
5		**Body restrictions** Easy motion to make
5		**Additional** Passenger can reach it also
4		**Frequency of use** Control not often used
4		**Familiarity/Expectation**
	3	Similar to subject's car
	1	Convenient
3		**Part of system** Same location as rest of system
3		**Other**

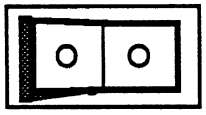


Zone 12: Front Ceiling (n=21)		
n		Reason
8		**Familiarity/Expectation**
	3	Similar to subject's car
	3	Expects switch to be there
	2	Convenient
3		**Body restrictions** Easy motion to make
2		**Space restrictions** Won't stick out or get in way
2		**Handedness/Balance of use** Too many controls for left hand
6		**Other**

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Dome Light

Reasons for choosing types of switches for specfic functions
(n = 107 total observations)

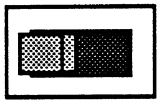


Rocker Switch (n = 36)

n		Reason
6		**Feedback**
		Should sense when activated
5		**Aesthetics**
	2	Subject likes the way it looks
	2	Switch looks simple to use
	1	Nice design/Looks unique
4		**Labelling/Illumination**
	3	Labelling matches function
	1	Easy to see/read
4		**Familiarity/Expectation**
	2	Has similar switches elsewhere
	1	Expects switch to look like this
	1	Everyone knows how to use it
3		**Partiality/General preference**
		Subject likes rocker switches
3		**Properties of operation**
	2	Feels right when you move it
	1	Switch should move easily
3		**Grasping/Touching**
	1	Surface is smooth
	1	Big enough to easily grasp
	1	Big enough to easily locate
8		**Other**

Push Pull Switch (n = 18)

n		Reason
3		**Familiarity/Expectation**
		Similar to subject's car
3		**Grasping/Touching**
	2	Can use while wearing gloves
	1	Big enough to easily grasp
2		**Aesthetics**
		Switch looks simple to use
2		**Part of system**
		Same switch as rest of system
2		**Handedness/Balance of use**
		Can operate with left hand
6		**Other**



Slide Switch (n = 18)

n		Reason
3		**Labelling/Illumination**
	1	Labelling matches function
	1	Easy to see/read
	1	Switch is easily illuminated
3		**Properties of operation**
	1	Switch represents function well
	1	Should move easily
	1	Easier to use than others
3		**Grasping/Touching**
	1	Surface is rough
	1	Big enough to easily grasp
	1	Other switches are too big
2		**Part of system**
		Different than rest of system
7		**Other**

Pushbutton (n = 16)

n		Reason
5		**Aesthetics**
	3	Switch looks simple to use
	1	Subject likes the way it looks
	1	Nice design/looks unique
3		**Familiarity/Expectation**
	1	Expect switch to look like this
	1	Convenient
	1	Has similar switches elsewhere
2		**Grasping/Touching**
		Big enough to easily grasp
6		**Other**

Overall reasons for switch preference†	n	%
Aesthetics	20	18.7
Familiarity/Expectation	14	13.1
Grasping/Touching	13	12.1
Properties of operation	12	11.2
Part of a system	8	7.5
Labelling/Illumination	8	7.5
Feedback	8	7.5

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Front Windshield Washer

Location Preferences

Drivers strongly preferred stalk locations for the windshield washer function as indicated on the following left page. The left stalk was preferred slightly more than the right stalk (30% vs. 28%). The lower left panel (pooled zone 4) and lower console (pooled zone 8) were each selected by 9% as shown on the following right page.

Switch Preferences

Drivers commonly preferred stalk controls for this function (57%), supporting the demand for the stalk locations. This percentage was rather high for switch preference, which usually was selected by about 30% of the participants. Combination switches were also somewhat popular (20%). Many other switches were preferred by one or two people, (as shown in the following left figure) but the consensus favored stalks.

Method of Operation Preferences

Overall, drivers preferred a push in motion (46%) for the windshield washer. The windshield washer was, however, a control for which the overall summary could be misleading. As shown on the right hand page, only 4% of those responding favored the push in motion for stalk controls, but always preferred it for non-stalk controls. The instances in which a push in motion was used on stalk controls usually referred to pushbuttons or surfaces on the stalk. However, since this motion is often associated with beam flashing, (when the entire stalk is pushed inward) the possibility of accidental use may arise. Other motions chosen (for stalks) included, push right (22%), pull out (15%), and push left (13%), as shown on the following left page.

Combined Preferences

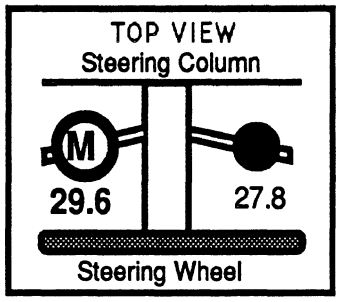
Due to the popularity of the stalk locations, stalk switches were consistently preferred. Their preferred method of operation depended upon whether the stalk was on the left or right. Among drivers who selected the left stalk control, 80% preferred a push right method (toward the steering column). This action however, is often associated with setting the cruise control, and could therefore lead to accidental use or confusion between the two controls. The method of operation used on the right stalks varied with a push left motion (toward the steering column) or a pull out motion (toward the driver). Combination switches were located on areas to the right of the steering column and utilized a push in motion.

Summary of Preferences

Location:	• **stalk areas** • **left stalk preferred slightly more than right**
Switch:	• **stalk control**
Method of Operation:	• **left stalk: push right (toward centerline)** • **right stalk: push left or pull out**

Front Windshield Washer

(n = 54 total observations)

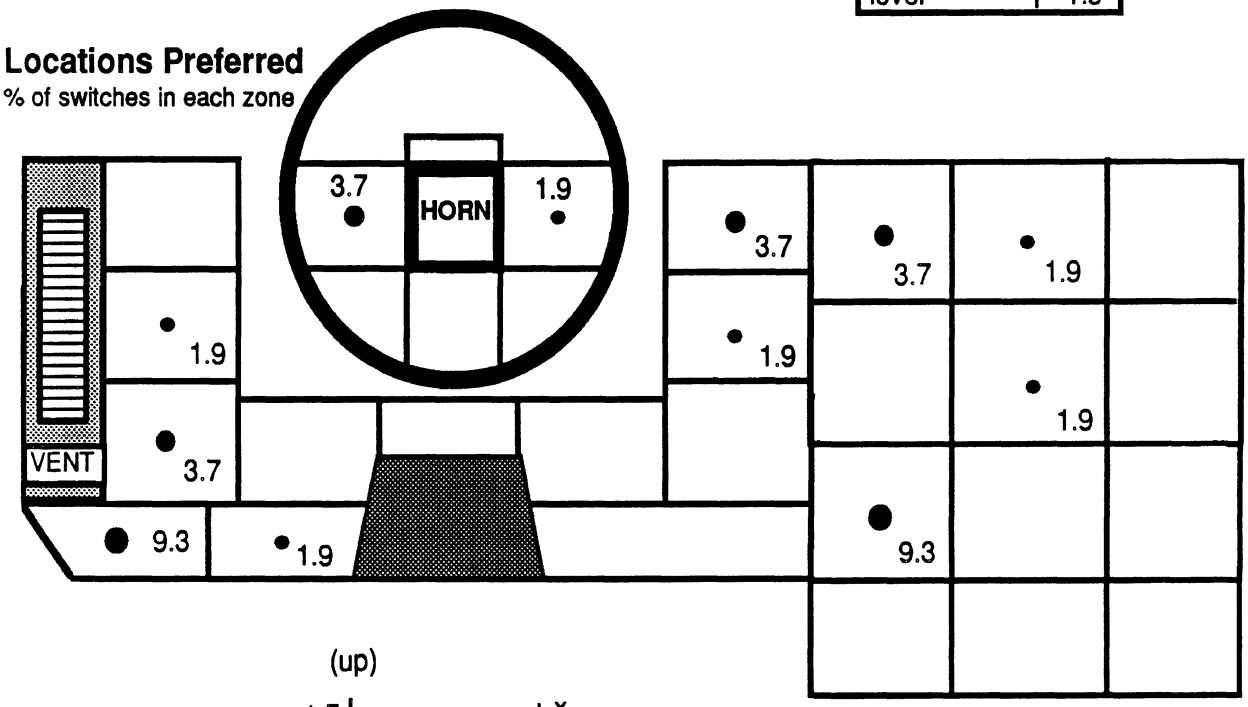


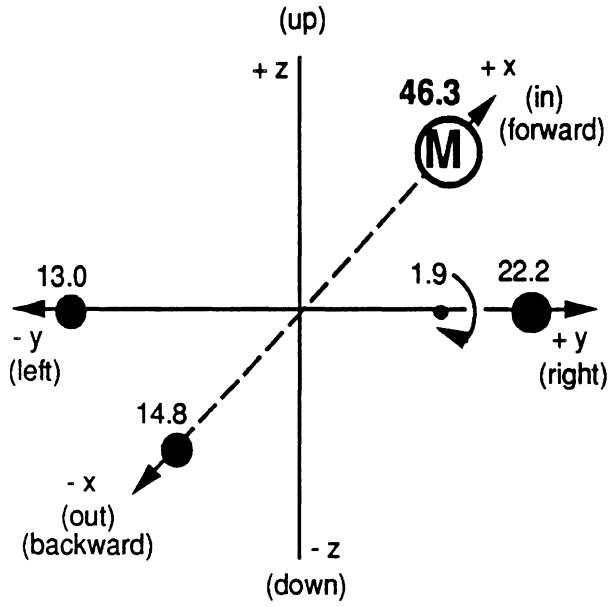
Switches Preferred

Switch	%
stalk	57.4
combination	20.4
knob	5.6
rocker	3.7
slide	3.7
push surface*	3.7
pushbutton	1.9
push-pull	1.9
lever	1.9

Locations Preferred

% of switches in each zone





Methods of Operation Preferred

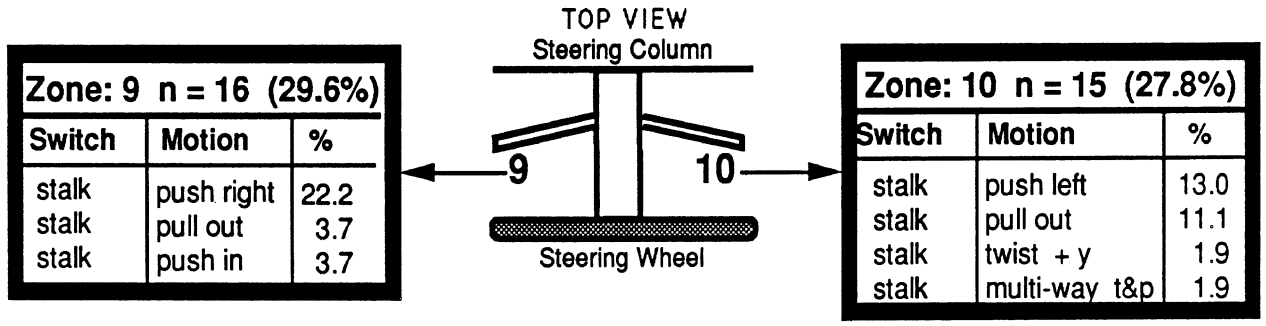
(axes relative to the driver)

Method of Operation		%
↗	push in	46.3
→	push right	22.2
↙	pull out	14.8
←	push left	13.0
↻ +y	twist + y	1.9
	multi-way t & p	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Front Windshield Washer

Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)

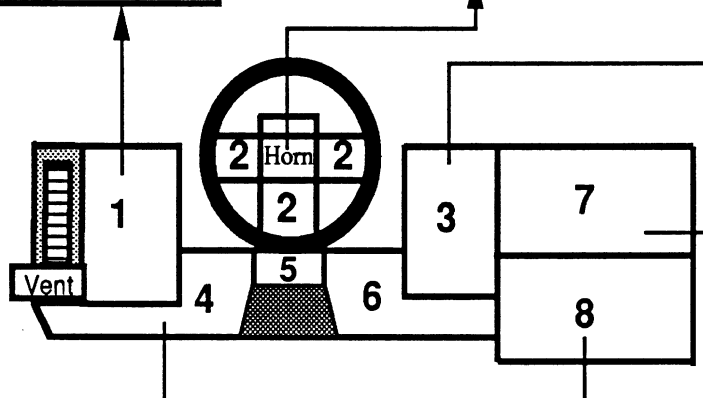


Zone: 9 n = 16 (29.6%)

Switch	Motion	%
stalk	push right	22.2
stalk	pull out	3.7
stalk	push in	3.7

Zone: 10 n = 15 (27.8%)

Switch	Motion	%
stalk	push left	13.0
stalk	pull out	11.1
stalk	twist + y	1.9
stalk	multi-way t&p	1.9



Zone: 1 n = 3 (5.6%)

Switch	Motion	%
slide	push in	3.7
rocker	push in	1.9

Zone: 2 n = 3 (5.6%)

Switch	Motion	%
combination	push in	5.6

Zone: 3 n = 3 (5.6%)

Switch	Motion	%
combination	push in	5.6

Zone: 7 n = 4 (7.4%)

Switch	Motion	%
combination	push in	3.7
push surface*	push in	1.9
pushbutton	push in	1.9

Zone: 4 n = 5 (9.3%)

Switch	Motion	%
knob	push in	5.6
push-pull	push in	1.9
rocker	push in	1.9

Zone: 8 n = 5 (9.3%)

Switch	Motion	%
combination	push in	5.6
push surface*	push in	1.9
lever	push in	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Why Locations Were Preferred

As indicated on the following left page, the most commonly cited reason for selecting windshield washer locations was body restrictions (16%). In particular drivers preferred to make an easy motion. For the left stalk location, one person stressed, "It's easy to get at when you're driving - it's accessible." Drivers continued to attribute their location preferences to multiple reasons, as one related familiarity, body restrictions, and field of view to her right stalk location, "My car is this way and I've found it's easy to use because you don't have to reach for the dashboard, so you can do it without looking." Comments referring to familiarity such as this were also common (15%), especially for the stalk locations.

Drivers also considered handedness (14%) in selecting locations, particularly the stalks, for they enabled drivers to use the control easily, as one person explained, "It's easy for my right hand and I can operate it without looking." The issue of handedness often led to drivers' concern with keeping both hands on the steering wheel (13%). A participant supported his selection of the left stalk (most preferred location) selection by stating, "It's right at your fingertips, you don't have to take your hands off the wheel."

Why Types of Switches Were Preferred

Familiarity/Expectation was a common factor in switch selection, as shown on the following right page. Decisions were based on familiarity 19% over all switches, and 25% for stalk controls specifically (most preferred switch). As in previous functions, drivers tended to give more than one reason for switch preference. One driver attributed selection to both familiarity and grasping: "It's similar to my car, easy to grasp and easy to use."

Labelling (17%) had a strong influence despite that participants were advised to ignore such qualities of the switch. In particular, combination switches were selected on this basis, as one driver stated, "The label suggests the function--it says what it does." Labelling was also a common determinant of stalk control selection. Another factor over all switches was properties of operation (10%), which covered the movement of the switch and its representation of the function. One participant explained, "It has a good feel, it's obvious when it's being turned--nice firmness in the clicks." This factor often influenced stalk control and combination switch selection. The concern for grasping and touching (8%), also arose for some people, as one driver chose a stalk for its texture and size, "It has grooves so you can feel and use it with mittens."

A final item in switch preference involved the tendency to group the front windshield washer and wiper together on one switch as part of a system. An interesting trend occurred strongly for this function where over 75% of the people preferred manufacturer-labeled switches. This was not the case for the other functions, and suggests a strong influence of familiarity and labelling in windshield washer switch selection

Summary of Reasons Why

Preferred Location:

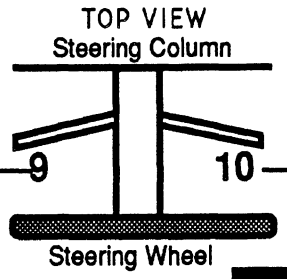
- **no dominant reason**
- **drivers chose locations similar to their current vehicle**
- **drivers wanted to operate the control while keeping one or both hands on steering wheel**

Preferred Switch:

- **drivers chose switches similar to those in their current vehicle**
- **the labelling of a switch also affected driver selection**

Front Windshield Washer

Reasons for choosing locations of specific functions by pooled zones
(n = 109 total observations)

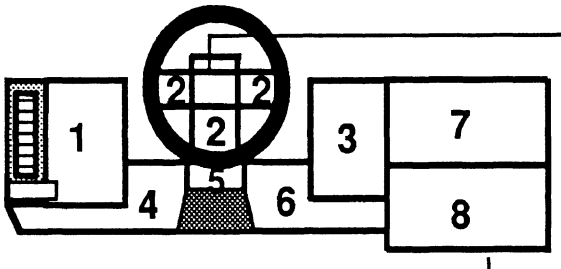


Zone 9: Left Stalk (n=27)

n		Reason
6		**Handedness/Balance of use** Can operate with left hand
4		**Body restrictions** Easy motion to make
4		**Familiarity/Expectation**
	2	Similar to subject's car
	1	Convenient
	1	Feels it's an industry standard
3		**Relation to other controls**
	2	Keep hands on wheel when using
	1	Won't confuse with other controls
3		**Field of view**
	2	Don't need to see it to use it
	1	Easy to see in that location
7		**Other**

Zone 10: Right Stalk (n=30)

n		Reason
9		**Familiarity/Expectation**
	7	Similar to subject's car
	2	Expects switch to be there
6		**Relation to other controls** Keep hands on wheel when using
4		**Handedness/Balance of use**
	3	Can operate with right hand
	1	Too many controls for left hand
2		**Aesthetics** Instrument panel looks balanced
2		**Body Restrictions** Easy motion to make
2		**Field of view** Don't need to see it to use it
2		**Frequency of use** Control used often
3		**Other**



Zone 2: Steering Wheel (n=7)

n		Reason
3		**Relation to other controls** Keep hands on wheel when using
2		**Body Restrictions** Easy motion to make
2		**Labelling/Illumination** Labelling matches function

Zone 8: Lower Console (n=11)

n		Reason
2		**Body Restrictions** Easy motion to make
2		**Labelling/Illumination** Easy to read
2		**Part of system** Same location as rest of system
5		**Other**

Overall reasons for location preference†

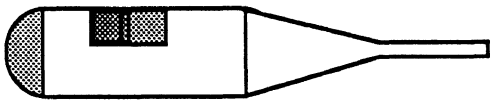
	n	%
Body restrictions	17	15.6
Familiarity/Expectation	16	14.7
Handedness	15	13.8
Relation to other controls	14	12.8
Field of view	9	8.3

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Front Windshield Washer

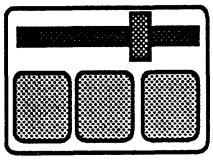
Reasons for choosing types of switches for specific functions

(n = 125 total observations)



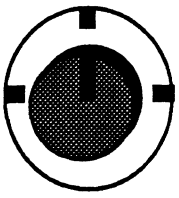
Stalk Control (n = 73)

n		Reason
18		**Familiarity/Expectation**
	9	Similar to subject's car
	3	Expects switch to look like this
	2	Similar to a friend's car
	2	Convenient
	2	Feels it's an industry standard
8		**Labelling/Illumination**
	6	Labelling matches function
	2	Easy to see/read
8		**Properties of operation**
	3	Switch represents function well
	3	It feels right when you move it
	1	Switch should move easily
	1	Easier to use than others
6		**Body restrictions**
		Easy motion to make
6		**Part of system**
		Same switch as rest of system
6		**Grasping/Touching**
	3	Rough surface prevents slipping
	2	Big enough to easily grasp
	1	Can use while wearing gloves
5		**Aesthetics**
	3	Switch looks simple to use
	1	Subject likes the way it looks
	1	Instrument panel looks balanced
5		**Time requirements**
	2	Need to operate it quickly
	2	Can operate it without thinking
	1	Need to find it quickly
11		**Other**



Combination Switch (n = 25)

n		Reason
5		**Labelling/Illumination**
	3	Switch is easy to see/read
	2	Labelling matches function
3		**Body restrictions**
		Easy motion to make
3		**Familiarity/Expectation**
	2	Similar to subject's car
	1	Has similar switches elsewhere
3		**Properties of operation**
	2	Switch should move easily
	1	Switch represents function well
3		**Aesthetics**
	1	Subject likes the way it looks
	1	Nice design/looks unique
	1	Switch looks simple to use
8		**Other**



Knob (n = 8)

n		Reason
4		**Grasping/Touching**
	2	Big enough to easily grasp
	1	Can use while wearing gloves
	1	Big enough to easily locate
2		**Properties of operation**
		Switch represents function well
2		**Other**

Overall reasons for switch preference:†	n	%
Familiarity/Expectation	**24**	**19.2**
Labelling/Illumination	**17**	**13.6**
Properties of operation	**13**	**10.4**
Aesthetics	**12**	**9.6**
Grasping/Touching	**11**	**8.8**

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Front Windshield Wiper

Location Preferences

The stalk locations were highly preferred for the windshield wiper. The left stalk was favored slightly over the right (30% vs. 28%), as indicated on the following left page. Although the stalk locations were very much preferred, six other pooled zones, as shown on the following right page were each selected by more than 5% of the respondents. This broad spread was unique to the windshield wiper, the only function which did not have any small percentage pooled zones. The other pooled zones were on the main instrument panel or steering hub, with the lower panel and console zones chosen more frequently than upper panels and consoles.

Switch Preferences

Due to the popularity of the stalk locations, stalk controls were the preferred switch chosen for the windshield wiper (57%). Combination switches were also commonly selected (22%), and occasionally knobs were preferred (6%). Six other types of switches were selected each by less than 5% of the respondents, following an opposite trend from that for location preference, where all preferences were greater than 5%. It should be noted that most drivers selected switches which controlled both the windshield wiper and washer. This integrated two functions onto one switch, presenting the wiper function as part of a washer/wiper system.

Method of Operation Preferences

The overall preferred method of operation for the windshield wiper involved a twisting motion around the horizontal (stalk) axis (46%). This method was used specifically in conjunction with stalk controls (the preferred switch type) as shown on the following right page. Other motions preferred for stalk controls included a multi-way twist and push motion on the left stalk, and a push up and down motion on the right stalk. The push up and down motion was also used for combination switches, push surfaces, slide switches and levers.

It is interesting to note that the preferred methods of operation for the windshield wiper are much different than those preferred for the windshield washer. This was a prime example of using different methods of operation for different functions on the same switch. This enabled multiple functions to be integrated onto one switch without the threat of accidentally operating the wrong function.

Combined Preferences

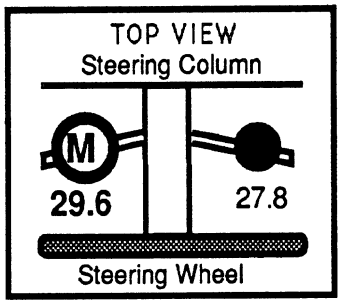
With the exception of one participant, all of the drivers tested wanted the windshield washer and wiper functions integrated onto one control. As expected, stalk controls were chosen for stalk locations, but interestingly, combination switches were typically located to the right of the driver (pooled zones 2, 3, 7 and 8), and controlled with the right hand, whereas knobs, slides and rockers were placed on the left (pooled zones 1 and 4), utilizing the left hand.

Summary of Preferences

Location:	• **stalks (left slightly more than right)**
Switch:	• **stalk controls** • **combination switches**
Method of Operation:	• **twist around horizontal (+/- y) axis**

Front Windshield Wiper

(n = 54 total observations)

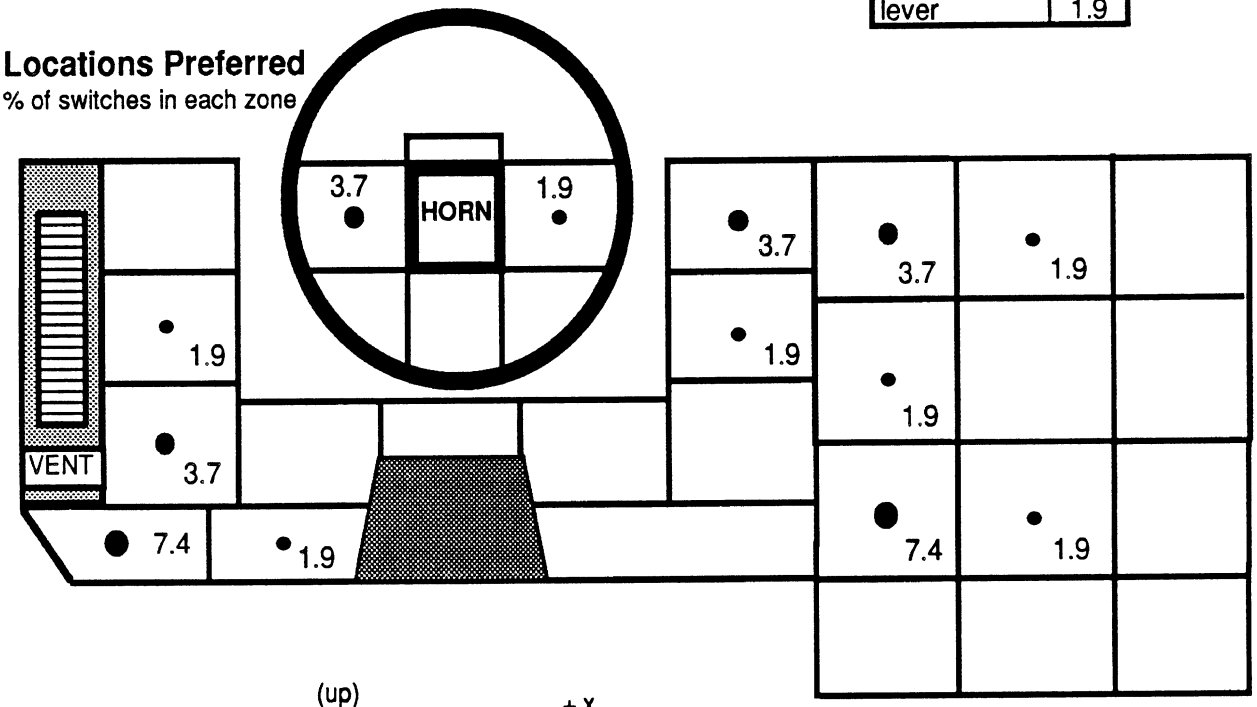


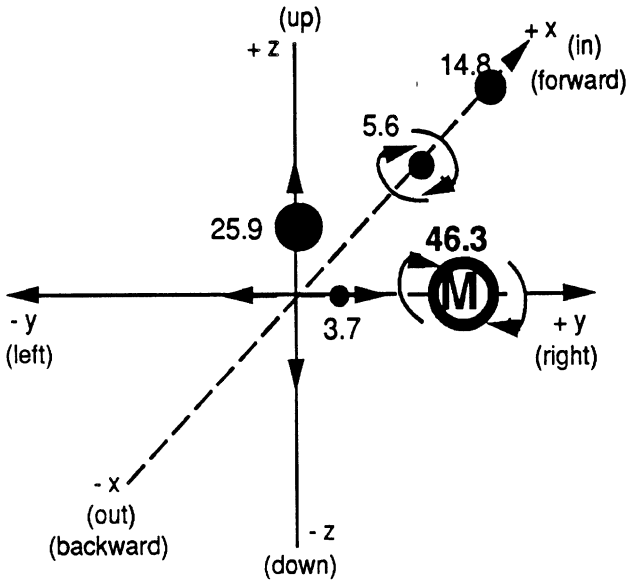
Switches Preferred

Switch	%
stalk	57.4
combination	22.2
knob	5.6
rocker	3.7
slide	3.7
push surface*	1.9
pushbutton	1.9
push-pull	1.9
lever	1.9

Locations Preferred

% of switches in each zone





Methods of Operation Preferred

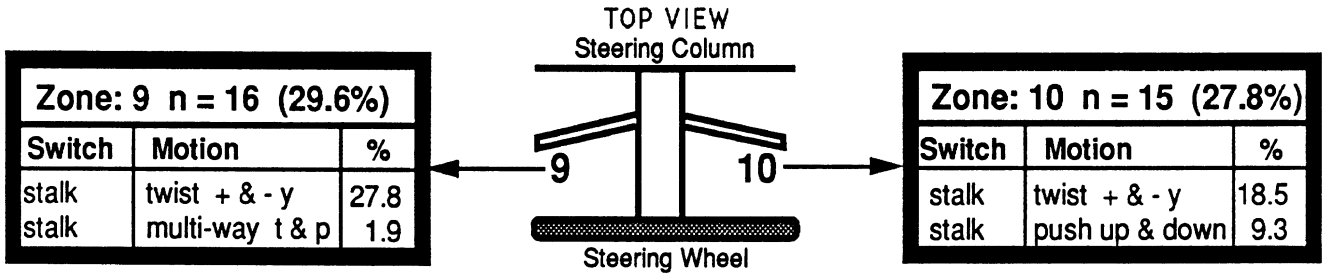
(axes relative to the driver)

Method of Operation	%
twist + & - y	46.3
push up & down	25.9
push in	14.8
twist + & - x	5.6
push right & left	3.7
multi-way t & p	3.7

*Note: Drivers may have confused push surfaces with pushbuttons.

Front Windshield Wiper

Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)

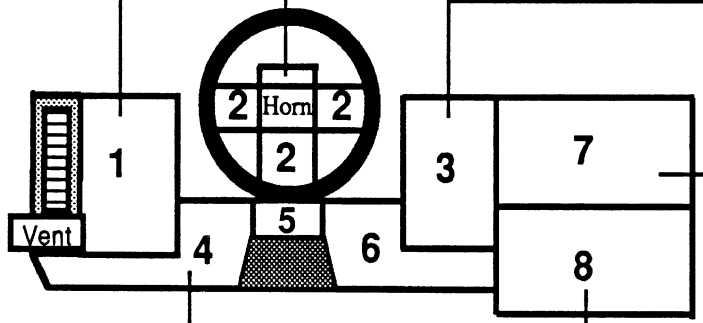


Zone: 9 n = 16 (29.6%)

Switch	Motion	%
stalk	twist + & - y	27.8
stalk	multi-way t & p	1.9

Zone: 10 n = 15 (27.8%)

Switch	Motion	%
stalk	twist + & - y	18.5
stalk	push up & down	9.3



Zone: 1 n = 3 (5.6%)

Switch	Motion	%
slide	push up & down	1.9
slide	push r & l	1.9
rocker	push in	1.9

Zone: 2 n = 3 (5.6%)

Switch	Motion	%
combination	push in	3.7
combination	push r & l	1.9

Zone: 3 n = 3 (5.6%)

Switch	Motion	%
combination	push up & down	5.6

Zone: 7 n = 4 (7.4%)

Switch	Motion	%
combination	push in	3.7
push surface*	push up & down	1.9
pushbutton	push in	1.9

Zone: 4 n = 5 (9.3%)

Switch	Motion	%
knob	twist + & - x	3.7
knob	multi-way t & p	1.9
push-pull	twist + & - x	1.9
rocker	push in	1.9

Zone: 8 n = 5 (9.3%)

Switch	Motion	%
combination	push up & down	5.6
lever	push up & down	1.9
push surface*	push in	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Why Locations Were Preferred

Drivers wanted the reach for front windshield wipers to be an easy motion to make, as reported by 18% of the responses. This often led to other reasons for location preference, as shown on the following left page. For example, one driver mentioned the following reasons for the lower console location: "I can reach it easily and see it clearly. . .it can be quickly operated." Also, familiarity/expectation (15%) was again a major factor in location selection, especially for the right stalk.

The importance of operating the control while keeping one or both hands on the steering wheel was also recognized, since 15% based decisions on being able to keep both hands on the wheel, which favored the stalk locations. As one driver explained, "It's handy there, I don't have to take my hands off the wheel." Handedness (16%) was an matter of similar concern, which often referred to the need to operate the control without removing hands from the steering wheel. This common reference to keeping hands on the steering wheel made it a key issue (30% combined) in choosing the location for the windshield wipers.

Why Switch Types Were Preferred

Familiarity/expectation was the key factor (18%) in driver preferences for windshield wiper switches. This was especially true for the stalk control (preferred switch), as one driver explained, "The design is popular, I'm familiar with it." The labelling of switches (15%) was again prominent, especially among switches from production cars, despite the experimenter's instruction to ignore such characteristics. This issue was most important to drivers who selected combination switches or stalk controls, in which the labelling matched the function; as a driver explained, "It is easy to read, the labelling makes it seem like part of a system."

Drivers were also concerned with the aesthetic qualities (12%) of a switch. This was the case for most of the switches chosen. A final issue of importance was the grasping/touching characteristics of the switch (10%). This issue primarily supported the knob and stalk controls, because participants liked the large size and often the texture of these switches. One common concern was the ability to use the control while wearing gloves or mittens, as a driver supported the stalk control, "It has grooves that you can feel, you would be able to operate it using mittens."

It is interesting that although 98% of the participants placed the windshield washer and wiper on one switch, very few mentioned choosing a switch because it was part of a system. In this case, it appeared that most drivers subconsciously thought of the windshield wiper and washer as one control, and often had difficulties differentiating between the two. This was supported by their tendency to choose manufacturer-labelled switches which represented both functions on one control.

Summary of Reasons Why

Preferred Location:

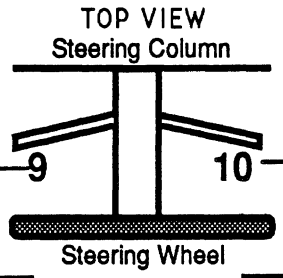
- **body restrictions (drivers wanted locations that were easy to reach**
- **drivers were concerned with keeping one or both hands on the steering wheel when using the control**

Preferred Switch:

- **familiarity/expectation- drivers chose switches similar to their current vehicles**
- **drivers based selections on the labelling and aesthetics of the switch**

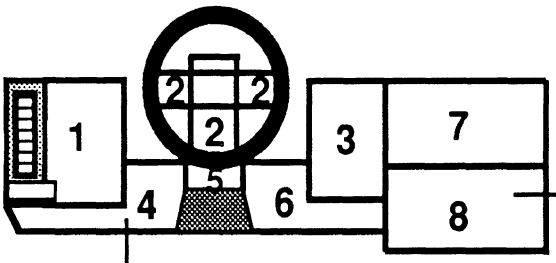
Front Windshield Wiper

Reasons for choosing locations of specific functions by pooled zones
(n = 103 total observations)



Zone 9: Left Stalk (n=27)		
n		Reason
7		**Handedness/Balance of use** Can operate with left hand
5		**Body restrictions** Easy motion to make
4		**Relation to other controls**
	3	Keep hands on wheel when using
	1	Won't confuse with other controls
3		**Familiarity/Expectations**
	2	Similar to subject's car
	1	Feels it's an industry standard
9		**Other**

Zone 10: Right Stalk (n=30)		
n		Reason
9		**Familiarity/Expectation**
	7	Similar to subject's car
	2	Expects switch to be there
6		**Relation to other controls** Keep hand on wheel when using
4		**Handedness/Balance of use**
	3	Can operate with right hand
	1	Too many controls for left hand
2		**Aesthetics** Instrument panel looks balanced
2		**Body Restrictions** Easy motion to make
2		**Field of view** Don't need to see it to use it
2		**Frequency of use** Control used often
3		**Other**



Zone 8: Lower Console (n=11)		
n		Reason
2		**Body Restrictions** Easy motion to make
2		**Labelling/Illumination** Easy to read
2		**Part of system** Same location as rest of system
5		**Other**

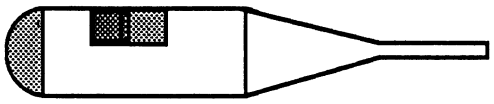
Zone 4: Lower Left Panel (n=13)		
n		Reason
3		**Handedness/Balance of use** Can operate with left hand
2		**Body restrictions** Easy motion to make
8		**Other**

Overall reasons for location preference†	n	%
Body restrictions	18	17.5
Handedness	16	15.5
Familiarity	15	14.6
Relation to other controls	15	14.6
Field of view	8	7.8

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

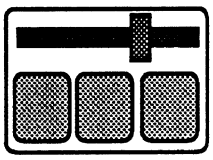
Front Windshield Wiper

Reasons for choosing types of switches for specific functions
(n = 127 total observations)



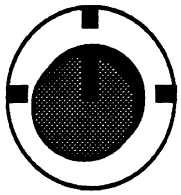
Stalk Control (n = 74)

n		Reason
17		**Familiarity/Expectation**
	9	Similar to subject's car
	2	Expects switch to look like this
	2	Similar to a friend's car
	2	Convenient
	2	Feels it's an industry standard
8		**Labelling/Illumination**
	6	Labelling matches function
	2	Easy to see/read
8		**Aesthetics**
	3	Switch looks simple to use
	4	Subject likes the way it looks
	1	Instrument panel looks balanced
8		**Grasping/Touching**
	4	Rough surface prevents slipping
	3	Big enough to easily grasp
	1	Can use while wearing gloves
8		**Properties of operation**
	3	It feels right when you move it
	2	Switch represents function well
	2	Switch should move easily
	1	Easier to use than others
6		**Body restrictions**
		Easy motion to make
6		**Time requirements**
	3	Need to operate it quickly
	2	Can operate it without thinking
	1	Need to find it quickly
13		**Other**



Combination Switch (n = 27)

n		Reason
7		**Labelling/Illumination**
	4	Switch is easy to see/read
	3	Labelling matches function
3		**Body restrictions**
		Easy motion to make
3		**Familiarity/Expectation**
	2	Similar to subject's car
	1	Has similar switches elsewhere
3		**Properties of operation**
	2	Switch should move easily
	1	Switch represents function well
3		**Aesthetics**
	1	Subject likes the way it looks
	1	Nice design/looks unique
	1	Switch looks simple to use
8		**Other**



Knob (n = 8)

n		Reason
4		**Grasping/Touching**
	2	Big enough to easily grasp
	1	Can use while wearing gloves
	1	Big enough to easily locate
2		**Properties of operation**
		Switch represents function well
2		**Other**

Overall reasons for switch preference†	n	%
Familiarity/Expectation	**23**	**18.1**
Labelling/Illumination	**19**	**15.0**
Aesthetics	**15**	**11.8**
Properties of operation	**13**	**10.2**
Grasping/Touching	**13**	**10.2**

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Hazard

Location Preferences

The steering column was preferred for the location of the hazard function, in particular the lower right quadrant, as indicated on the following left page. The pooled steering column area (zone 11), although the most common, represented only one-third of the responses. The lower left panel (zone 4) was also quite common (24%) for the hazard location. The steering wheel and three other pooled zones on the instrument panel were also suggested, as shown on the following right page. Of those, the lower panels were most preferred, which demonstrated a tendency to locate the hazard function in the vicinity of the steering column.

Switch Preferences

The rocker switch was commonly preferred (56%) for the hazard function, as shown on the following left page. It was the preferred switch for all but one of the pooled zones (on the following right page). Other drivers preferred the push button (13%) which was second to the rocker for the lower panel and console regions (pooled zones 4, 6, and 8). Similar to this was the push surface (11%), which was the preferred for the steering wheel (pooled zone 2). A push-pull switch (11%) was also called for occasionally.

Method of Operation Preferences

Drivers consistently preferred a push in (toward front of vehicle) motion (59%) to activate the hazard switch. This corresponded with the types of switches preferred, since the majority implied a pushing method. However, the position or location of the switch greatly affected the direction in which this push was applied. For example, three different methods of operation were used for the rocker switch (preferred), depending upon its location. Rocker switches placed on the instrument panel, steering wheel, or console areas used a push in (forward) motion, while the same switch, when placed on the side of the steering column, required a push left motion, and a push down motion when located on top of the steering column. The effect of switch location or orientation extended to the other preferred switch types as well.

Combined Preferences

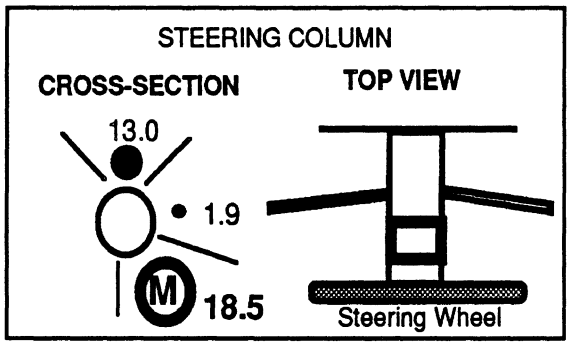
There were no interactions between preferred location and switch type. For every pooled zone except one (where it was the second choice) the preferred switch was a rocker. There were, however, differences in terms of the methods of operation used for various locations. For instance, the push in motion, the most common for all instrument panel locations (pooled zones 1 - 8) was never even suggested for steering column mounting (pooled zone 11), which was the preferred location.

Summary of Preferences

Location:	• **steering column area**
Switch:	• **rocker**
Method of Operation:	• **push in (toward front of vehicle) for all locations except the column**
	• **for column mounting, method depends upon switch orientation. top of column - push down side of column - push left**

Hazard

(n = 54 total observations)

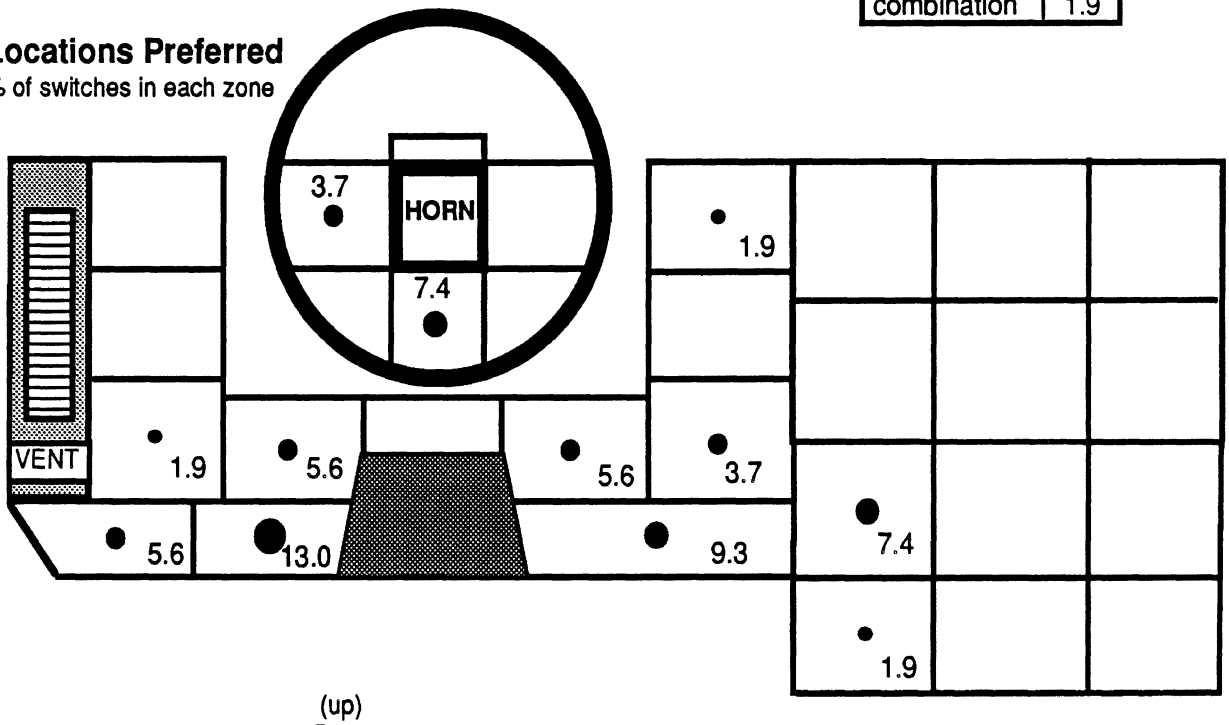


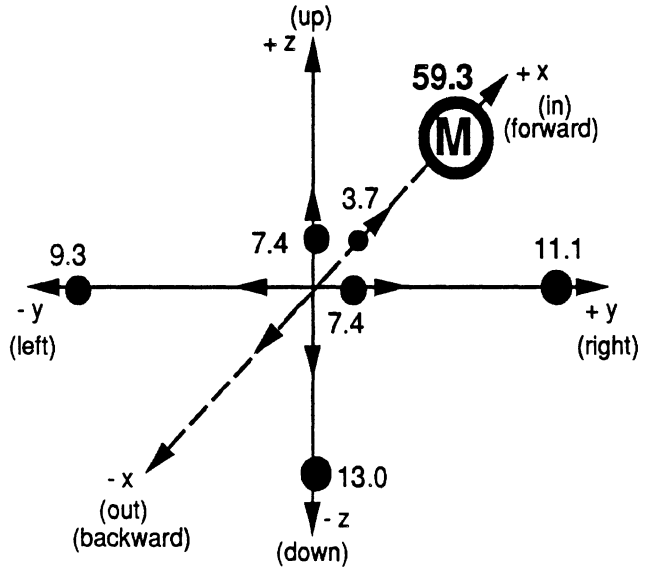
Switches Preferred

Switch	%
rocker	55.6
pushbutton	13.0
push surface*	11.1
push-pull	11.1
toggle	5.6
slide	1.9
combination	1.9

Locations Preferred

% of switches in each zone





Methods of Operation Preferred

(axes relative to the driver)

Method of Operation	%
push in	59.3
push down	13.0
push left	9.3
push right & left	7.4
push up & down	7.4
push in & out	3.7

*Note: Drivers may have confused push surfaces with pushbuttons.

Hazard

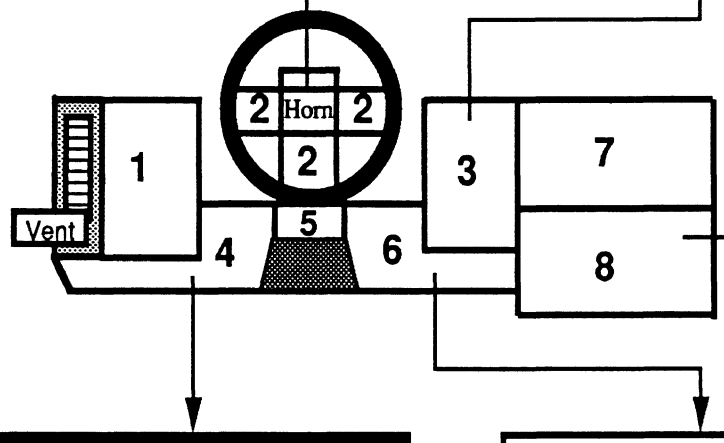
Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)

Zone: 2 n = 6 (11.1%)

Switch	Motion	%
push surface*	push in	5.6
rocker	push in	3.7
slide	push up & down	1.9

Zone: 3 n = 3 (5.6%)

Switch	Motion	%
rocker	push in	3.7
push-pull	push up & down	1.9



Zone: 8 n = 5 (9.3%)

Switch	Motion	%
rocker	push in	7.4
pushbutton	push in	1.9

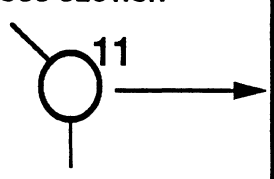
Zone: 4 n = 13 (24.1%)

Switch	Motion	%
rocker	push in	14.8
pushbutton	push in	5.6
push surface*	push in	1.9
toggle	push up & down	1.9

Zone: 6 n = 8 (14.8%)

Switch	Motion	%
rocker	push in	9.3
pushbutton	push in	1.9
push surface*	push in	1.9
push-pull	push in & out	1.9

STEEIRING COLUMN
CROSS-SECTION



Zone: 11 n = 18 (33.3%)

Switch	Motion	%
rocker	push down	9.3
rocker	push left	7.4
push-pull	push r ight & left	7.4
pushbutton	push down	3.7
toggle	push up & down	3.7
push surface*	push left	1.9

Pooled Zones with less than 5% Preference

Zone	n	%
1	1	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Why Locations Were Preferred

Drivers based location preferences mostly on the frequency of use of the function (13%). Since the hazard function is used infrequently, drivers tended to prefer locations that were out of the way (10%). One driver explained how the steering column (preferred location) allowed this: "It's on the right hand side, so I can reach it when driving, but I don't use it too often and it won't get in the way." The issue of easily reaching the control was also stressed (10%) as drivers preferred locations requiring an easy motion to make, as a driver choosing the lower left panel mentioned, "It's a very convenient spot and easy to reach." One final point of concern was that of accidental use (10%) as one driver noted, "I want it to be easily accessible, but not running into the other switches."

Why Switch Types Were Preferred

Once again, participants commonly selected switches based on their labelling or illumination characteristics (21%). Not only did they prefer switches in which the labelling matched the hazard function, but many chose switches which would be lighted or flash when activated, as a driver supported his rocker (preferred) switch selection by saying, "I like the big red switch so it will light up red when the flashers are on so that I'll know when they're on." This also led to the concern for feedback (8%), in which drivers identified the need to easily sense when the switch was activated.

Typical responses for hazard switch selection combined a few specific reasons. For instance, aesthetics (15%) and labelling were often jointly alluded to. As one driver stated, "I like the triangle [ISO hazard symbol]. It symbolizes a warning, and is just the right size so I won't hit it accidentally." This also brought forth the notion of accidental use, which was a concern to many drivers. The push-pull switch was viewed as an effective way to avoid this, as one driver stated: "It can't be accidentally operated. . .pull out to turn on and push in to turn off." Finally, the grasping/touching characteristics were important to some drivers (10%), "It's big and easy to grasp. I like the way it works."

Summary of Reasons Why

Preferred Location:

- **drivers preferred locations that were out of the way due to infrequent hazard switch use and the need to avoid accidental operation**

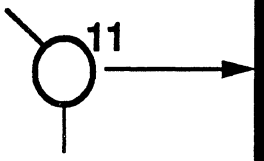
Preferred Switch:

- **drivers wanted switches to be illuminated when activated**
- **drivers preferred switches with labels that identified the function**

Hazard

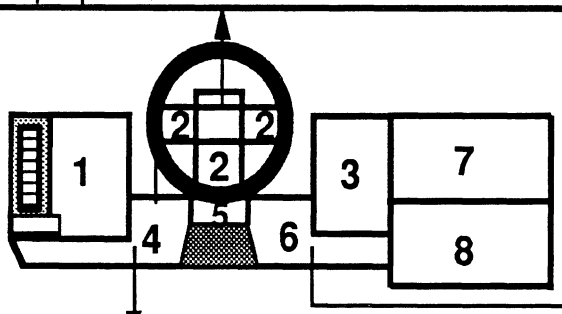
Reasons for choosing locations of specific functions by pooled zones
(n = 123 total observations)

STEERING COLUMN
CROSS-SECTION



Zone 11: Steering Column (n=44)		
n		Reason
7		**Frequency of use** Control not often used
7		**Space restrictions**
	6	Won't stick out or get in way
	1	Only place left to put switch
5		**Avoding accidental use** Don't want accidentally turn on
5		**Familiarity/Expectation**
	2	Convenient
	2	Feels it's an industry standard
	1	Similar to subject's car
4		**Field of view**
	2	Easy to see in that location
	2	Don't need to see it to use it
3		**Body restrictions** Easy motion to make
3		**Imperitiveness of use** Control only used in emergencies
3		**Relation to other controls**
	2	Won't confuse with other controls
	1	Keep hands on wheel when using
7		**Other**

Zone 2: Steering Wheel (n=13)		
n		Reason
2		**Body restrictions** Easy motion to make
2		**Avoiding accidental use** Should require thought before using
2		**Time requirements** Must be located quickly
7		**Other**



Zone 4: Lower Left Panel (n=31)		
n		Reason
5		**Field of view**
	4	Easy to see in that location
	1	Need to see it to use it
4		**Frequency of use** Control not often used
4		**Handedness/Balance of use**
	3	Can operate with left hand
	1	Too many controls for left hand
3		**Avoiding accidental use**
	2	Don't want to accidentally use
	1	Should require thought before using
3		**Imperitiveness of use**
	2	Control used only when not moving
	1	Control used only in emergencies
2		**Part of system** Same location as rest of system
2		**Space Restrictions** Won't stick out or get in way
8		**Other**

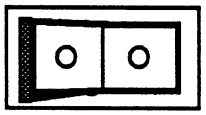
Zone 6: Lower Right Panel (n=16)		
n		Reason
4		**Frequency of use** Control not often used
3		**Time requirements**
	2	Must be located quickly
	1	Must be operated quickly
2		**Body restrictions** Easy motion to make
2		**Space restrictions** Won't stick out or get in way
5		**Other**

Overall reasons for location preference†	n	%
Frequency of use	16	13.0
Body restrictions	12	9.8
Avoiding accidental use	12	9.8
Space restrictions	12	9.8
Field of view	10	8.1

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

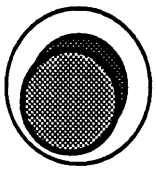
Hazard

Reasons for choosing types of switches for specific functions
(n = 113 total observations)



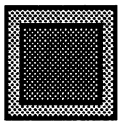
Rocker Switch (n = 61)

n		Reason
18		**Labelling/Illumination**
	8	Labelling matches function
	4	Switch is easily illuminated
	3	Switch is well illuminated
	3	Switch is easy to see/read
8		**Aesthetics**
	4	Switch looks simple to use
	3	Nice design/looks unique
	1	Subject likes the way it looks
6		**Familiarity/Expectation**
	3	Similar to subject's car
	1	Expects switch to look like this
	1	Convenient
	1	Car manufacturer standard
5		**Feedback**
		Should sense when it is activated
5		**Grasping/Touching**
	4	Big enough to easily locate
	1	Big enough to easily grasp
19		**Other**



Pushbutton (n = 14)

n		Reason
3		**Labelling/Illumination**
		Labelling matches function
2		**Feedback**
		Should sense when it is activated
2		**Grasping/Touching**
		Big enough to easily grasp
2		**Aesthetics**
	1	Subject likes the way it looks
	1	Instrument panel looks balanced
5		**Other**



Push Surface* (n = 13)

n		Reason
3		**Avoiding accidental use**
		Don't want to accidentally use
2		**Labelling/Illumination**
		Labelling matches function
2		**Aesthetics**
	1	Subject likes the way it looks
	1	Instrument panel looks balanced
2		**Properties of use**
	1	Switch represents function well
	1	Shouldn't be too easy to move
4		**Other**

Push Pull Switch (n = 11)

n		Reason
3		**Properties of operation**
	1	Switch represents function well
	1	Switch should move easily
	1	Easier to use than others
2		**Avoiding accidental use**
		Don't want to accidentally activate
2		**Grasping/Touching**
	1	Can use while wearing gloves
	1	Big enough to easily grasp
4		**Other**

Overall reasons for switch preference†	n	%
Labelling/Illumination	24	21.2
Aesthetics	17	15.0
Grasping/Touching	11	9.7
Properties of operation	10	8.8
Feedback	9	8.0

*Note: Drivers may have confused push surfaces with pushbuttons.
†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Headlights On/Off

Location Preferences

The lower left corner of the instrument panel was the preferred specific location (39%) for the headlights function, as indicated on the following left page. This location was part of the combined lower left panel region (pooled zone 4) which was preferred by half of the participants. Only two other pooled zones, the left panel (zone 1) and the left stalk (zone 9) were selected by over 5% of the respondents. On the left panel (17%) preferences increased toward the bottom part of the zone, adding further support to the lower left panel region. It is interesting to note that the only locations selected by at least 5% were all left-sided locations, implying that the headlights on/off function is should be located to the driver's left.

Switch Preferences

Although the push-pull switch was selected most (32%), it was preferred only marginally over other switch types. The stalk control (24%) was also common, due to the popularity of the stalk location. The pushbutton (15%) was selected with some regularity, among others shown on the following left page. Often, the push-pull or stalk controls were selected with the intention of integrating two or more light functions (headlights, dome light, panel brightness) onto one control.

Method of Operation Preferences

There was no strongly preferred method of operation for the headlights control. This was due to the lack of consensus in switch preference. The method preferred depended upon the implied motion of the switch. The most commonly stated method was a push in (forward) motion (35%), which was used with the push, rocker, and combination switches as well as the thumbwheel. The push-pull switch required a push in and out motion (33%), while the stalk control followed a twisting motion around the +/- y (horizontal) axis (24%). Overall, the preferred method of operation followed the motion required by the constraints of the switch and location selected.

Combined Preferences

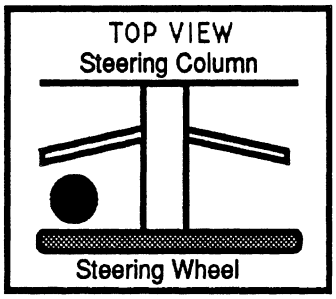
An interesting feature of switches chosen for the headlights was their tendency to be regionally preferred. As expected, stalk controls were chosen for the stalk locations, but trends also followed for other, more versatile switch types. Combination switches were most often selected for the left panel (zone 1), while push-pull switches and pushbuttons were almost isolated to the lower left panel (zone 4).

Summary of Preferences

Location:	• **lower left panel** **all selected locations were on the left side**
Switch:	• **no dominantly preferred switch** **push-pull common for panel areas** **stalks used for left stalk location**
Method of Operation:	• **no dominantly preferred method** **push in, push in & out, twist +/- y (horizontal axis) were selected most**

Headlights On/Off

(n = 54 total observations)

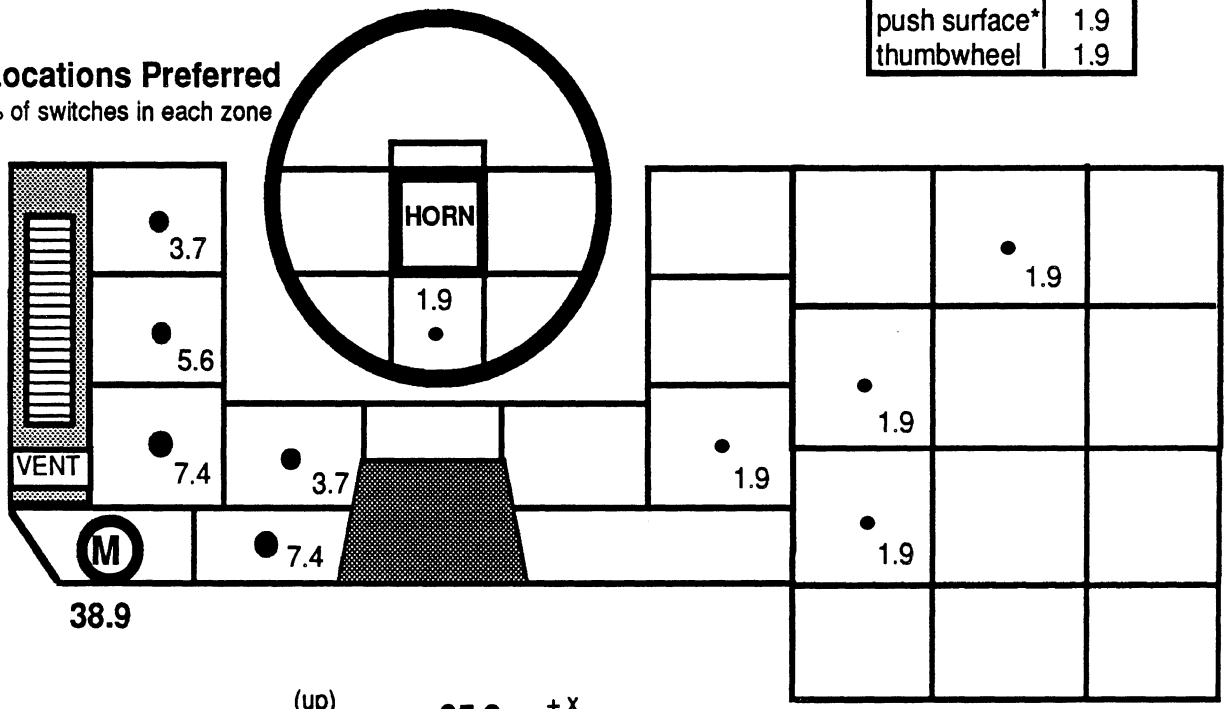


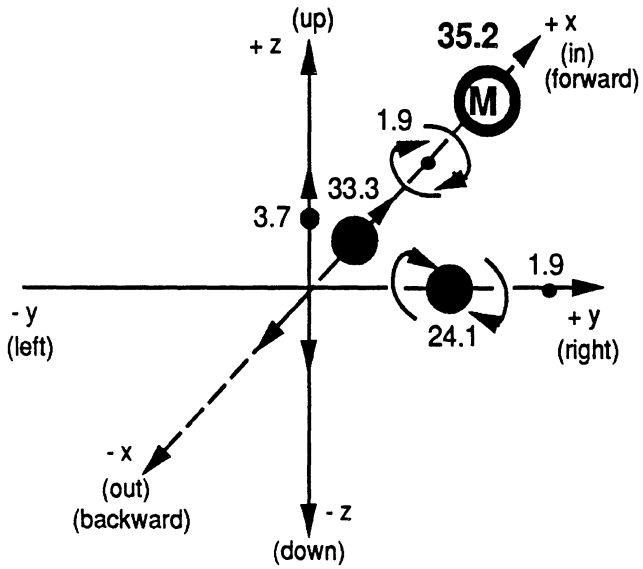
Switches Preferred

Switch	%
push-pull	31.5
stalk	24.1
pushbutton	14.8
rocker	11.1
combination	9.3
knob	3.7
slide	1.9
push surface*	1.9
thumbwheel	1.9

Locations Preferred

% of switches in each zone





Methods of Operation Preferred

(axes relative to the driver)

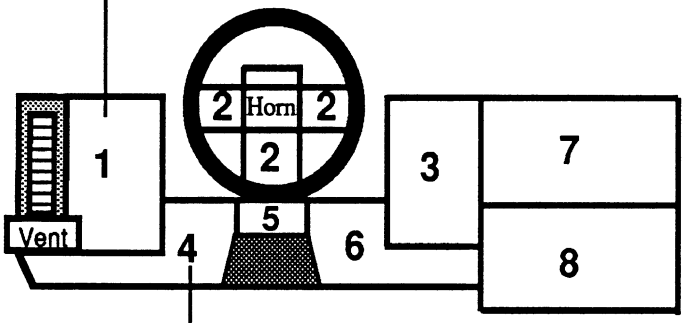
Method of Operation		%
	push in	35.2
	push in & out	33.3
+y - y	twist + & - y	24.1
	push up & down	3.7
	push right	1.9
+x - x	twist + & - x	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Headlights On/Off

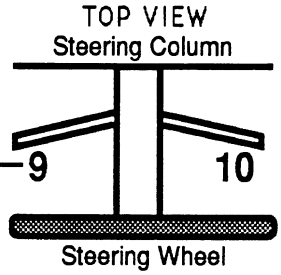
Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)

Zone: 1 n = 9 (16.7%)		
Switch	**Motion**	**%**
combination	push in	5.6
push-pull	push in & out	3.7
rocker	push in	3.7
pushbutton	push in	1.9
push surface*	push in	1.9



Zone: 4 n = 27 (50.0%)		
Switch	**Motion**	**%**
push-pull	push in & out	24.1
pushbutton	push in	11.1
rocker	push in	7.4
knob	push in & out	1.9
knob	twist +&- x	1.9
combination	push in	1.9
thumbwheel	push right	1.9

Zone: 9 n = 13 (24.1%)		
Switch	**Motion**	**%**
stalk	twist + & - y	24.1



Pooled Zones with less than 5% Preference		
Zone	**n**	**%**
2	1	1.9
3	1	1.9
7	2	3.7
8	1	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Why Locations Were Preferred

The most influential factor in location selection was familiarity/expectation (23%). About a third of the responses for the lower left panel (preferred location) were attributed to familiarity. The left stalk was also selected because of familiarity. As one driver stated, "It's familiar for me, every car I've driven has had the headlights control here [left stalk]. It's right there for using in the dark." As recognized by this driver, finding and operating this control in the dark is an important consideration.

Body restrictions were also highly mentioned in location preference, as many drivers (16%) specified an easy motion to make. This issue was prominent for all three locations selected, as shown on the following left page. Favoring the lower left panel, a driver commented, "It's easy to slide my hand over and turn on the lights." Some drivers also wanted the headlights to be located as part of a system (10%), as one person expressed, "I want the light switches together on the left side. . .it's easy to find and reach" This comment supported the location preference data in which the only locations preferred by at least 5% were to the left of the driver.

Why Switch Types Were Preferred

The familiarity/expectation factor was also the most important in switch preference for the headlights control (19%). Its greatest influence was on stalk control selection, on which over a third of the responses were based. As one driver briefly commented, "I'm used to it in my car and it's convenient." Also stressed was the aesthetic need for a simple looking switch (14%). Regarding a push-pull selection (the preferred switch), a driver responded, "It's a simple and easy switch--it doesn't distract you from driving."

The labelling or illumination characteristics of the switch once again influenced preferences (11%). This was the primary reason for pushbutton selection ("I want it to light up when it's on. . .it's easy to see from behind the steering wheel." Equally mentioned were the grasping/touching qualities of the switch. ("It's easy to get a good grip, even if you have gloves on.") A final point of interest, especially for the push-pull switch was the tendency for drivers to group the headlights function with other light functions (dome light and/or panel brightness) using one switch for the entire system.

Summary of Reasons Why

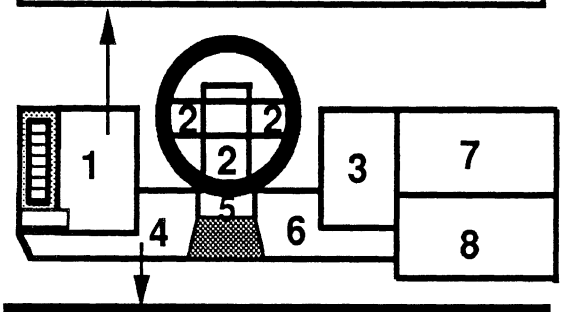
Location:
- **familiarity/expectation**
  drivers chose locations similar to their current vehicles

Switch:
- **familiarity/expectation**
  drivers chose switches similar to their current vehicles

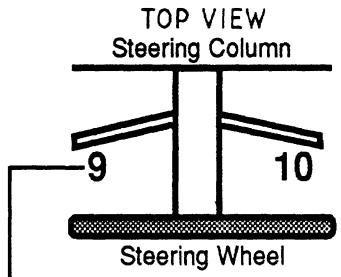
Headlights On/Off

Reasons for choosing locations of functions by pooled zones
(n = 110 total observations)

Zone 1: Left Panel (n=23)	
n	Reason
4	**Body Restrictions** Easy motion to make
3	**Part of System** Same location as rest of system
3	**Handedness/Balance of use** Can operate with left hand
3	**Familiarity/Expectation**
1	Similar to subject's car
1	Similar to a friend's car
1	Expects it to be there
3	**Field of View**
1	Easy to see in that location
1	Must see it to use it
1	Don't need to see it to use it
7	**Other**



Zone 4: Lower Left Panel (n=56)	
n	Reason
15	**Familiarity/Expectation**
6	Expects switch to be there
4	Similar to subject's car
4	Feels it's an industry standard
1	Convenient
8	**Body Restrictions** Easy motion to make
4	**Handedness/Balance of use**
3	Can operate with left hand
1	Can operate with either hand
3	**Relation to other controls**
2	Keep hand on wheel when using
1	Won't confuse with other controls
3	**Field of view**
2	Easy to see in that location
1	Don't need to see it to use it
3	**Time requirements**
2	Must be located quickly
1	Must be operated quickly
20	**Other**



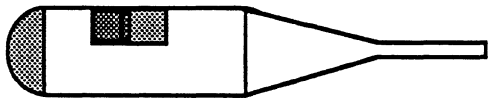
Zone 9: Left Stalk (n=26)	
n	Reason
7	**Familiarity/Expectation**
6	Similar to subject's car
1	Convenient
5	**Body Restrictions** Easy motion to make
4	**Part of System** Same location as rest of system
3	**Relation to other controls** Keep hand on wheel when using
3	**Field of view** Don't have to see it to use it
4	**Other**

Overall reasons for location preference†	n	%
Familiarity/Expectation	25	22.7
Body restrictions	18	16.4
Part of system	10	9.1
Handedness	10	9.1
Field of view	9	8.2

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

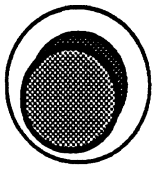
Headlights On/Off

Reasons for choosing types of switches for specific functions
(n = 116 total observations)



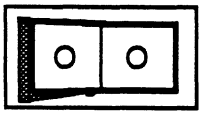
Stalk Control (n = 36)

n		Reason
13		**Familiarity/Expectation**
	9	Similar to subject's car
	2	Convenient
	1	Expects switch to look like this
	1	Feels it's an industry standard
5		**Body restrictions**
		Easy motion to make
3		**Properties of operation**
	1	Switch should move easily
	1	Easier to use than others
	1	It feels right when you move it
3		**Grasping/Touching**
	1	Can use while wearing gloves
	1	Switch surface is smooth
	1	Switch surface is rough
12		**Other**



Pushbutton (n = 18)

n		Reason
6		**Labelling/Illumination**
	4	Labelling matches function
	2	Switch is easy to see/read
3		**Aesthetics**
	2	Switch looks simple to use
	1	Subject likes the way it looks
2		**Feedback**
		Should sense when activated
7		**Other**

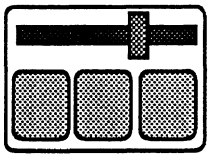


Rocker Switch (n = 11)

n		Reason
4		**Labelling/Illumination**
		Labelling matches function
7		**Other**

Push Pull Switch (n = 31)

n		Reason
6		**Familiarity/Expectation**
	4	Similar to subject's car
	1	Expects switch to look like that
	1	Feels it's an industry standard
5		**Aesthetics**
		Switch looks simple to use
4		**Properties of operation**
	2	Switch should move easily
	1	Switch represents function well
	1	Easier to use than others
3		**Part of system**
		Same switch as rest of system
3		**Grasping/Touching**
	2	Can use while wearing gloves
	1	Big enough to easily grasp
3		**Field of view**
	2	Don't have to see it to use it
	1	It will stand out and be seen
7		**Other**



Combination Switch (n = 8)

n		Reason
2		**Familiarity/Expectation**
		Similar to subject's car
2		**Labelling/Illumination**
		Switch is easy to see/read
4		**Other**

Overall reasons for switch preference†

	n	%
Familiarity/Expectation	22	19.0
Aesthetics	16	13.8
Labelling/Illumination	13	11.2
Grasping/Touching	13	11.2
Properties of operation	10	8.6

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Ignition

Location Preferences

Drivers preferred to limit the location of the ignition to the steering column and lower right panel and console areas (except one driver who selected the right stalk). The steering column (pooled zone 11) was the dominantly preferred location, with 50% of the drivers choosing the lower part, and 11% choosing the side of the console. The lower right panel (pooled zone 6) was selected by 22%, most of whom preferred the lower portion. The ignition was the only function which showed this degree of consensus for location preferences.

Switch Preferences

The only switch selected by drivers was the key switch. Only one key switch was available, which limited drivers' selections. However, they were not required to use this switch. At least one participant pondered the idea of using a pushbutton, but decided he preferred a key switch. The ignition was the only function for which a key switch was selected by drivers.

Method of Operation Preferences

Due to the nature of the function, all drivers preferred a twisting motion for the ignition. The direction of this motion depended upon the orientation of the switch. A twist +/- y (horizontal axis) was used for the steering column locations, while the panel and console locations implied a twist +/- x (forward axis) motion.

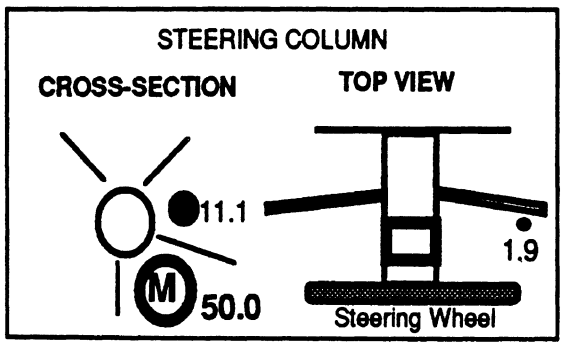
Summary of Preferences

Location:	**• steering column**
Switch:	**• key (100% consensus)**
Method of Operation:	**• twist +/- y (horizontal axis)**

For ignition, the only issue of any discrepancy among drivers was the location, which as previously mentioned was centralized to the steering column and lower right panel areas. Because no alternative switches or methods of operation were suggested by drivers, the ignition preferences were not included in the other preference analyses. Also, the reasons behind driver preferences for the ignition were not as thoroughly examined as the other functions, since there was little controversy, and most preferences were based on expectations.

Ignition

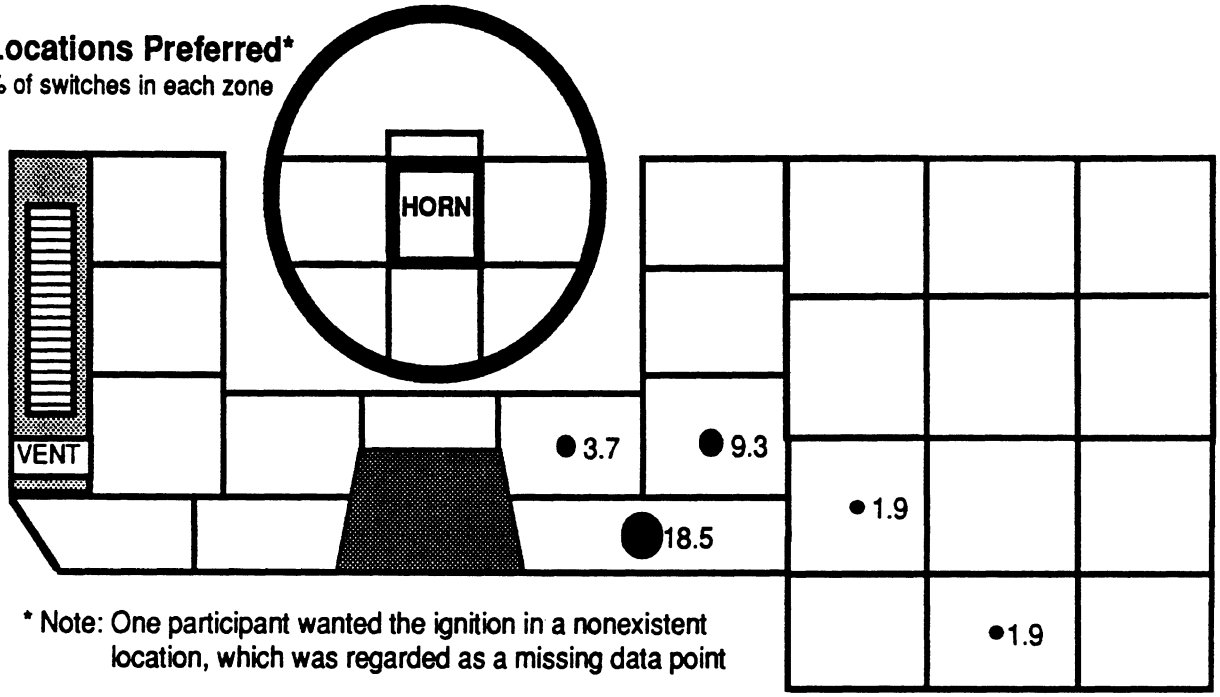
(n = 53 total observations*)



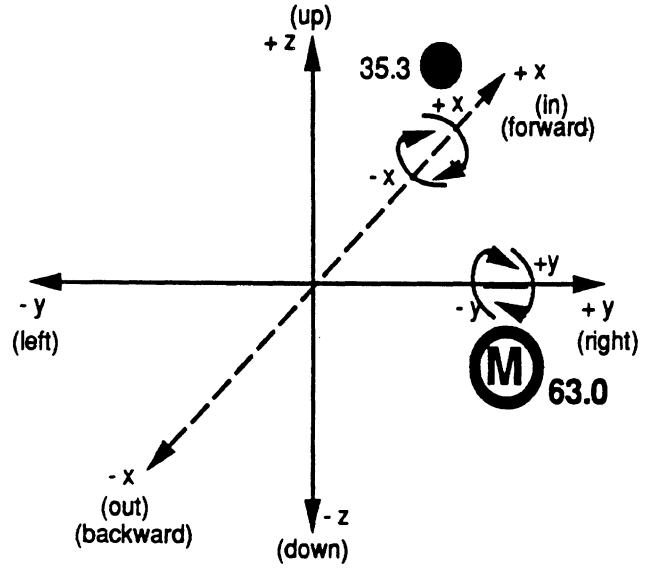
Switch Preferred:	%
Key	100

Locations Preferred*

% of switches in each zone



* Note: One participant wanted the ignition in a nonexistent location, which was regarded as a missing data point



Methods of Operation Preferred*

(axes relative to the driver)

Method of Operation	%
twist + & - y	63.0
twist + & - x	35.3

Panel Brightness

Location Preferences

Drivers preferred the lower left corner of the instrument panel for locating the panel brightness, as shown on the following left page. The pooled lower left panel area (zone 4) was by far the preferred region, selected by more than half (56%) of the participants. Over 80% of the drivers wanted the panel brightness on their left side. This included the left panel (pooled zone 1) which was the second most commonly selected location (20%). All other location preferences were of much less significance (less than 6% each).

Switch Preferences

There was no predominant preference for the panel brightness switch. In fact, the switches most preferred for this function were rather uncommon for other functions in this study. The thumbwheel was most preferred (22%), and almost exclusively used for the panel brightness function. The second-most preferred choice, a knob (20%), was used minimally among most other functions. The push-pull switch was also somewhat common (19%) for drivers wanting panel brightness integrated with the other lighting functions (headlights and dome light). Many additional switches were selected infrequently as shown on the following left page.

Method of Operation Preferences

A twisting motion around the forward axis (+/- x), as shown on the following left page, was preferable (37%) for the panel brightness control. This motion was used almost exclusively with the knob and push-pull switches (drivers used the outer-end of the push-pull switch as if it were a knob). A push right-left motion was also commonly selected (22%), and used most often with thumbwheels or slide switches. Depending on the orientation of these switches, a push up-down motion was also used (17%). Finally, the push in motion was also used with some regularity (15%), primarily for push surfaces and rocker switches, as shown on the following right page.

Combined Preferences

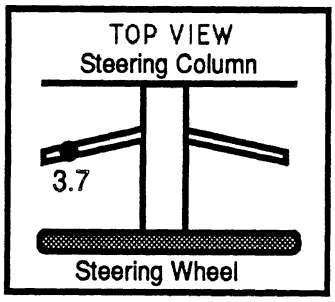
There was a strong relationship between preferred locations and methods of operation. In the preferred lower left panel region (zone 1, on the following right page), a twist +/- x (forward axis) motion was predominant (67% in this region), mainly due to the regionally heavy use of knobs and push-pull switches. For the other 3 pooled zones gathering at least 5% of the responses, a push right-left motion was common. Similar to this was the push up-down motion, which arose when the same types of switches were vertically oriented. Thus, for panel brightness, the type, location, and orientation of switches all affected its operation.

Summary of Preferences

Location:	• **lower left panel**
Switch:	• **no dominant preference thumbwheels, knobs, and push-pull switches were often selected**
Method of Operation:	• **twist +/-x (forward axis) for lower left panel**
	• **push right-left or push up-down for other areas (depending on switch orientation)**

Panel Brightness

(n = 54 total observations) •

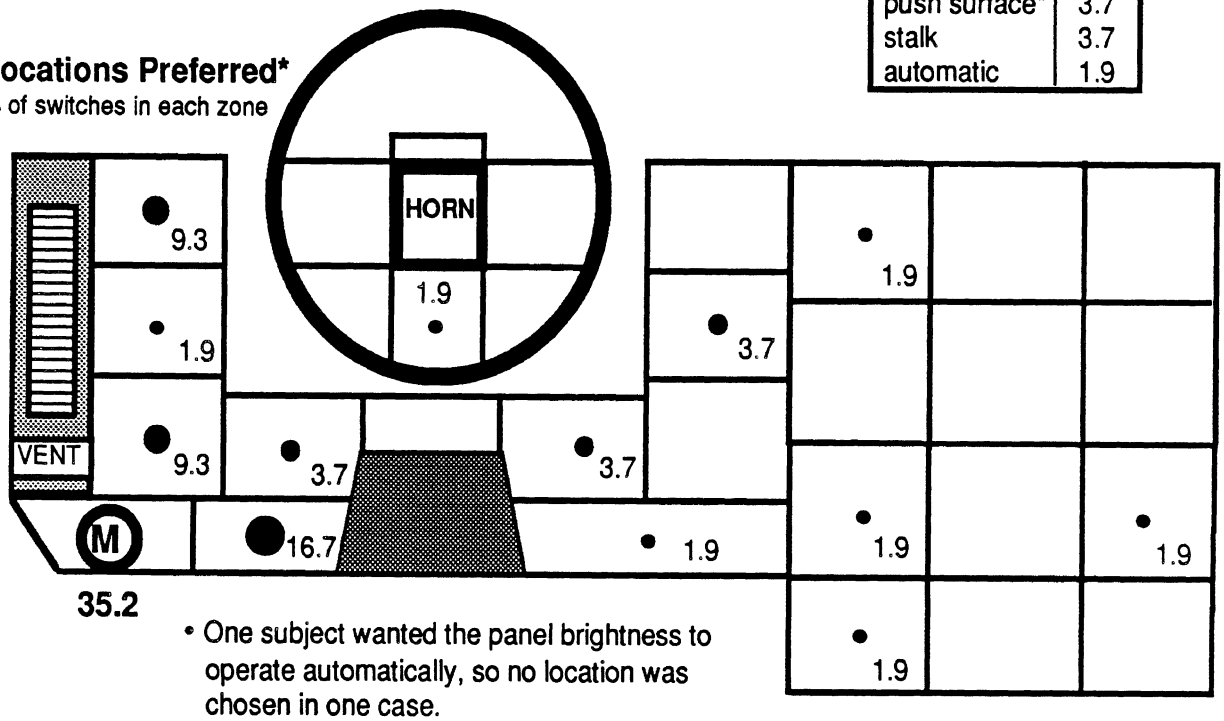


Switches Preferred

Switch	%
thumbwheel	**22.2**
knob	20.4
push-pull	18.5
slide	11.1
combination	7.4
rocker	5.6
pushbutton	5.6
push surface*	3.7
stalk	3.7
automatic	1.9

Locations Preferred*

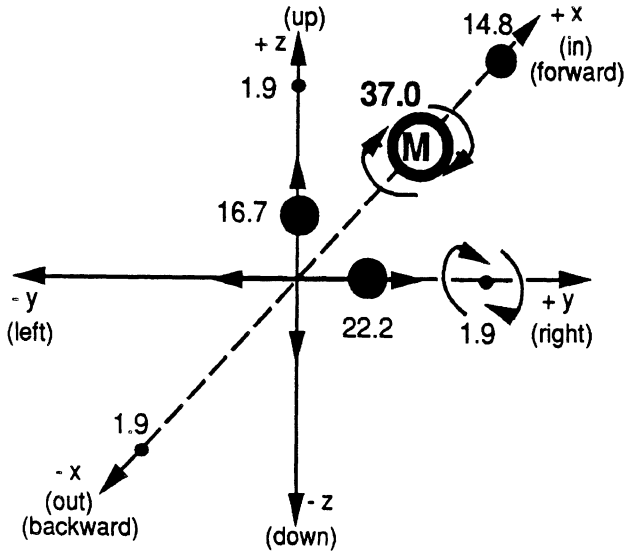
% of switches in each zone



• One subject wanted the panel brightness to operate automatically, so no location was chosen in one case.

Methods of Operation Preferred

(axes relative to the driver)



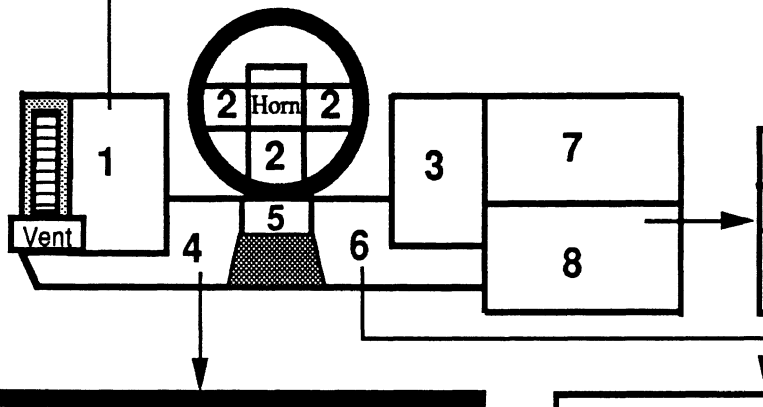
Method of Operation		%
	twist + & - x	**37.0**
	push right & left	22.2
	push up & down	16.7
	push in	14.8
	push up	1.9
	twist + & - y	1.9
	pull out	1.9
	multi-way t& p	1.9
	automatic	1.9

*Note: Drivers may have confused push surfaces with pushbuttons.

Panel Brightness

Switch / Motion Preferences by Pooled Zones
(n = 54 total observations)

Zone: 1 n = 11 (20.4%)		
Switch	**Motion**	**%**
combination	push up & down	5.6
thumbwheel	push right & left	5.6
knob	twist + & - x	3.7
slide	push right & left	1.9
push-pull	push in	1.9
pushbutton	twist + & - x	1.9



Zone: 8 n = 3 (5.6%)		
Switch	**Motion**	**%**
thumbwheel	push right & left	3.7
knob	twist + & - x	1.9

Zone: 4 n = 30 (55.6%)		
Switch	**Motion**	**%**
push-pull	twist +&- x	16.7
knob	twist +&- x	13.0
thumbwheel	push up & down	5.6
rocker	push in	3.7
slide	push right & left	3.7
pushbutton	push in	3.7
knob	multi-way t & p	1.9
thumbwheel	push right & left	1.9
thumbwheel	push up	1.9
push surface*	push in	1.9

Zone: 6 n = 3 (5.6%)		
Switch	**Motion**	**%**
slide	push right & left	3.7
thumbwheel	push right & left	1.9

Pooled Zones with less than 5% Preference

Zone	n	%
2	1	1.9
3	2	3.7
7	1	1.9
9	2	3.7

*Note: Drivers may have confused push surfaces with pushbuttons.

Why Locations Were Preferred

As shown on the following left page, there was no dominant reason why people preferred particular locations for the panel brightness control. Familiarity/expectation was often referred to (14%) as drivers liked locations similar to their own cars, or where they would expect them. The lower left panel (zone 4) was especially chosen for this reason, as one driver stated: "I'm used to having it there. . .it's handy to find." Many drivers felt the panel brightness was only used infrequently (14%), and based locations accordingly ("You don't use it that often, once you turn it on it doesn't have to be that accessible").

Also affecting its location was the tendency of some people to group the panel brightness with the other light functions (14%). A driver who chose the lower left panel for this reason and explained, "I want it next to the headlights to keep all the light switches in the same area." An easy motion for reaching and using the switch was important to some drivers (9%), as one stated of the left panel (zone 1): "It's easy to reach and operate with the left hand." Overall, locations for the panel brightness were selected for many reasons which are shown on the following left page.

Why Switch Types Were Preferred

Drivers were influenced by the aesthetic qualities of the switch (18%), and typically wanted a simple-looking switch. This especially supported push-pull, slide and thumbwheel switch selection, as one thumbwheel user stated, "It looks easy to manipulate, just dial to desired brightness." Other physical characteristics highly considered were the properties of operation of the switch (17%). Drivers preferred switches which represented the panel brightness function. Since this function implied a continuous incremental adjustment, the thumbwheel and knob were favored because they enabled this operation. Drivers also tended to chose switches similar to those in their own vehicles, as familiarity/expectation was often cited (16%). The grasping/touching characteristics of the switch were also considered (13%). This issue was particularly important to people chosing push-pull switches, knobs, and thumbwheels. One driver interested in the size and function representation of a knob said, "I like the size of it, it's easy to turn, and you can turn it as high or low as you want." Other factors influencing the panel brightness switch are given on the following right page.

Summary of Reasons Why

Preferred Location:

- **no dominant reason**
- **familiarity, frequency of use, and being part of a system were common**

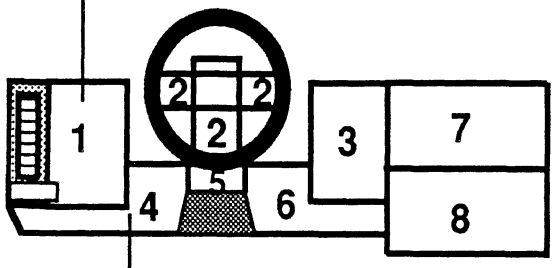
Preferred Switch:

- **no dominant reason**
- **drivers commonly preferred simple looking switches, switches that represented the function, or switches similar to their current vehicles**

Panel Brightness

Reasons for choosing locations of specific functions by pooled zones
(n = 93 total observations)

Zone 1: Left Panel (n=20)		
n		Reason
5		**Field of view**
	4	Easy to see in that location
	1	Don't need to see it to use it
4		**Part of system** Same location as rest of system
3		**Body restrictions** Easy motion to make
3		**Frequency of use** Control not often used
2		**Handedness/Balance of use** Can operate with left hand
3		**Other**



Zone 4: Lower Left Panel (n=51)		
n		Reason
11		**Familiarity/Expectation**
	4	Similar to subject's car
	3	Expect switch to be there
	2	Feels it's an industry standard
	1	Similar to a friend's car
	1	Convenient
8		**Frequency of use** Control not often used
6		**Part of system** Same location as rest of system
6		**Handedness/Balance of use**
	4	Can operate with left hand
	1	Can operate with either hand
	1	Too many controls for right hand
4		**Space restrictions** Won't stick out or get in way
2		**Body restrictions** Easy motion to make
2		**Safety** Safest location possible
2		**Labelling/Illumination** Switch labelling matches function
2		**Relation to other controls** Keep hand on wheel when using
2		**Sequence of use** Used in sequence with others
6		**Other**

Overall reasons for location preference†	n	%
Familiarity/Expectation	14	14.0
Part of system	14	14.0
Frequency of use	14	14.0
Handedness	10	10.8
Body restrictions	8	8.6

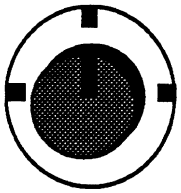
†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

Panel Brightness

Reasons for choosing types of switches for specific functions
(n = 102 total observations)

Push Pull Switch (n = 25)

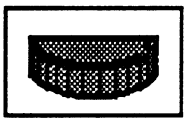
n		Reason
5		**Aesthetics**
		Switch looks simple to use
4		**Part of system**
		Same switch as rest of system
4		**Grasping/Touching**
	2	Can use while wearing gloves
	1	Switch surface is smooth
	1	Big enough to easily locate
12		**Other**



Knob (n = 23)

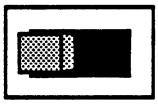
n		Reason
6		**Grasping/Touching**
	2	Can use while wearing gloves
	1	Rough surface prevents slipping
	1	Big enough to easily grasp
	1	Big enough to easily locate
	1	Other switches are too big
5		**Properties of operation**
		Switch represents function well
5		**Familiarity/Expectation**
	3	Similar to subject's car
	1	Similar to a friend's car
	1	Expects switch to look like that
7		**Other**

Overall reasons for switch preference†	n	%
Aesthetics	**18**	**17.6**
Properties of operation	**17**	**16.7**
Familiarity/Expectation	**16**	**15.7**
Grasping/Touching	**13**	**12.7**
Labelling/Illumination	**8**	**7.8**



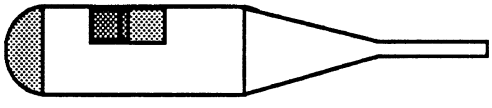
Thumbwheel (n = 18)

n		Reason
6		**Properties of operation**
	3	Switch should move easily
	2	Switch represents function well
	1	Easier to use than others
3		**Aesthetics**
	2	Nice design/looks unique
	1	Subject likes a simple layout
3		**Grasping/Touching**
	2	Can use while wearing gloves
	1	Big enough to easily grasp
6		**Other**



Slide Switch (n = 11)

n		Reason
4		**Labelling/Illumination**
	2	Switch is easy to see/read
	1	Labelling matches function
	1	Switch is easily illuminated
3		**Aesthetics**
		Switch looks simple to use
4		**Other**



Stalk Control (n = 8)

n		Reason
2		**Body restrictions**
		Easy motion to make
6		**Other**

†Note: Overall reasons represent total of frequent reasons (shown) plus infrequent reasons (not shown).

How Did the Preferred Locations and Switches Differ from the Controls in Participants' Cars?

More than any other reason (but not often), drivers reported they preferred particular locations for controls and particular switches because they were expected or resembled what was in their cars. To examine this, the actual and preferred locations and switches were compared. Diagrams showing the actual locations (by pooled zones), switches, and methods of operation are given for each of the functions in Appendix K. The diagrams are similar to the preferred switch/motion by pooled zones diagrams given in the previous results sections, thus direct comparisons can be made. In brief, the extent to which preferences mirrored the locations and switches in participants cars varied from function to function. Statistical evidence and tables showing these relationships follow. The location and switch data are considered separately.

Whenever possible statistics relating the various measures were computed. While the most appropriate statistic to examine significant differences is Chi-Squared, there were some difficulties in applying it. Typically there were about a dozen categories for the dependent measure (switch classes, pooled zones) and 432 data points (54 drivers times 8 functions since ignition was not considered). If the independent variable has only 2 levels (e.g., such as sex), that leads to 24 cells (2 x 12) for the 432 data points to be partitioned among, or an average of about 13 per cell. When there are more than 2 levels, the number of data points per cell is normally below 10. This was the case for preferred versus actual controls since there were at least 6 levels for each function, resulting in several empty or small cells. The rule of thumb is that every cell in a Chi-Squared analysis should have at least 5 and preferably 10 data points. Further, because the data are not distributed uniformly, there will be many instances in even a 2 x 12 analysis where many cell sizes will be small, even 0. When the cell sizes are small, the Chi-Squared values tend to be inflated, suggesting significance where it is absent.

Preferred vs. Actual Locations

While drivers tended to put controls in the same place as in their own car, there was a statistically significant difference between the preferred and actual pooled zones for the data aggregated across the eight functions (Chi-squared(12)=417, p=.0001). Shown in Table 9 is a comparison of those two distributions. The primary difference was that people were far less likely to want controls on the left stalk (56 preferred vs. 95 actual).

Table 9. Summary of Preferred Vs. Actual Locations for Controls

Actual	Preferred Location													
	L Pan	Hub	R Pan	L Low	Mid Pan	R Low	Top Con	Low Con	L Stalk	R Stalk	Col	Fwd Roof	Ctr Roof	TOTAL
L Panel	16	1	1	12	0	0	0	4	0	0	0	1	1	36
Hub	0	35	0	2	0	0	0	1	1	0	0	0	0	39
R Panel	0	0	6	7	0	3	2	0	0	2	1	0	0	21
L Low	7	4	3	50	0	2	2	2	1	0	0	6	4	81
Mid Panel	0	2	0	4	0	2	0	2	0	0	7	0	0	17
R Low	0	1	0	1	0	1	0	0	0	0	0	0	0	3
Top Con	1	0	0	0	0	0	2	1	0	0	0	0	0	4
Low Con	0	1	0	0	0	0	0	1	0	0	0	0	1	3
L Stalk	7	6	0	17	0	1	1	6	48	9	0	0	0	95
R Stalk	0	4	0	0	0	0	4	4	4	25	0	0	0	41
Column	0	6	3	5	0	4	0	1	0	0	11	0	0	30
Fwd Roof	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Ctr Roof	1	0	1	3	0	1	1	1	0	0	0	6	8	22
L Pod	0	0	0	0	0	0	0	0	2	0	0	0	0	2
R Pod	0	0	0	0	0	0	0	0	0	2	0	0	0	2
TOTAL	32	60	14	101	0	14	12	23	56	38	19	14	14	

Note: For the actual locations, 35 data points are missing: 34 because 17 cars didn't have cruise controls and 1 because a location for 1 control in 1 car was not recorded.

For the individual functions, connections were difficult to establish because of the small number of data points. Typically the 54 responses were partitioned among 8-10 locations, leaving only about 5 entries per cell, too few for an adequate Chi-Square test. In fact, because the data were distributed nonuniformly, typically at least half of the cells had less than 5 data points, often 3 or less. This was particularly true for the cruise control functions where only 37 of the 54 participants had this option in their vehicle. Should these correlations be of interest in future studies, the sample size should at least be doubled, and possibly quadrupled.

The cruise on/off function was most preferred on the steering wheel spokes (46%). (See Table 10.) This location (pooled zone 2) was also the most common in the cars participants normally drove (43%). The stalk locations (pooled zones 9 & 10) were used much more in the actual cars than drivers preferred. Twelve of the 37 actual cars used this location, however, only five of the drivers who currently had the cruise control option in their car preferred the stalks. Similar views were also conveyed for stalks regarding the cruise control set function (Table 11).

Table 10. Preferred vs. Actual Locations for Cruise On/Off

Actual	Preferred Location						
	Hub	R Panel	L. Low	R. Low	Low Con	L. Stalk	R. Stalk	TOTAL
Hub	14	0	1	0	0	1	0	16
L. Low	2	0	2	0	0	0	0	4
R. Low	1	0	0	1	0	0	0	2
Low Con	1	0	0	0	1	0	0	2
L. Stalk	1	0	2	1	0	5	2	11
R. Stalk	1	0	0	0	0	0	0	1
Column	1	0	0	0	0	0	0	1
TOTAL	21	0	5	2	1	6	2	

Table 11. Preferred vs. Actual Locations for Cruise Set

Actual	Preferred Location							
	L. Panel	Hub	L. Low	R. Low	Low Con	L. Stalk	R. Stalk	TOTAL
Hub	0	21	1	0	1	0	0	23
L. Stalk	0	1	2	0	0	5	3	11
R. Stalk	0	1	0	0	0	0	1	2
Column	0	1	0	0	0	0	0	1
TOTAL	0	24	3	0	1	5	4	

Preferred locations for the dome light switch varied somewhat from where the switch was in drivers' cars (Table 12). Auto industry practice is to place the dome light switch in the center of the ceiling (pooled zone 13, 41%) or the lower left panel area. Drivers, on the other hand, equally preferred the front (pooled zone 12) and center ceiling (26% each) locations. Also the lower left panel area (pooled zone 4) was used more frequently in actual cars (39%) than drivers preferred (24%).

Table 12. Preferred vs Actual Locations for the Dome Light Switch

Actual	Preferred Location									
	L. Panel	Hub	R. Panel	L. Low	R. Low	Top Con	Low Con	Fwd Roof	Ctr Roof	TOTAL
L. Panel	3	0	0	2	0	0	1	1	1	8
L. Low	1	1	1	8	0	0	0	6	4	21
Low Con	0	0	0	0	0	0	0	0	1	1
Fwd Roof	0	0	0	0	0	0	0	1	0	1
Ctr Roof	1	0	1	3	1	1	1	6	8	22
TOTAL	5	1	2	13	1	1	2	14	14	

The front windshield washer and wiper were located together on both actual and preferred instrument panels. (See Tables 13 and 14.) Further, preferred and actual designs tended to be fairly similar. Of the 31 drivers who preferred the stalk locations (zones 9 and 10), 25 had the controls in similar locations in their own cars. However, the left (30%) and right (28%) stalks were preferred much less than in

production vehicles (50% and 35% respectively). Drivers instead placed the windshield washer/wiper on the left panel (6%), steering wheel (6%), and lower console (9%) (pooled zones 1, 2 & 8), which were never used in the actual vehicles.

Table 13. Preferred vs. Actual Locations for the Front Windshield Washer

Actual	Preferred Location							
	L. Panel	Hub	R. Panel	L. Low	Top Con	Low Con	L. Stalk	R.Stalk	TOTAL
R. Panel	0	0	3	0	1	0	0	1	5
L. Low	0	0	0	1	0	0	0	0	1
Top Con	0	0	0	0	1	0	0	0	1
L Stalk	3	2	0	4	0	3	13	2	27
R. Stalk	0	1	0	0	2	2	2	12	19
R. Pod	0	0	0	0	0	0	0	1	1
TOTAL	3	3	3	5	4	5	15	16	

Table 14. Preferred vs. Actual Locations for the Front Windshield Wiper

Actual	Preferred Location							
	L. Panel	Hub	R. Panel	L. Low	Top Con	Low Con	L. Stalk	R.Stalk	TOTAL
R. Panel	0	0	3	0	1	0	0	1	5
L. Low	0	0	0	1	0	0	0	0	1
Top Con	0	0	0	0	1	0	0	0	1
L Stalk	3	2	0	4	0	3	13	2	27
R. Stalk	0	1	0	0	2	2	2	12	19
R. Pod	0	0	0	0	0	0	0	1	1
TOTAL	3	3	3	5	4	5	15	16	

The steering column (zone 11) was the most preferred location for the hazard function (33%) and also the most common location found in the cars people normally drove (52%). All of the drivers who preferred this area had a similar location in their actual cars (pooled zone 5, on top of the column was also used in actual cars). A difference in preferred and actual hazard switch locations arose, however, as only a third of the drivers chose the steering column, while other locations were also used. (See Table 15.) In particular the lower left panel (zone 4) was preferred by 24% of the drivers, yet not used in any of the actual cars.

Table 15. Preferred vs. Actual Locations for the Hazard Switch

Actual	Preferred Location							
	L. Panel	Hub	R. Panel	L. Low	R Low	Low Con	Column	TOTAL
L. Panel	0	0	0	0	0	1	0	1
R. Panel	0	0	0	4	2	0	0	6
Mid Panel	0	2	0	4	2	2	7	17
Top Con	1	0	0	0	0	1	0	2
Column	0	4	3	5	4	1	11	28
TOTAL	1	6	3	13	8	5	18	

Preferred and actual locations for the headlights on/off control were very similar. (See Table 16.) Three areas (pooled zones 1, 4 & 9) accounted for most of the responses. Slight differences occurred in that the left panel (zone 1) and left stalk (zone 9) were used more often in the actual vehicles than drivers preferred. Meanwhile, the lower left panel (zone 4) was used only 33% in the actual vehicles but preferred by 50% of the participants.

Table 16. Preferred vs. Actual Locations for the Headlights On/Off

Actual	Preferred Location							
	L. Panel	Hub	R. Panel	L. Low	Top Con	Low Con	L. Stalk	TOTAL
L. Panel	6	1	1	7	0	1	0	16
L. Low	2	0	0	15	1	0	0	18
L. Stalk	1	0	0	5	1	0	12	19
L. Pod	0	0	0	0	0	0	1	1
TOTAL	9	1	1	27	2	1	13	

Regarding the panel brightness control, the two most common locations (pooled zones 1 & 4) accounted for roughly the same relative fraction of the actual and preferred instrument panel designs. (See Table 17.)

Table 17. Preferred vs. Actual Locations for the Panel Brightness

Actual	Preferred Location									
	L. Panel	Hub	R. Panel	L. Low	R. Low	Top Con	Low Con	L. Stalk	Column	TOTAL
L. Panel	7	0	0	3	0	0	1	0	0	11
R. Panel	0	0	0	3	1	0	0	0	1	5
L. Low	4	1	2	23	2	1	2	1	0	36
R. Low	0	0	0	1	0	0	0	0	0	1
L. Pod	0	0	0	0	0	0	0	1	0	1
TOTAL	11	1	2	30	3	1	3	2	1	

Preferred vs. Actual Switches

In general, there was a weak connection, between the switches preferred by drivers and those found in their cars (Chi-Square(6)=132, p=.0001). (In that calculation, the three types of switches chosen by five or less were omitted to satisfy calculation requirements, as were the preferences for combination switches which were miscoded in the actual vehicles and therefore did not correspond.) As shown in Table 18, the number of cases in which drivers preferred switches identical to those is their actual cars was very small. In fact, the connection between driver preferences and their actual vehicles was much weaker for switches than for locations. In general, as shown in Table 18, people wanted more rocker switches (84 preferred vs. 15 actual) and push- button/surfaces (75 vs. 67), but fewer stalk controls (97 vs. 134) and push-pull switches (43 vs. 62).

Table 18. Preferred vs. Actual Switches Overall

Actual	Preferred Switch											
	Rocker	Thumbwh	Toggle	Slide	PButt/Surf	Push-Pull	Paddle	Knob	Combo	Stalk	Lever	TOTAL
Rocker	11	0	0	0	2	0	0	0	1	1	0	15
Thumbwheel	3	4	0	5	2	2	0	2	1	3	0	22
Toggle	0	0	0	0	0	0	0	0	0	0	0	0
Slide	20	3	1	5	9	0	0	1	8	1	1	49
PButton/Surface	24	0	0	1	28	4	2	0	8	0	0	67
PushPull	7	5	4	1	12	28	0	2	2	1	0	62
Paddle	2	0	0	0	1	0	0	0	0	0	0	3
Knob	10	3	0	4	7	4	0	10	1	6	0	45
Combo	0	0	0	0	0	0	0	0	0	0	0	0
Stalk	7	0	0	4	14	5	0	4	13	85	2	134
Lever	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	84	15	5	20	75	43	2	19	34	97	3	

Note: For the actual locations, 35 data points are missing, 34 because 17 cars didn't have cruise controls and 1 because a location for 1 control in 1 car was not recorded. It is possible that some of the responses for combination switches were miscoded. Regarding preferred switches, many drivers misinterpreted push surfaces to be pushbuttons, therefore a pooled category (pushbutton/surface) has been used to compare with the actual vehicles, which used only pushbuttons.

Following are detailed comparisons, by function, of the switches drivers preferred and those that were installed in their cars. Because of the small number of data points (54) and relatively large number of cells, Chi-Square statistics have not been computed.

One of the most commonly preferred switches for the cruise on/off function, the rocker switch, was used in only 2 of the 37 actual cars which had this option. (See Table 19.) The pushbutton and similar push surface, which predominated in actual vehicles (60%) was only moderately preferred by drivers (35%). Stalk-mounted cruise on/off switches were found in cars 50% more often (8 preferred vs. 12 actual) than drivers preferred.

Table 19. Preferred vs. Actual Switches for Cruise On/Off

Actual	Preferred Switch					
	Rocker	Thumb	PButt/Surf	Paddle	Stalk	TOTAL
Rocker	1	0	0	0	1	2
Slide	0	0	1	0	0	1
PButt/Surf	11	0	10	1	0	22
Stalk	2	0	3	0	7	12
TOTAL	14	0	14	1	8	

Data for the cruise set function was similar to that for cruise on/off. (See Table 20.). However, more people preferred a pushbutton/surface. This was similar to the presence of pushbuttons in their actual vehicles (18 preferred vs. 21 actual). Rocker switches were preferred by 9 drivers, although only 2 actual vehicles used a rocker for the cruise set. Stalk controls were also common in both preferred and actual cars.

Table 20. Preferred vs. Actual Switches for Cruise Set

Actual	Preferred Switch						
	Rocker	Thumb	Slide	PButt/Surf	Paddle	Stalk	TOTAL
Rocker	1	0	0	1	0	0	2
Slide	0	0	0	1	0	0	1
PButt/Surf	7	0	0	13	1	0	21
Paddle	0	0	0	1	0	0	1
Stalk	1	0	0	2	0	9	12
TOTAL	9	0	0	18	1	9	

There was almost no relationship between the switches drivers preferred for the dome light and what was in their car. (See Table 21.) The rocker switch, which was preferred most (33%) was not installed in any of the cars people actually drove. The production cars were commonly fitted with slide (50%) and push-pull (24%) switches, each of which was preferred by less than 15% of the participants.

Table 21. Preferred vs. Actual Switches for the Dome Light Switch

Actual	Preferred Switch									
	Rocker	Thumb	Toggle	Slide	PButt/Surf	PushPull	Combo	Stalk	Lever	TOTAL
Thumb	3	0	0	3	1	1	0	1	0	9
Slide	12	2	1	5	5	0	1	0	1	27
PButt/Surf	0	0	0	0	1	0	0	0	0	1
PushPull	1	2	1	0	3	6	0	0	0	13
Knob	2	0	0	0	1	1	0	0	0	4
TOTAL	18	4	2	8	11	8	1	1	1	

Drivers who had stalk-mounted wiper/washer controls in their cars usually preferred that switch design. (See Tables 22 and 23.) Of the 46 cars fitted with them (out of 54), 31 of their drivers preferred that type of switch for wiper/washer.

Table 22. Preferred vs. Actual Switches for the Front Windshield Washer Switch

Actual	Preferred Switch							
	Rocker	Slide	PButt/Surf	PushPull	Knob	Combo	Stalk	Lever	TOTAL
PButt/Surf	0	0	0	0	0	5	0	0	5
Knob	0	0	0	0	1	0	2	0	3
Stalk	2	2	3	1	2	6	28	1	46
TOTAL	2	2	3	1	3	11	31	1	

Table 23. Preferred vs. Actual Switches for the Front Windshield Wiper Switch

Actual	Preferred Switch							
	Rocker	Slide	PButt/Surf	PushPull	Knob	Combo	Stalk	Lever	TOTAL
Slide	0	0	0	0	0	5	0	0	5
Knob	0	0	0	0	1	0	2	0	3
Stalk	2	2	2	1	2	7	29	1	46
TOTAL	2	2	2	1	3	12	31	1	

Most preferences for the hazard switches were unrelated to what drivers had in their cars. Drivers by far preferred a rocker switch (56%) which was only installed in 15% of their cars The most commonly used switches in drivers' cars, push-pull switches (25%), were preferred less than half as often (11%). The only similarity between preferred and actual switches found in drivers' cars was for the pushbutton/surface.

Table 24. Preferred vs. Actual Switches for the Hazard Switch

Actual	Preferred Switch						
	Rocker	Toggle	Slide	PButt/Surf	PushPull	Combo	TOTAL
Rocker	8	0	0	0	0	0	8
Slide	7	0	0	2	0	0	9
PButt/Surf	6	0	1	4	2	1	14
PushPull	6	3	0	6	4	0	19
Paddle	1	0	0	0	0	0	1
Knob	2	0	0	1	0	0	3
TOTAL	30	3	1	13	6	1	

For the headlights on/off switch, people often chose the same type of switch that was in their car. Of the 17 people who preferred a push-pull switch, 10 had similar switches in their own cars. Likewise, 12 of the 13 who chose stalk controls for headlights on/off had that same type of switch in their own car.

Table 25. Preferred vs. Actual Switches for the Headlights On/Off

Actual	Preferred Switch								
	Rocker	Thumb	Slide	PButt/Surf	PushPull	Knob	Combo	Stalk	TOTAL
Rocker	1	0	0	1	0	0	1	0	3
Slide	1	0	0	0	0	0	0	0	1
PButt/Surf	0	0	0	0	2	0	2	0	4
PushPull	0	1	0	2	10	1	1	0	15
Paddle	1	0	0	0	0	0	0	0	1
Knob	3	0	1	2	2	1	1	1	11
Stalk	0	0	0	4	3	0	0	12	19
TOTAL	6	1	1	9	17	2	5	13	

The only switch drivers preferred for ignition was the key switch. This was also the only switch appearing in the cars they drove, therefore enforcing the idea that the ignition was preferred primarily due to expectation and industry standardization.

Panel brightness switch preferences were moderately related to the actual switches found in people's cars. Knobs were much more common in industry designed vehicles (39%) than drivers preferred (20%). Many drivers chose to integrate the panel brightness function onto a push-pull switch with the headlights control (19%), all but two of whom had similar designs in their own vehicles.

Table 26. Preferred vs. Actual Switches for the Panel Brightness

Actual	Preferred Switch								
	Rocker	Thumb	Slide	PButt/Surf	PushPull	Knob	Combo	Stalk	TOTAL
Thumb	0	4	2	1	1	2	1	2	13
Slide	0	1	0	0	0	1	2	0	4
PushPull	0	2	1	1	8	1	1	1	15
Knob	3	3	3	3	1	7	0	1	21
TOTAL	3	10	6	5	10	11	4	4	

Summary

Thus, there was often a mismatch between the kinds of switches found in cars now, where they are presently found, and what people want, though the extent of the mismatch varied considerably from function to function. For location, fewer drivers wanted stalk-mounted wiper/washer controls than had them. On the other end of the spectrum, those that had spoke-mounted cruise controls preferred them.

For switches, the greatest mismatches occurred for cruise controls and hazard switches. Across all controls, drivers wanted more rocker switches and pushbutton/surfaces, and fewer stalks, knobs, push-pull switches, and slide switches. These overall findings should be applied with caution as the type of switch drivers prefer is function-specific.

How Did Preferences Differ for Controls on Pod-Based Versus Conventional Instrument Panels?

This section focuses primarily on differences in location preferences and switch type preferences, though method of operation is also considered. The data for instrument panels with pods (a sports car) come from Green, Kerst, Ottens, Goldstein, and Adams, 1987 and Green and Goldstein, 1989. The data for podless or conventional instrument panels (a sedan) are from this study.

Differences are examined control by control. Readers may find it useful to have the Green et al (1987) and the Green and Goldstein (1989) reports open to the sections that deal with specific controls (pages 26-109 and 20-37, respectively). Readers may also find it useful to flip to the associated pages earlier in the results section of this report as well.

As a reminder, the pod instrument panel/sports car data was from a sample of over 100 drivers who sat in a mockup with pods adjacent to the steering wheel. The vehicle had bucket seats and a center console. A floor-mounted shift was implied but not presented. A total of 24 functions were examined.

In this experiment concerning a conventional instrument panel/sedan, only 9 of the 24 functions were examined, though locations and switches for several of those not evaluated were based on the results from Green, et al (1987). The mockup in this study had a bench seat, no center console, a column-mounted shift lever, and a flat instrument panel. Further, except for one person, all participants drove 1985 or later model-year cars. (There was no constraint on what participants drove in the previous experiment.)

Cruise On/Off

With regard to the cruise on/off function, there was remarkable agreement between the two studies. In the sports car (pod design), 45% of those responding wanted this function on the steering wheel spokes. For sedans (conventional design) the figure was 46%. Given the statistical error inherent in these measurements, the values are identical. In the sports car study there was almost a 2:1 preference favoring the left spoke over the right (19% vs. 11%). For sedans there was a slight preference for the right spoke (24% vs 20%). It may be that drivers made based their preference on a well-established human factors principle, "Balance the workload among limbs". Probably drivers not only assumed that the sports car had a floor-mounted transmission, but that it was a manual transmission as well, as is usually the case. Since shifting a manual transmission is a significant load on the right hand, moving the cruise on/off to the left spoke would balance the workload.

The second choice for the sports car was on the right pod (13%), a location not present in the sedan, where the second choice was on the lower left panel (17%). Preferences for mounting on the left column were almost identical (15% in the sedan, 13% in the sports car).

In both cases the favored switch was a rocker. This preference was slightly higher for the sedan (41%) than the sports car (34%). The combined push button/surface was the second choice in both the sedan (35%) and sports car (28%).

Cruise Set

The preferred location for the set switch was on the steering wheel hub (49% for pod-based instrument panels, 57% for conventional instrument panels). In the former, the favored zone was the right spoke (22%), with the left spoke being the second choice (12%) and the bottom spoke being a relatively strong third choice (10%). For the later, the right spoke was strongly preferred over the left (37% vs 13%), and there was not a strong third choice. The relatively greater preference for the right spoke on conventional instrument panels is consistent with the workload balancing principle described earlier for the cruise on/off function. Also remarkably consistent across studies was the preference for stalk controls, 16 and 12% for left and right stalks on pod-based panels, 15 and 13% for conventional designs.

Preferences for switch types were also similar. The favored switch was a pushbutton/surface, particularly for spoke-mounting (37% pod-based designs vs. 42% conventional), utilizing a push-in motion for operation. Stalk controls were also common, equally for both designs (27%).

Dome Light

For both conventional instrument panels (sedans) and pod-based designs (sports cars) a large number of potential locations for dome light controls were identified. At a detailed level, the favored specific location for the conventional sedan design was the lower left corner of the panel (19%). In the pod-based design the center ceiling directly in front of the dome light was most preferred (17%). (Interestingly, that same left zone was preferred by 15% of those responding to the pod-based design.) There were additional small differences in preferences for pooled zone roof locations. In the sports car study the preferences were 27% and 14% for the center and front portions of the roof, whereas in the sedan study the figures were both 26%. In the sports car study people sometimes mounted the dome light on the pods, which were not present in the sedan study.

Concerning switch type, rocker switches were most popular in both cases (41% for the sports car, 33% for the sedan). Detailed data on preferences for switch type by location were not analyzed for the dome light in the sports car study.

Front Washer

There were some differences between the two studies concerning the location of the windshield washer. In the sports car study, the preferred locations were right stalk (32%), right pod (18%), left stalk (17%), and left pod (13%). For sedans (conventional instrument panel) the preferences were left stalk (30%), right stalk (28%). When pods are provided, some drivers prefer to locate the washer there instead of on stalks, especially the right pod, a popular location in the sports car study. That change is important enough to cause a different location to be preferred overall.

In both studies the same types of control and motions were preferred for right stalk (push left #1, pull out #2) and left stalk (push right #1, pull out #2). For the left stalk, the push right motion was preferred far more often than the pull out motion. For other zones the preferred switch varied from location to location in no consistent pattern. Further, for sedans, drivers consistently preferred push in as the motion for those other locations while in sports cars the motion varied considerably.

Front Wiper

Because they were often combined, the pattern for the windshield wiper control is similar to that for the washer. For sports cars the preferred locations were right stalk (33%), right pod (18%), left stalk (17%), and left pod (13%). In sedans (conventional instrument panel) the preferred locations were left stalk (30%), right stalk (28%). Obviously, when stalk-mounting was preferred, stalks were identified as the desired switches. For panel-mounting (in sports cars) no single type of switch was consistently preferred (knobs, rocker switches, slide switches, and combination switches were all called for with some degree of regularity).

In terms of method of operation for the right stalk, twisting it was preferred roughly 2:1 over the second choice, push up. For the left stalk, twisting it was also strongly preferred. For panel-mounted controls, there was no consistent preference for a particular motion as a wide variety of controls were preferred, many of which did not share a common method of operation.

Hazard

In the sports car study, the preferred location for the hazard switch was below the right pod (16%). No single specific location was chosen nearly that often, though the combined total of the column locations (pooled zone 11) was 17%. In the sedan, the bottom of the steering column was preferred (19%). The top and side of the column were also chosen (13% and 2%, respectively) favoring the entire column area (pooled zone 11) by 33% of the drivers. Apparently providing pods caused almost half of the drivers who would place the hazard switch on the steering column to choose a pod (either left or right side) instead.

In both types of vehicles there was a very consistent preference for rocker switches, 47% in sports cars (pod design), 56% in sedans (conventional design). Surprisingly, the overall preferences for a push in motion were the same (59%).

Headlights On/Off

Because some people preferred mounting the on/off switch on pods, there were differences between the sedan and sports car preferences. In sport cars the preferred location was on the left stalk (28%), though if one treats the left pod as a single zone, that was the preferred location (31%). The third choice was low on the left side of the panel (22%). In sedans (conventional design) that location was chosen by 50% of those responding, a very strong consensus. The left stalk was the second choice (24%) and higher on the left panel was third. In sedans no one wanted this function anywhere on the right side, either on the instrument panel or on a stalk.

Concerning switches, obviously stalks were preferred when stalk mounting was required for both vehicles. In both cases there was agreement that the stalk should twist about its lengthwise axis.

For panel mounting low on the left, the favored switch was of a push-pull design (51% of the responses for sports cars, 48% of the responses for sedans). For mounting on the left side of the panel and on a panel, there was a wide variety of switches and motion combinations, each of which was preferred by a few people.

Ignition

The column-mounted transmission of the sedan caused the preferred ignition location to vary from that of the sports car (having a floor-mounted shift). Although the steering column pooled zone was the preferred location for both (50% for the sports car, 61% for the sedan), the specific location on the column preferred by drivers was different. The side of the column was most preferred (41%) among sports car (pod-equipped) drivers. In the sedan, however, this location was the third choice, while the lower right quadrant of the column was selected by 50% of the sedan drivers. Over 10% of the sports car drivers preferred locations which did not exist in the sedan, including the lower right pod and the floor portion of the console.

There were no differences in switch preferences, since in both car models 100% of the drivers chose a key switch for the ignition . Similarly, methods of operation for both the sports car and sedan entailed a twisting motion, where the axis around which the motion occurred depended on the orientation of the switch.

Panel Brightness

For both sports cars and sedans (pod and podless instrument panels), the preferred location was the same, low and outboard on the left side of the panel, though the preference was stronger in podless designs (35% vs. 28%). The second choice was the inboard on the lower left side of the panel (17%), which combined with the previous value yields a total of 55% for the lower section. Interestingly, the lower inboard section was infrequently preferred for instrument panels with pods. Instead, preferred locations were distributed across the left and right pod, but especially the left (29%), with the top 1/3 being preferred (14%).

Since a vertical surface was chosen in virtually all cases for both vehicle types, it seems reasonable to aggregate switch preferences across them. The preferred switch for instrument panels with pods was a knob (35%), followed by a thumbwheel (28%). For podless designs the preferences were less strong and reversed (thumbwheel 22%, knob 20%). In both cases a pull-push switch was the third choice. The switch choice did depend on the location and was consistent in both cases. Thumbwheels were preferred for pods and upper section of the instrument panel, knobs and pull-push switch for location low on the panel. When thumbwheels were preferred, people wanted them oriented vertically (up for increase).

How Did Driver Characteristics Influence Their Preferences for Locations and Switches?

In this study three types of information was collected that related to driver characteristics: biographical data (age, sex, etc.), anthropometric data (standing height, etc.), and their experience with particular types of vehicles (airplanes, motorcycles, etc.). Detailed descriptions of those characteristics appear in Appendices B and C. In addition, general information was obtained describing the types of vehicles they drove. Information relating the locations and types of switches in their cars to their preferences was described earlier.

Biographical Factors

With regards to the types of switches people preferred, there appeared a significant difference between men and women (Chi-Square(11)=23.5, p=.015) when all the data were included. As shown in Table 27, women tended to prefer pushbuttons, knobs, and slide switches more than men, and combination switches somewhat less. However, this is more likely an artifact of the analysis, due to the small size of many of the cells in the Chi-Square data analysis. When the small cells are removed (toggle switch, paddle switch, and lever), as they should be, there are no significant differences between men and women (Chi-Square(8)=12.4, p=.131)

Table 27. Sex Differences in Preference for Switches

Sex	Switch Types											
	Rocker	Thumb Wheel	Toggle	Slide	Push-Button	Push Pull	Paddle	Knob	Push Surface	Combo	Stalk	Lever
Men	46	11	0	8	20	25	3	7	13	22	57	3
Women	51	6	5	13	32	18	0	12	18	12	49	0

Note: In this and subsequent tables there is 1 data point missing.

When partitioned into 2 age groups (19-39, 43-77), a significant difference was found (Chi-Square(11)=31.3, p=.001). Those results are shown in Table 28. Here younger people are more likely to prefer toggle switches and stalks, but less likely to prefer push-pull switches (such as commonly used for headlights on/off). They have a somewhat greater preference for stalks. As before, removing the small cells (toggle, paddle, lever) markedly decreases the extent of significant differences (Chi-Square=15.2, p=.056).

Table 28. Age Differences in Preferences for Switches

Age	Switch Types											
	Rocker	Thumb Wheel	Toggle	Slide	Push-Button	Push Pull	Paddle	Knob	Push Surface	Combo	Stalk	Lever
Young	61	10	0	11	30	11	3	10	16	18	66	3
Old	36	7	5	10	22	32	0	9	15	16	40	0

The only other factor examined was eyewear (glasses vs no glasses). It had no effect on switch preferences (Chi-Square(11)=15.9, p=.144).

The effects of biographical differences on location preferences are quite similar. The effect of sex was significant (Chi-Square(11)=20.4, p=.039) but not age (Chi-Square(11)=8.57, p=.661). In general, men had a stronger preference for hub controls but did not want controls on the top of the console. Tables 29 and 30 show the sex and age data respectively. The authors have no explanation as to why these differences occurred. They are probably statistical artifacts resulting from the small cell sizes.

Table 29. Location Preferences as a Function of Sex

Sex	Location											
	Left Panel	Hub	Right Panel	Left Low	Right Low	Console Top	Console Low	Left Stalk	Right Stalk	Column	Fwd Roof	Ctr Roof
Men	18	45	8	45	8	0	16	31	23	9	7	6
Women	16	27	8	60	8	12	11	30	19	10	7	8

Table 30. Location Preferences as a Function of Age

Age	Location											
	Left Panel	Hub	Right Panel	Left Low	Right Low	Console Top	Console Low	Left Stalk	Right Stalk	Column	Fwd Roof	Ctr Roof
Young	17	42	10	24	5	5	6	16	9	6	3	6
Old	17	30	6	81	11	7	21	45	33	13	1	8

Unlike the switch type data, there were significant differences due to eyewear (Chi-Square(11)=19.3, p=.055). People with eyewear had a stronger preference for controls mounted close to the steering wheel--on the hub and on stalks. See Table 31. It may be that people with glasses found it easier to read labels in those locations but, as in other cases, this could be a statistical artifact.

Table 31. Location Preferences and the Role of Eyewear

Eyewear Location	Left Panel	Hub	Right Panel	Left Low	Right Low	Console Top	Console Low	Left Stalk	Right Stalk	Column	Fwd Roof	Ctr Roof
None	10	19	11	24	5	5	6	16	9	6	3	6
% of 120	8	16	9	20	4	4	5	13	8	5	3	5
Wear	24	53	5	81	11	7	21	45	33	13	11	8
% of 312	7	17	2	26	4	2	7	14	11	5	4	3

Note: In this table there are 120 responses from those who did not wear glasses but 312 from those who did. Hence, the comparison should focus on the likelihood (here a percentage), that a control would be placed in a particular zone.

For many of the other factors there were too few data points to compute a meaningful Chi-Squared statistic. There were only two left-handed participants, so the handedness which might influence the choice of location was ignored. Similarly there were very few people who reported any disabilities (2), so that factor was ignored.

Thus, it is possible that these biographical factors could have some impact on preferences. However, the small cell sizes used in the calculations are at least at the limit of prudent choice. When the cells with small values are removed, statistical significance is rarely achieved.

Physical Characteristics

This section examines the relationship between driver size and choices for switches and locations. Perhaps larger people, for example, while they sit farther from the instrument panel, could reach more of the instrument panel because their arms were longer. If that were so, they might be less concerned about having controls close to the steering wheel.

To examine the impact of physical characteristics an Analysis of Variance (ANOVA) was computed for each of the 10 physical measurements comparing the 10 pooled zones. The results are shown in Table 32.

Table 32. Summary of Pooled Zone ANOVAs

Dependent Measure	ANOVA p	
Seat Position	.385	(not significant)
Near Acuity	.277	(not significant)
Standing Height	.064	(marginally significant)
Seated Head Height	.052	(marginally significant)
Seated Eye Height	.007	(very significant)
Shoulder Elbow Length	.292	(not significant)
Elbow-Wrist Length	.275	(not significant)
Hand Length	.473	(not significant)
Index Finger Width	.362	(not significant)
Weight	.173	(not significant)

Three measures, all of which in some way relate to upper torso length, were related to the choice of where controls were preferred. Since there were 10 dimensions of interest and the cutoff was p=.1, one would have expected one measure to be significant of average by chance. Even three is not too surprising because the three measures are well correlated. (See Appendix B.) Table 33 shows the means used in the ANOVA. Notice that the rank orders are extremely similar. The authors are unable to offer an explanation. One theory was that for people with long torsos, vertical distance (above ground) should determine preferences. Indeed, the two preferred locations, console top and forward roof are well above ground. But the vertical distance explanation doesn't make sense because the number 3 and 5 ranked choices were low on the instrument panel (left and right respectively).

Table 33. Anthropometric Measures and Pooled Zone Preferences

Pooled Zone	Standing Ht.	Seated Ht.	Eye Height
Console Top	162.0 (1)	86.4 (1)	75.4 (1)
Forward Roof	166.6 (2)	87.4 (2)	76.1 (2)
Left Low	167.6 (3)	88.1 (5)	76.6 (3)
Column	167.5 (4)	88.0 (4)	76.7 (4)
Right Low	167.9 (5)	88.0 (3)	77.2 (6)
Left Panel	168.7 (6)	88.5 (8)	78.0 (8)
Right Stalk	169.3 (7)	88.4 (7)	77.0 (5)
Left Stalk	169.3 (8)	88.4 (6)	77.2 (7)
Right Panel	169.6 (9)	89.5 (10)	79.0 (9)
Console Low	171.1 (10)	89.6 (9)	79.3 (12)
Center Roof	171.6 (11)	89.8 (12)	79.0 (10)
Hub	172.1 (12)	90.5 (11)	79.1 (11)

Note: The mean values, computed across drivers and functions, are all shown in centimeters. So, if a driver placed two controls on the top of the console, their height was averaged twice into the data set (that led to the 162 cm mean).

With regard to switch type, a summary of the ANOVAs is shown in Table 34. These ANOVAs were computed without the means for toggle switches, paddle switches, and levers included. Only a few of those switches were present and including that data led to extreme violation of the equal cell size assumption required for calculation.

Table 34. Summary of Switch Preferences ANOVAs

Dependent Measure	ANOVA p	
Seat Position	.230	(not significant)
Near Acuity	.002	(very significant)
Standing Height	.010	(very significant)
Seated Head Height	.003	(very significant)
Seated Eye Height	.000	(highly significant)
Shoulder Elbow Length	.010	(very significant)
Elbow-Wrist Length	.250	(not significant)
Hand Length	.177	(not significant)
Index Finger Width	.115	(not significant)
Weight	.000	(highly significant)

Shown in Table 35 are the switches rank ordered based on the anthropometric data. To simplify the data, the means are not shown. The sizes of the means are similar to those shown in Table 33. They differences fall into three groups based on the similarity of rank orders and the correlation data in Appendix B. One group consists of standing height, seated head height, seated eye height, and weight. A second, quite similar to the first, contains only shoulder-elbow length. The third contains only near acuity.

Why did these patterns occur? One possible explanation is that the most of the switches near the top of the list can be operated using the extended fingers and are easier to reach for people with short arms. Switches such as stalks, slide switches and combination switches may required the fingers to be curled, so the reach available is reduced. The authors have no explanation for the other two patterns.

Table 35. Anthropometric Measures and Switch Preferences

Switch	Stand Ht.	Seated Ht	Eye Ht.	Weight
Knob	1	1	1	2
Push Surface	2	2	2	1
Push-pull	3	3	3	4
Thumbwheel	4	6	7	8
Pushbutton	5	4	5	3
Stalk	6	5	8	5
Rocker	7	7	6	7
Slide	8	9	9	6
Combination	9	8	4	9

Switch	Shoulder Elbow
Thumbwheel	1
Push Surface	2
Pushbutton	3
Knob	4
Combination	5
Slide	6
Push-pull	7
Stalk	8
Rocker	9

Switch	Near Acuity
Rocker	1
Knob	2
Stalk	3
Push Surface	4
Slide	5
Pushbutton	6
Combination	7
Push-pull	8
Thumbwheel	9

Experience Factors

It could be that experience with vehicles other than cars influenced the types of switches people wanted and where they wanted them. Such information can be readily obtained from market segment profiles. Related information, concerning the influence of what they drive now, was covered earlier.

Except for three cases, whether or not one had operated any of the vehicles listed (aircraft, power boat, construction equipment, heavy truck, farm machinery, industrial truck, military vehicle, motorcycle, snowmobile) did not significantly influence driver preferences for switch types or location ($p>.1$). The exceptions were Aircraft Experience and switch preferences (Chi-Square(11)=20.4, $p=.039$), Snowmobile Experience and switch preferences (Chi-Square(11)=17.3, $p=.098$, and Snowmobile Experience and location preferences (Chi-Square(11)=21.5, $p=.029$). The aircraft data should be ignored as only 3 of the 12 pairs of cell had both pairs of cell values in excess of five, the desired minimum. There were only six people who had operated aircraft. The number of people who had experience with snowmobiles was larger (14 of the 54 tested). However, it is likely the snowmobile finding is spurious. By chance, one would expect one significant outcome on average for the location and switch data, which is what occurred here.

CONCLUSIONS

This section examines six questions:

1. Which locations, switches, and methods of operation do drivers prefer?
2. Why do drivers prefer various locations and switches?
3. How do the preferred locations and switches differ from the controls in participant's cars?
4. How do preferences differ for controls on pod-based versus conventional instrument panels?
5. How do driver characteristics influence their preferences for locations and switches?
6. How could the "Potato Head" test procedure be improved?
7. What further studies should be conducted?

Which Locations, Switches and Methods of Operation Do Drivers Prefer?

Table 36 contains a summary of the driver preferences for locations, switch types, and method of operation of the nine functions tested for a conventional instrument panel (sedan configuration). Only the pooled zones selected by more than 20% of those responding are shown. This arbitrary number seemed to include all instances in which people agreed where switches should be located and how they should operate. The pooled zones make sense to use because driver performance in operating controls degrades when a control is more than six inches from where it is expected (Turner and Green, 1987), or, of course, on a different plane. The pooled zones are areas that fit that dimensional constraint.

Concerning switches, all combinations preferred by 10% or more of the sample are listed, except where no single switch exceeded that amount. In that case, the clear preferred choice for that location was shown, if there was one.

When given complete freedom over where functions should be located and the type of switch to be used, rarely did a majority of drivers agree. Excluding ignition, the most preferred location (pooled zone) was selected by 41% of those responding on average. However, when switch motion combinations are introduced, the figure falls to 26%, just over 1 out of 4. Further, when other constraints are introduced (exact location, specific switch design, etc.) there is even less agreement.

Table 36. Summary of Preferences for Conventional Instrument Panels

Function	Pooled Zone (%)	Switch & Motion (%)
Cruise On/Off	Spokes (46) (right preferred)	pushbutton/surface* - push in (24)
		rocker - push in (22)
	Stalks (20) (left preferred)	stalk - push right (27)
Cruise Set	Spokes (57) (right preferred)	pushbutton/surface* - push in (35)
	Stalks (28)	stalk - push right (15)
Dome Light	Center Ceiling (26)	rocker - push up (11)
	Front Ceiling (26)	pushbutton - push up (9)
	Low, L Panel (24)	no consistent choice
Front Washer	Left Stalk (30)	stalk -push right (22)
	Right Stalk (28)	stalk - push left (13)
		stalk - pull out (11)
Front Wiper	Left Stalk (30)	stalk - twist + & - y (28)
	Right Stalk (28)	stalk - twist + & - y (19)
Hazard	Column (33)	rocker - push down (9)
	Low, L Panel (24)	rocker - push in (14)
Headlights On/Off	Low, L Panel (50)	push-pull (24)
		pushbutton (11)
	Left Stalk (24)	stalk - twist + & - y (24)
Ignition	Column (61)	key - twist +&-Y (63)
Panel Brightness	Low, L Panel (56)	push-pull - twist + & - x (17)
		knob twist + & -x (13)
	High, L Panel (20)	no clear preference

*Note: The push surface was misinterpreted as a flush mounted pushbutton.

If preferences are to be the primary means of selecting secondary control locations, switch types, and methods of operation, the following are recommended for conventional instrument panels:

The cruise on/off and cruise set functions should be located on the steering wheel spokes, preferably on the right. A rocker switch should be used for on/off and a pushbutton for set. Drivers preferred to operate both controls by pushing them in (forward). Although a pushbutton/surface was equally preferred for the cruise on/off, good human factors suggests that controls operated without looking should feel differerent in order to avoid errors.

In recommending a location, there are other conflicting pieces of information to consider. The Functional Grouping Principle states that functions used together should have their controls and displays adjacent to each other. Thus the On/Off and

Set switches should be adjacent. The Principle of Avoiding Inadvertent Operation suggests the opposite. While the two switch types are different, they have the same method of operation and are in the same area. Since the controls are operated without looking at them, there are opportunities for inadvertent operation. This error can occur when the cruise function is on and the driver intends to turn it off, but instead hits the set switch, setting in the current speed. Thinking it was off, the driver could then back off the accelerator to slow down, but find the vehicle unresponsive. While the cruise control can be disengaged by stepping on the brake, the driver may think the vehicle is "running away and out of their control," and may not take that action. The extent to which this could be a problem should be investigated.

Air bags are a further complicating factor. If installed in the steering wheel hub, placing the cruise switches there as well is difficult.

The dome light switch should be mounted on the lower left panel or ceiling. For the lower left panel location, a push-pull switch was preferred. For the ceiling, people were evenly split between a forward and center location. The switch used on the ceiling should have a push up motion. While the specific type of switch is probably not critical, a rocker switch was preferred and is recommended. The data from the previous study of pod-type instrument panels made the same recommendation.

The wiper and washer controls should be stalk-mounted. When it came to selecting the left or right side, there was no practical difference between the two. (Out of 54 participants, 2 more preferred the left side than the right.) When combined with the preferred motion pattern, there is greater agreement for left locations. However, the authors are concerned that opportunities for inadvertant operation may arise if other functions are also operated on the left stalk (beam select, turning indicator, headlights, cruise control.) Therefore, depending on the distribution of other controls among stalk locations, the right stalk is generally recommended, as in the previous study. The absolute level of agreement for the preferred motion on the right stalk was low. To facilitate rapid operation (by not requiring a grasp), good human factors practice suggests pushing the lever up for wiper on (compatible with the wiper motion) and, pulling or pushing the stalk to operate the washer.

Drivers preferred to have the hazard switch mounted either on the steering column or low on the left side of the instrument panel. In both cases a rocker switch was preferred. The level of agreement among drivers for this function was low, so the recommendation for this switch is weak.

Drivers preferred to have the headlights on/off switch mounted low on the left side of the instrument panel. This location was preferred by half of those responding, a high level of agreement. While the preferred switch (by 24% of those responding) was a push-pull type, the authors do not recommend it. That type of switch provides poor feedback about its position. A common error is for people to pull the switch at dusk, and seeing their panel brightness increase, think their headlights are on. As it gets darker, they then have trouble seeing ahead and others have trouble seeing them. Alternative switches preferred for the lower left panel include pushbuttons, rocker switches, and knobs. The authors would most recommend using a knob for the headlights on/off as it provides good feedback.

The ignition switch should be mounted on the column, not the instrument panel. Column mounting was preferred by a 3:1 margin. There is insufficient evidence in the data to suggest a specific switch design.

Based on the preferences, the panel brightness switch should be located low on the left side of the instrument panel. While the combined preferences were for switches that twist (e.g., push-pull switch), the overall preference was for a thumbwheel. To be consistent with the recommendation for the headlight switch, a thumbwheel is recommended for this control.

Why Were Various Locations and Switches Preferred?

There was no single predominant reason why drivers preferred particular locations for controls. The most commonly cited reason was related to familiarity/expectation. This reason accounted for about one fifth of the reasons cited. People generally said that they were accustomed to a function being in a specific place or, because of what they had driven, expected it in a particular place.

The second most commonly cited reason had to do with the ease of making a motion to operate a control. In some sense this had to do with how easy it was to reach a control. This reason was cited almost as often as familiarity/expectation. Other reasons cited included handedness/balance of use (dividing the workload evenly among hands) and frequency of use.

Related to this, drivers had the sense that more frequently used controls (wiper) should be in closer proximity to them than those less frequently used (hazard), and that was particularly true for controls used while the vehicle is in motion.

A genuine surprise from these results was how often human factors principles were cited by drivers, though indirectly, as influencing their decisions. To some degree this occurred because the list of reasons used to code responses was based on ideas presented in human factors textbooks. Drivers could have responded that switch arrangements were arbitrary or that arrangement of switches formed a pattern that was pleasing to the eye. Instead what they said was that driver expectation, frequency of control use, workload balance among the hands, functional grouping, and so forth were important.

Some of the reasons for preferring various types of switches were similar to the reasons for preferring locations. The most common, familiarity/expectation was the same in both cases. However, the second-most commonly cited reason was aesthetics, that is people liked the was the switch looked, though in some cases it was that the switch looked simple to use. Cited almost as often were reasons associated with labelling and illumination. People wanted switches that had legible and easy to understand markings, and in a number of cases made mention of lights (sometimes built into a switch) to indicate that something was on. Physical characteristics of switches (forces) were cited less frequently as being important. In some sense that is good because when the switches were modified for surface mounting for this and the previous experiment, no effort was made to keep the operating forces identical to design values. (It was far too costly.) Also interesting was how rarely people identified the sound of a switch as being important. Again, the frequency with which a reason is cited is linked to the list used to help participants and this item was not covered. While many in the industry are interested in the best sound for a switch, drivers are not.

How Did the Preferred Locations and Switches Differ from the Controls in Participant's Cars?

The most commonly stated reason for location preference was familiarity/expectation (17%). While some linkage between the preferred and actual locations would therefore be expected, the two distributions were in fact significantly different . Overall, people were half as likely to want controls on the left stalk. However, the key differences were not overall, but by control. People wanted hub-mounted cruise controls, stalk-mounted windshield wiper/washer controls, and panel-mounted headlights on/off switches. Also, they were more likely to want the dome light switch on the front ceiling than it was found in their cars and the hazard switch on the panel.

Regarding switch preferences, drivers were generally not influenced by the actual switches in their cars, as previously noted.

How Did Preferences Differ for Controls on Pod-Based Versus Conventional Instrument Panels?

In the first driver preference study, pods were not used as locations for a large number of functions. Therefore, neither their presence, nor placing the shift lever on the column versus the floor seemed to have an overwhelming influence on where drivers wanted controls, the types of switches preferred, or how they should operate.

For both types of instrument panels drivers preferred to have the cruise on/off and set functions on the steering wheel spokes. In fact, the preferences in one case differed by only 1%, well within the limits of statistical error for the 2 experiments (100 plus and 50 plus participants). For sports cars (the pod design), there was a slightly greater preference on the left spoke.

Preferences for dome light switches were similar. Lower left panel and roof-mounting was preferred, though somewhat less often in the sports car where pod locations (primarily left pods) were an attractive alternative.

For windshield wiper and washer, stalk locations were generally preferred for both types of instrument panels. In the pod-equipped car there was, a tendency for the right pod to be selected for the washer (an easy to reach location), However, not a tendency for the right side of a conventional instrument panel to be selected. Further, there were also trends with regard to method of operation preferences. Less agreement of the methods of operation arose for vehicles with pods.

For the hazard switch, the pod was a likely chosen location in the sports car (pod equipped). For conventional sedans, column-mounting was clearly preferred.

For lighting controls (headlights on/off, panel brightness) the lower left instrument panel location was highly preferred in the conventional, sedan design. However, in the pod-based sports car, pod-mounting was often used instead. Preferences for switches varied with the orientation and type of mounting required.

Finally, for ignition, locating the transmission shift on the column affected the specific locations. The steering column was the preferred location for both column and floor shift models, but more so with the column mount. For floor-mounted shifters, the side portion of the column was favored, however, this area is where the

column shift was mounted for the conventional car, therefore drivers typically placed ignition on the lower part of the column, underneath the shifter. A key switch was chosen by all of the drivers in both cars, with a twisting method of operation depending on the switch orientation.

Thus, there were the same general preferences for both types of instrument panel designs--spoke-mounted cruise controls, stalk-mounted wiper/washer controls, and lower left panel or ceiling-mounted dome lights (the front ceiling panel was preferred more in the conventional design than with pods). However, providing a pod did lead to consistent changes in preferences, often making pod-mounting a good second choice for headlights, panel brightness, and windshield washers/ wipers. This may show a tendency for drivers to want controls located in close proximity to their hands on the steering wheel. Further, it is suspected that having a manual shift lever made it more likely that drivers wanted some of the cruise functions on the left spoke, not the right, to balance the workload on their hands.

How Do Driver Characteristics Influence Their Preferences for Controls?

A limited number of driver-related factors influenced the types of switches they preferred, where they wanted them, or how they should operate. There were some differences in terms of the kinds of switches men and women preferred, but no differences in location. In one case there was a difference in switch preference due to age. Because of the small cell sizes used in the calculations, these results could be spurious. Finally, there were some slight differences between those that did and did not wear glasses or other eyewear in terms of where controls were preferred. The differences don't seem to fit an easily explained pattern.

Three physical measurements were linked to where people wanted switches--seated eye height, and to a lesser extent seated head height and standing height. The data do not follow an easily explained pattern.

Surprisingly, several physical measures were significantly linked to switch preferences. They fall into three groups. People with larger torsos (greater standing height, seated head height, seated eye height, and weight) were more likely to prefer switches that required grasping (slide switches, stalks) than switches operated with the fingers extended (push surface). There were also significant relationships found for shoulder-elbow length and near acuity. Again, the authors have no explanation for these findings.

In general, the types of vehicles people have driven (heavy trucks, motorcycles, etc.) or how many they had experience with had no bearing on the types of switches people wanted or where they wanted them. In many tests related to experience, the sample size was too small to carry out a proper comparison. For example, only six people in the sample had flown a plane.

Thus, except for some aspects of driver size influencing the types of switches people prefer (but surprisingly, usually not where they want them), very few individual differences influenced control selection or placement. This seems to disagree with common wisdom that different types of people want different types of cars. It does not. While younger people may prefer sports cars and older people prefer family cars, that was not the issue here. In the two experiments conducted so far, people were tested in specific cars with a fixed type of panel shape and a specific type of shift lever and location for it. When choices are constrained in that

manner, differences due to sex, age, probably socio-economic status, and other factors become minor. In some sense, defining a vehicle this way defines the market segment and the way drivers view a car.

How Could the "Potato Head" Test Procedure Be Improved?

This certainly was not the last driver preference experiment for controls ever to be conducted. The authors learned several lessons they would like to pass along.

In general, the experiment proceeded very smoothly. People understood the idea behind the method and found it to be easy to express their ideas about vehicle design. Clearly, it was important to give drivers a large number of alternative switches (hundreds) and to do so in a real mockup. As before, drivers did change their preferences for switch location and type after operating the simulator, so that too should be incorporated in future studies.

One key difference between this and the previous experiment was that the preference responses of every driver were videotaped. This was an important and useful addition. While the computer program facilitated accurate recording of what people wanted and why, there were nonetheless a few errors that slipped through the computer screening. It was helpful to be able to go back and see what drivers did and said.

In future studies, either an SE30 or Mac II family computer (which currently includes the II, IIx, and IIcx) should be used to record the data. A Mac SE, used for the first few participants, proved to be far too slow. Further, compilers for the HyperCard stacks, which are likely in the future, should be examined. While that is being investigated, it may be desirable to modify the stack output so the format can be loaded directly into MIDAS (Michigan Interactive Data Analysis System), a mainframe statistical program at the University of Michigan, for analysis. Currently the data is sorted and checked by a combined manual/computerized process that takes additional time.

In fact, the only significant problem encountered in data collection was some inconsistency between experimenters in how "the reasons why" were coded. These inconsistencies were resolved during the analysis of the data in this experiment. In the future the authors would suggest that a pilot subject be tested and that the experimenters independently code a videotape of the session. Then, as a group, the experimenters should go back to review the tape and the codes used.

There were a few minor problems that occurred during data collection. Some participants mentioned that they might want to mount switches on top of the column. If that is an acceptable location, it should be covered with Velcro® in future studies.

Also, there were delays in coding that could be avoided. While they did go away with time, giving the experimenter an additional list of the major categories for the reasons, would aid in looking up the why codes.

It should be emphasized that these changes are relatively minor. Nonetheless, these changes should be seriously considered for future studies.

What Further Studies Should Be Conducted?

Hub-Mounted Controls

The two experiments completed so far represent two points on a three-point range. They include the classic design, the sedan, in which most of the controls are mounted on the instrument panel. The initial experiment involved a pod design, a more futuristic configuration in which surfaces where controls can be mounted tend to be closer to the driver.

The third, unexplored point is where only steering wheel hub and spokes, and possibly pods, are surfaces on which controls could be mounted. There would be no controls on the instrument panel per se and usually stalk controls would not be fitted. Similar approaches have been used for many contemporary concept cars. If these concepts are to reach fruition and lead to cars people want, then the control configurations should be based on input from drivers.

Clearly, placing an air bag in the steering wheel hub will make it difficult to place controls there as well. The authors see the air bag as a challenge, not an insurmountable obstacle.

As part of the preparation for this study the experimenters should collect the artwork and pictures showing the instrument panel layouts for contemporary concept cars, and if possible, drive them. Securing cooperation for this effort from competitors of the sponsor could be difficult.

Based on experience from these two studies, the authors would suggest testing about 50 people. While participants should be stratified based on age and sex to be consistent with previous research (and therefore comparable), constraints on market segment profiles would make the study extremely costly and difficult to conduct.

The study should use the same mockup as in the past with the driving task, but modified to have an instrument panel shape and steering wheel likely to appear in future cars. Doing away with the steering wheel is unwise. The advantage of the wheel is that it allows for a wide variety of positions in which it can be grasped, thus reducing fatigue. Further, it provides the mechanical advantage needed for steering when the power assist fails. These are not properties that other controls (e.g., a joystick) have.

The same switches should also be used. However, all labels on the current switches should be removed.

Because spacing is tight, all of the controls that could be in that area should be included. Given the way drivers approached the last experiment, the hub experiment should proceed stepwise. Their first task would be to allocate space to each system (cruise, lighting, wiper/washer, climate, audio, turn signals, and horn). The second step would be to identify the types of switches and their method of operation for each function. The specific functions to be included (e.g., rear wiper) has yet to be determined. Since they are unlikely to be located in this area, some functions examined in Green et al 1987 (ignition, power windows, power seat, suspension adjust, mirror controls, etc, should not be considered.) The status of a navigation system is undetermined.

Finally, the authors believe that some effort should be made to get drivers to explain why particular controls and locations were selected. The approach used here has not been useful in identifying the reasons behind direction-of-motion stereotypes and that issue should be explored in a separate study.

Direction-of-Motion Stereotypes

The literature on direction-of-motion stereotypes, while extensive, is not very well integrated. There are some general rules about how controls should be moved to cause desired actions (e.g., clockwise to increase) and examples of what people are likely to do for a few control-display combinations. But, there are no formulas that allow designers to predict the probability various motions will be chosen as a function of the control and display location, orientation, and other factors.

This problem should be addressed in two phases. In the first, the literature on direction-of-motion stereotypes should be reviewed. There are at least 50 articles that have useful stereotype data, so this is not a simple review. In conjunction with the review, a mathematical model should be constructed to predict stereotypes, relying upon data in the literature. The model will not accurately predict performance for all many combinations because there are major gaps in the literature. Those gaps should be examined in a series of experimental studies.

Those studies should be conducted using the mockup at UMTRI. The mockup already has all of the surfaces of interest covered with Velcro® as well as all of the controls of interest. This procedure is likely to lead to better results than the pencil and paper approaches commonly described in the literature.

Preferences for Displays

The focus of the preference research to date has been on controls. Similar work could be conducted on displays. It should follow the pattern used here--doing an extensive survey of cluster displays in contemporary cars (similar to the 86 cars effort), developing a collection of graphics that contain tachometers, speedometers, warning lights, and gauges found in production vehicles, and then providing a mechanism for allowing drivers to select the displays they desire and place them where they want them. It is not clear if the selection should involve the use of printed graphics or computer graphics, but the process should have a "Potato Head"-like quality to it. Critical to the success of this type of project is a rapid prototyping capability.

Once the prototype was developed for each driver, they should operate the simulator as in the previous studies, and then based on difficulties in reading displays, drivers would be allowed to revise their preferences. For the reading test to be successful, it may be necessary for the display to actually operate. Based the authors' experience, a sample of about 50 people should be sufficient if only a single vehicle package was to be considered. If there are multiple packages of interest (e.g., sports car, sedan, etc.), then 50 people should be tested per package.

Test Sample Demographics

All of the UMTRI studies so far (Green, et al, 1987, Green and Goldstein, 1989, this report) have shown that individual differences play a minor role, if any, in control preferences when the body style and instrument panel configuration are

fixed. That is, there are rarely differences between men and women, older and younger people, well educated and less educated, short and tall people, etc., in terms of where controls should be located, what types of switches should be used, or how they should operate. Nonetheless, some people in industry have suggested that a study examining demographic differences should be conducted. Given the current evidence, the authors do not believe such a study should be conducted and mention it only for the sake of completeness.

"Potato Head" As a Design Aid

During the first experiment there were two instances when Chrysler designers came to UMTRI to review the test protocol and to serve as pilot subjects. Serving as a subject, and then discussing the design with other designers was a useful mechanism for generating new ideas. How that process should be formalized and what the research issues are have yet to be identified.

Closing Thoughts

This study reinforces in the authors' minds the usefulness of the "Potato Head" Method. The research provided information that directly identified the types of switches drivers preferred, where drivers wanted them, and how the switches should operate, for eight functions. While there were many trends, there were only a few cases where drivers consistently identified particular switch types or locations. Given this level of indifference, other criteria, in particular driver performance criteria (measures of ease of use), should be given heightened attention. For that reason, future studies should have collecting performance data as their main goal.

This research did not provide simple, clear-cut findings as to why drivers preferred various controls and displays. While it is true that familiarity/expected was the most commonly cited reason, many others were identified as well. This evidence, however, did provide some insight into those reasons which should help guide future product design.

Finally, there was little evidence that anything about participants influenced where or why they wanted particular switches, except possibly the car they drove. Where relationships were obtained, there was often no simple explanation as to why they occurred.

The authors have found the method used here to be a conceptually simple way to provide designers with information they can use to develop products that meet customer expectations. However, to get useful information a considerable amount of equipment (computers, a mockup, innumerable switches, etc.) is required, along with a trained professional staff to collect the data. The authors believe the method can be applied to many other contexts (e.g., home appliances), and are most interested in hearing from others who use the method.

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APPENDIX A
LIST OF VEHICLES DRIVEN BY PARTICIPANTS

This appendix contains a list of the vehicles driven by the participants in this study, all but one of which were 1985 models or newer. Included in a table are the make, year and model of the cars along with the sex and age group (young, middle, old) of the corresponding drivers.

- Appendix A- Vehicles Driven by Participants-

LIST OF VEHICLES DRIVEN BY PARTICIPANTS

As shown below, all of the participants except one (Subject 50), drove 1985-year model or newer vehicles. The make and models of participants vehicles varied widely: 20 participants drove foreign cars (of which 11 were Honda), 16 drove Ford/Mercury cars,and 9 each drove Chrysler and General Motors vehicles. The most common model driven was the Ford Taurus/Mercury Sable, which 7 participants own. This is interesting because the Taurus is a newer model, which utilizes somewhat unique switch types and methods of operation (for example knobs are used for the headlights, as well as many other functions). All but three of the foreign cars were driven by young or middle aged participants.

Vehicles Driven by Test Participants

Make	Year	Model	Participant: Sex	Age
Acura	1989	Integra	F	middle
Acura	1986	Integra	M	middle
BMW	1987	325 SI	M	middle
Buick	1989	Skylark	F	old
Buick	1987	Century	M	old
Buick	1985	Skylark	M	old
Chevrolet	1985	Celebrity	F	old
Chevrolet	1987	Cavalier	F	young
Chevrolet	1986	Nova	F	middle
Chrysler	1986	New Yorker	M	middle
Dodge	1988	Colt	M	young
Dodge	1987	600	M	old
Dodge	1987	600	F	old
Dodge	1986	Lancer	M	old
Dodge	1985	Charger	M	middle
Dodge	1985	Charger	F	middle
Ford	1988	Mustang	M	young
Ford	1987	Bronco	M	middle
Ford	1987	Taurus	M	old
Ford	1987	Taurus	F	old
Ford	1987	Taurus	F	middle
Ford	1986	Escort	M	middle
Ford	1986	Escort	M	old
Ford	1986	Taurus	F	young
Ford	1986	Taurus	M	middle
Ford	1986	Taurus	M	middle
Ford	1986	Tempo	F	old
Ford	1986	Thunderbird	M	middle
Ford	1982	Granada	F	old

Make	Year	Model	Participant: Sex	Age
Honda	1988	Accord	F	young
Honda	1988	Civic	F	young
Honda	1987	Accord	F	young
Honda	1987	Prelude	M	young
Honda	1986	Accord	M	middle
Honda	1986	Prelude	F	young
Honda	1985	Accord	M	young
Honda	1985	Accord	F	middle
Honda	1985	Accord	F	middle
Honda	1985	Civic	M	young
Honda	1985	Prelude	M	young
Mercury	1986	Sable	F	young
Mercury	1985	Grand Marquis	M	old
Mercury	1985	Grand Marquis	M	old
Mercury	1985	Lynx	M	young
Nissan	1986	Stanza	F	old
Pontiac	1987	Grand Am	M	young
Pontiac	1987	Grand Am	M	young
Pontiac	1986	Firebird	F	middle
Plymouth	1988	Sundance	F	middle
Plymouth	1987	Horizon	F	old
Toyota	1988	Camray	M	old
Toyota	1986	Corolla	M	old
Toyota	1986	Tercel	F	middle
Toyota	1985	Corolla	F	young
Toyota	1985	Tercel	F	young

APPENDIX B
PHYSICAL DESCRIPTION OF PARTICIPANTS

This appendix contains a summary of the physical characteristics of the participants of this study. The drivers seat position and nine anthropometric measurements were taken: Visual Acuity, Standing Height, Seated Head Height, Seated Eye Height, Shoulder-Elbow Length, Elbow-Wrist Length, Hand Length, and Index Finger Width. Provided for each is a histogram showing the distribution of measurements, a table listing minimum, maximum, and mean measurements, and a table showing correlations between measures.

PHYSICAL DESCRIPTION OF PARTICIPANTS

Ten measures related to driver physical characteristics were collected: fore-aft seat position, near acuity, standing height, seated head height, seated eye height, shoulder to elbow length, hand length, index finger width, and weight. It was thought these measures might be related to how far people sat from the instrument panel which would affect how far they could reach and how well they could read the control labels. Shown in Table 37 is a summary of these measures. Figures a through j show histograms for each. Based on the HANES data reported in the Anthropometric Source Book, this sample, on average, was 2 cm taller than adult population (mean standing height=166.8 cm, mean seated eye height=87.6 cm) and weighed about 9 pounds more (mean weight=152.8 pounds) (National Aeronautics and Space Administration, 1978).

Table 37. Summary of Driver Physical Characteristics

Dimension	Minimum	Mean	Maximum
Seat Position	0.0	10.4	18.0
Near Acuity (20/x)	13.0	25.6	100.0
Standing Height	148.7	169.1	190.5
Seated Head Ht.	76.5	88.7	98.5
Seated Eye Ht.	63.9	77.6	86.3
Shoulder-Elbow	29.0	34.0	39.5
Elbow-Wrist	22.0	27.7	33.5
Hand Length	15.0	18.1	20.5
Index Finger Width	1.4	1.7	2.1
Weight	106.0	161.6	240.0

Note: All dimensions are in centimeters except for near acuity (which shows the denominator in the Snellen Ratio) and weight (given in pounds). For seat position 0.0 was the forward-most location.

The following histograms show the distribution of the participants' dimensions. Again, all measurements except visual acuity (Figures 17, 19-26) are given in centimeters. Figure 18, visual acuity, is given as the denominator of a Snellen Ratio (where normal vision is 20/20). The numbers given on the horizontal axes represent the category midpoint (for example in Figure 17, the most common seat position was 10 cm, which included measurements from 9.1-11.0 cm). The vertical axes all show the number of participants falling in the given categories.

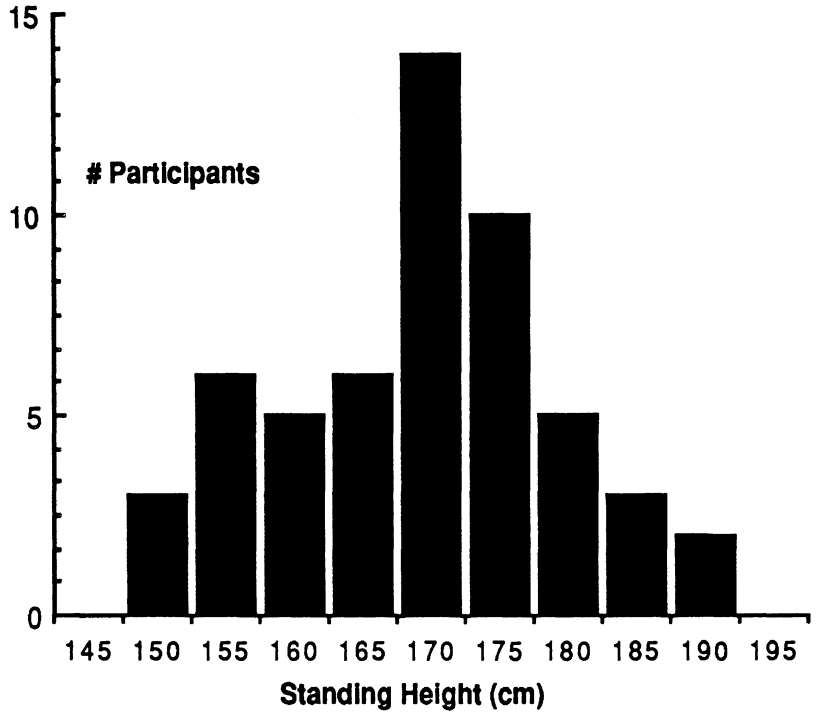


Figure 19. Standing Height vs. # Participants

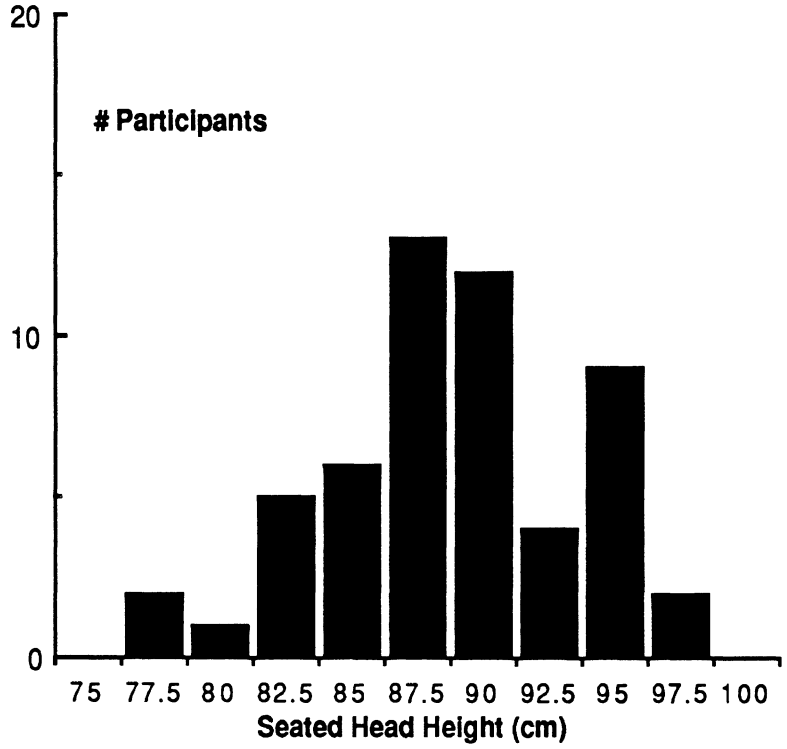


Figure 20. Seated Head Height vs. # Participants

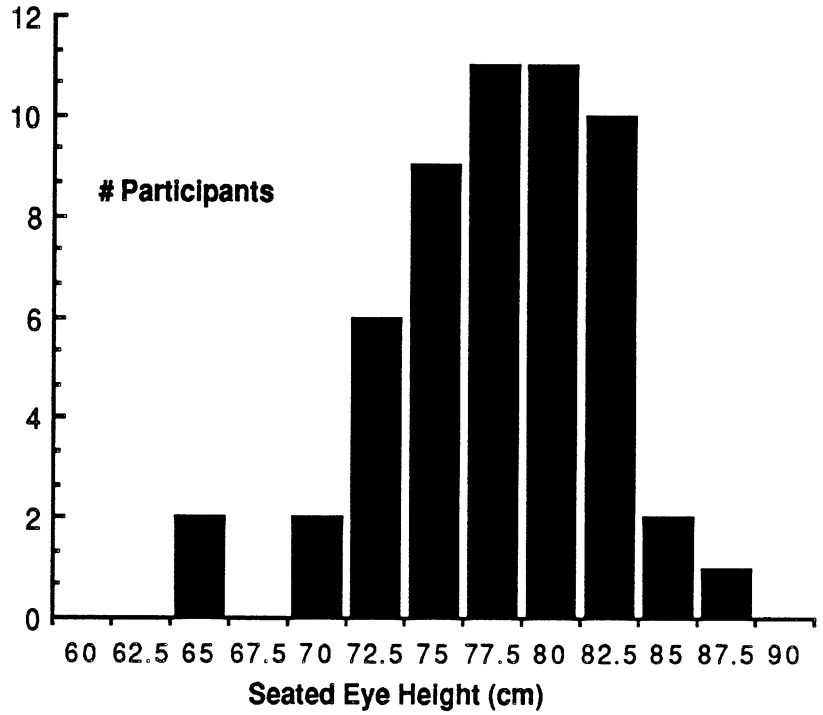


Figure 21. Seated Eye Height vs. # Participants

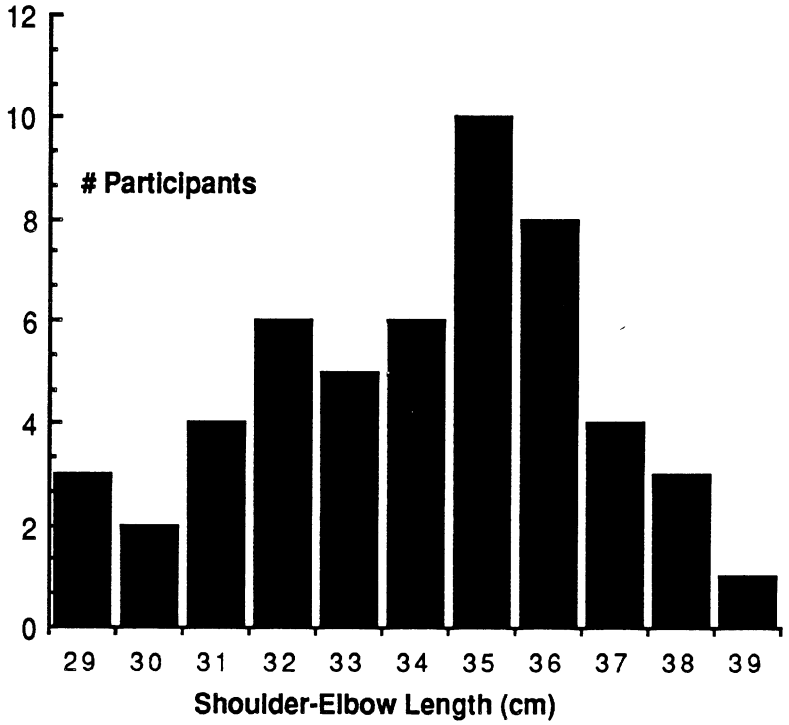


Figure 22. Shoulder-Elbow Length vs. # Participants

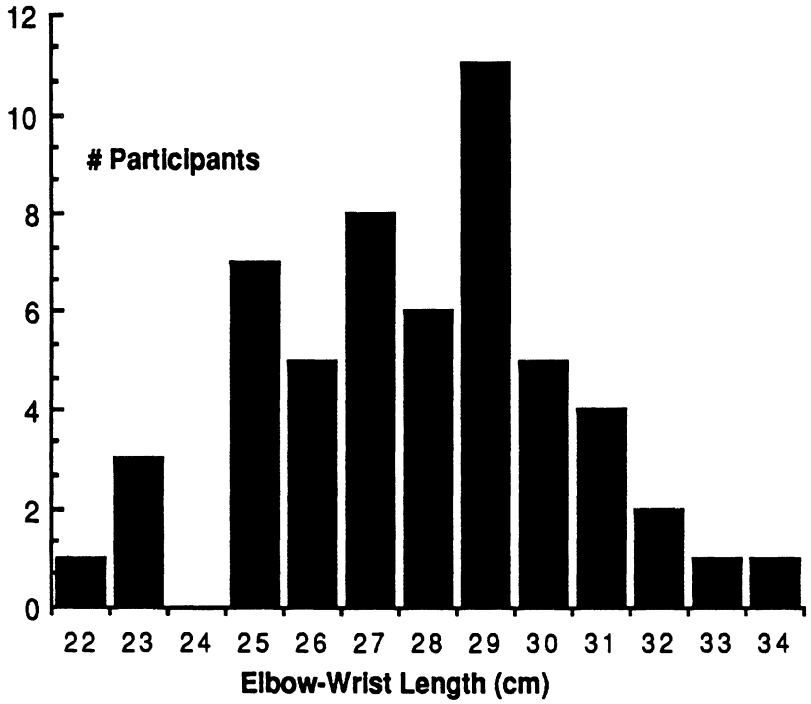


Figure 23. Elbow-Wrist Length vs. # Participants

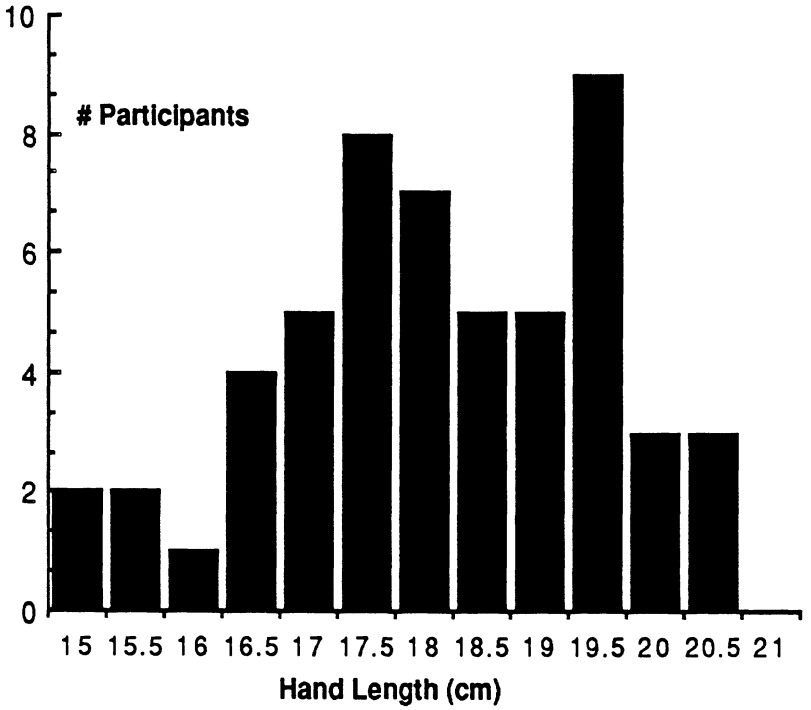


Figure 24. Hand Length vs. # Participants

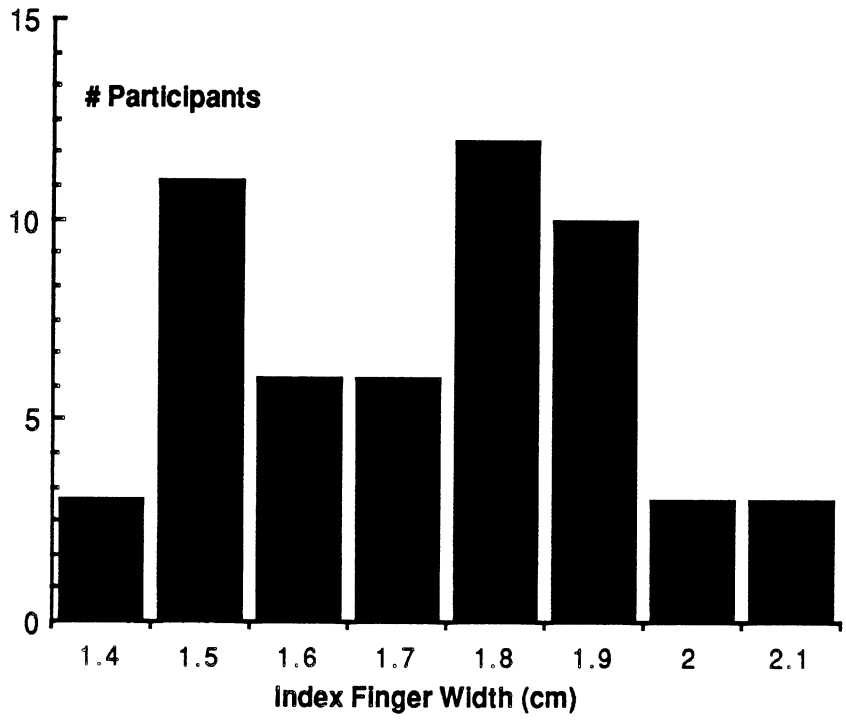


Figure 25. Index Finger Width vs. # Participants

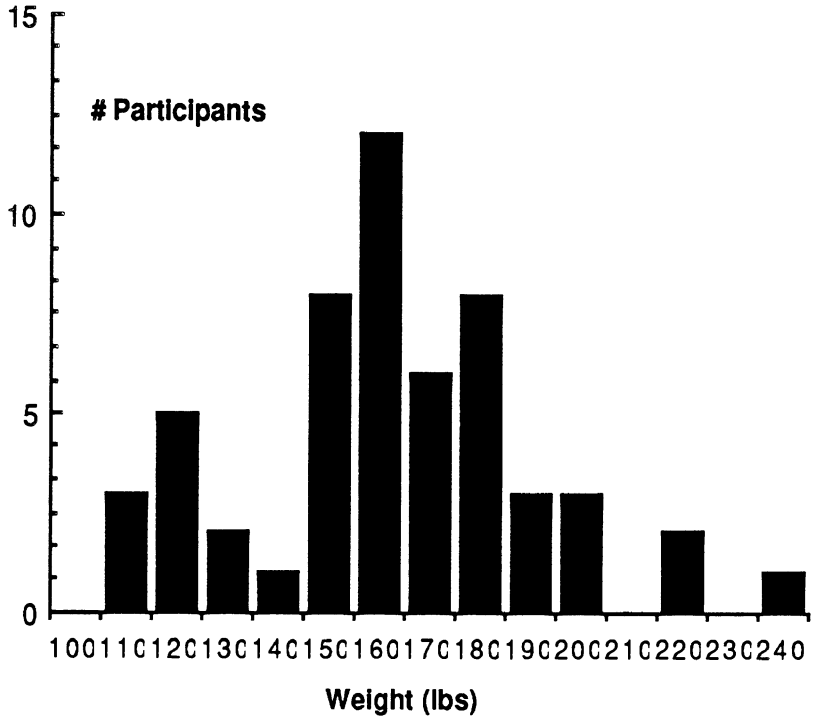


Figure 26 Weight vs. # Participants

Shown in Table 38 are the correlations between these measures. All correlations in excess of .27 are significant at the .05 level. Those in excess of .35 are significant at the .01 level. The correlations appear to be fairly typical values for adults. For example, Christensen (1988) in citing data from Clauser for Air Force personnel, reports the correlation between height (stature) and weight to be .52 (vs. .54 here), between height and hand length to be .65 (vs. .74), and height and sitting height to be .79 (vs. .88). Because Air Force personnel are a censured sample of adults (very tall and very short people are rejected), slightly lower correlations are expected for that sample.

Table 38. Correlation of Physical Dimensions

Dimension									
Seat Position									
Near Acuity	-.32								
Standing Height	.77	-.25							
Seated Head Ht.	.62	-.29	.88						
Seated Eye Ht.	.47	-.12	.76	.91					
Shoulder-Elbow	.56	-.29	.63	.47	.27				
Elbow-Wrist	.75	-.18	.87	.74	.65	.53			
Hand Length	.63	-.38	.74	.64	.56	.56	.74		
Index Finger Wid.	.27	.07	.36	.30	.22	.26	.49	.31	
Weight	.46	-.17	.54	.49	.44	.34	.62	.56	.49
	Seat Position	Near Acuity	Stand Height	Seated Head Ht.	Seated Eye Ht	Shoulder Elbow	Elbow Wrist	Hand Length	Index Fing W

- Appendix B - Physical Description of Participants-

APPENDIX C
PARTICIPANT BIOGRAPHICAL DATA

This appendix contains a summary of the biographical data provided by the participants of this study. Included for each participant is the educational background, as well as handedness and personal restrictions such as eyewear and physical disabilities Information concerning experience with other vehicles, and risk taking tendencies is also included. Finally, the positioning of drivers' hands on the steering wheel is summarized.

PARTICIPANT BIOGRAPHICAL DATA

A considerable amount of information was recorded concerning the 54 participants in this experiment. A summary of their biographical data appears in Table 39. The group was reasonably well educated, somewhat more likely to be right-handed than the adult population (10%), 3/4 wore some sort of corrective eyewear. Only two reported any physical disabilities, both of which were severe arthritis (a few other participants also noted having arthritis, and stated that this did affect some of their decisions for switches or locations).

Table 39. Summary of Biographical Data

Variable	Values						
Education Completed	some high school	high school	some trade school	some college	college	some grad work	grad work
	1	5	1	14	17	5	11
Handedness	right	left	ambidextrous				
	49	2	3				
Eyewear	none	glasses	bifocals	trifocals	contacts	glasses/contacts	
	15	13	10	3	11	2	
Physical Disability	no	yes					
	52	2					

The types of vehicles participants had operated is shown in Table 40. Surprisingly 40% had operated a heavy truck at one time. One participated reportedly had operated a flying saucer but that response was not explored in detail. The median number of vehicles people had operated (in addition to automobiles) was one. Hence, the sample did not consist of people who only drove cars.

Concerning the miscellaneous questions, 22 people reported they normally drive in the left-hand lane of a 2-lane expressway and 31 on the right. Another 39 reported they had conventional instrumentation while 14 had electronic displays. Finally, concerning purchasing a new gadget, 6 reported they would be the first on their block to buy it, 10 reported they would be last, and 37 were in between. (Note: For these three questions, one person failed to respond.) Hence, there is nothing unusual about this sample in terms of their risk-taking behavior when driving or their desire for new automotive technology.

Finally, Table 41 shows where drivers reported they placed their hands when they usually drove. While certainly this varies with the type of driving (e.g., city vs. open road) this information is still a useful summary. It was collected because there is interest in placing controls close to the hands and one cannot do that if the hand location is unknown.

Table 40. Types of Vehicles People Had Operated

Vehicle Type	Had Operated	Had Not
Aircraft	6	48
Power Boat	26	28
Construction Equipment	8	46
Heavy Truck	21	33
Farm Machinery	13	41
Industrial Truck	9	45
Military Vehicle (e.g., tank)	3	51
Motorcycle	19	35

Summary:

Total # Operated	0	1	2	3	4	5	6	7	8
# People Claiming	15	11	10	6	3	2	3	2	2

Table 41. Hand Locations Reported While Driving

		Right Hand Clock Position						
		1	2	3	4	5	12	not used
Left Hand Clock Position	6							2
	7				1	3		2
	8		1		1			
	9		2	12			1	1
	10		26					
	11	1		1				

Almost half of the drivers chose the 10 o'clock-2 o'clock combination. Others chose numerous other combinations with 9-3 being most popular. Note that 5 people did not keep their left hand on the wheel at all.

APPENDIX D
LIST OF SWITCHES TESTED

This appendix contains a list of the switches that were available for participants. There were 257 different switches, some having multiple copies, giving drivers over 1000 switches from which to choose. Over half of the different switches (138) were never used by any of the 54 participants in the study. The switches not used are designated by an asteric (*) following the switch number.

LIST OF SWITCHES TESTED

#	Switch Type	Function	"Size (W"" X H"")	Source	Model Number
1	Rocker		11/16 X 1	Littlefuse	780865BP
2	Rocker		.75 X 1	Littlefuse	780601BP
3	Rocker		7/8 X 11/16	Littlefuse	780765BP
4	Rocker		.75 X 13/16	Littlefuse	780693BP
5	Rocker		5/8 X 7/8	Littlefuse	780646BP
6	Rocker		3/8 X 5/8	Littlefuse	780609BP
7	Rocker		.75 X 9/16	GC Electric	35-620
8	Rocker		.6 X .75	GC Electric	35-632
9*	Paddle		.5 X 9/16	GC Electric	35-316
10*	Knob		1 7/16 dia.	GC Electric	37-576
11*	Knob		1 1/8 dia	GC Electric	37-574
12*	Knob		7/8 dia	Augat	92012
13*	Knob		11/16 dia	Augat	92007
14	Thumbwheel		1/16 X .75	GC Electric	35-850
15	Toggle		3/16 X .5	GC Electric	35-854
16	Slide		.25 X .25	GC Electric	35-240
17	Slide		.25 X 5/16	GC Electric	35-242
19	Slide		1/8 X 1/8	GC Electric	35-202
20	Pushbutton		3/8 X .5	GC Electric	35-413
21	Pushbutton		3/8 dia	GC Electric	35-411
22	Push/Pull		.5 dia		145701BP
23*	Push/Pull		7/16 dia	Littlefuse	145702BP
24	Push/Pull		7/8 dia	General	18110
25*	Rotary		3/16 X 3/8	Leviton	
26	Pushbutton		.75 X .75	GC Electric	35-484
27*	Pushbutton		3/16 X 3/8	Leviton	800-575
28	Thumbwheel		1/16 X .75	Leviton	801-413
29	Knob		9/16 dia	GC Electric	37-578
30	Rocker	Crs Control	5/8 X 1	85 Berlinetta	14084303
31*	Knob		9/16 dia	GC Electric	37-584
32	Rocker		11/16 X 7/8	Littlefuse	780692BP
33	Knob		.75 dia	GC Electric	37-572
34*	Knob		1 dia	GC Electric	37-544
35	Rocker	Hazard	1 X 1.75	84 Volkswagen Golf	
36*	Pushbutton		3/8 dia	GC Electric	35-406
37	Pushbutton		.5 dia	GC Electric	35-422
38*	Pushbutton		.25 dia	GC Electric	35-453
41	Pushbutton		3/8 X 3/8	GC Electric	35-412
42*	Pushbutton		3/8 dia	GC Electric	35-852
43	Rocker		5/16 X 11/16	GC Electric	35-662
44*	Pushbutton	Wipe/Wash	7/8 X 2	83 Honda Civic Wagon	
45	Pushbutton	Rear Defrost	7/8 X 2	83 Honda Civic Wagon	
47	Knob	Panel Bright	.5 dia	84 Honda Civic Wagon	
48*	Paddle	Wipe/Wash	2.5 X 2	85 Camero Berlinetta	
49*	Pod	Climate Ctrl	3 X 3.5		
50	Rocker	Headlt	2.25 X 2	84 Ford Tempo	
51	Rocker	Headlt	.5 X 1.5	87 Ford Aerostar	
52*	Paddle	Headlt/Foglt	3 X 2.25	87 Ford Mustang	
53*	Slide	Crs Control	1/16 X .25	87 Cadillac CDV	
54	Slide	Del Wipe/Wash	2.5 X 4	87 Chevrolet Beretta	
55	Slide	Wipe/Wash	1.25 X 3.25	87 Chevrolet Corvette	
56	Slide	Wipe/Wash	2.5 X 3	87 Chevrolet Beretta	
58	Combination	Headlt	2.25 X 2.75	87 Pontiac Grand Am	
59	Combination	Del Wipe/Wash	2 X 4.5	87 Pontiac Grand Am	
61	Stalk	Del Wipe/Crs	4.25 X 1	86 Toyota Camry	456239405
62*	Stalk	Del Wipe/Crs	5 X 1	86 Mazda 626	BG6766120C
63	Lever	Wipe	2.75 X 1.25	86 Toyota MR2	8465117020
64*	Lever	Headlt	2.75 X 1.25	86 Toyota MR2	8411117021
66*	Pushbutton	Rear Defog	1 dia	86 Toyota MR2	8479017020
67	Rocker	Headlt/Parklt	1 X 1.5	86 Pontiac Fiero	

- Appendix D - Switches Tested

#	Switch Type	Function	"Size (W"" X H"")	Source	Model Number
68*	Rocker	Heater	1 X 1.75	86 Volkswagen Jetta	
69	Rocker	Hazard	1 X 2	86 Volkswagen Jetta	
70	Knob	Headlt	2 dia	86 Saab 9000	
71*	Stalk	Crs Ctrl/Bright	6 X .5	Volkswagen Golf	
72*	Stalk	Wipe/Wash	4 X .5	Volkswagen Golf	
73*	Knob	Headlt	1.5 dia	86 Mercedes	2015400183/64
74	Stalk	Del Wipe/Crs	4.5 X 7/8	86 Pontiac 6000	
75	Stalk	Headlt	5 X .75	86 Mazda 626	BG6766120C
76*	Pushbutton	Hazard	1 dia	86 Mazda RX7	FB01661840
77*	Pushbutton	Rear Defrost	1 dia	86 Mazda RX7	FB01661740
78	Rotary	Del Wipe/Wash	2 dia	86 Mazda RX7	FB01661810
79*	Rotary	Headlt	2 dia	86 Mazda RX7	FB01661710
80*	Knob	Panel Bright	1 dia	86 Mazda RX7	FB01661730
81*	Paddle	Del Wipe	2.75 X 1.5	86 Mazda 626	GA9766170H00
82	Stalk	Wipe/Wash	5 X 1	87 Ford Taurus	
83*	Combination	Lights	2 X 2.75	85 Chevrolet Berlinetta	
85	Combination	Del Wipe	1 X 3.5	86 Volkswagen Golf	
86	Thumbwheel	Panel Bright	.25 X 1	86 Volkswagen Golf	
87	Stalk	Lights	5 X .75	82 Mazda 626	
88	Stalk	Del Wipe/Wash	2.25 X .75	83 Honda Civic Wagon	
89*	Stalk	Del Wipe/Wash	3 X .75	82 Mazda 626	
90	Rocker		3/8 X 1	Chrysler	
91	Combination	Del Wipe/Wash	1.75 X 4	86 Buick Somerset	25517587
92	Stalk	Del Wipe/Wash	5 X 1	86 Dodge Conquest	MB183952
93	Pushbutton		1.75 X 5.5	86 Buick Somerset	22534143
94	Combination	Wipe	1.5 X 3	86 Chevrolet Cavalier	14078936
95	Rocker	Lights	1.75 X 1.75	86 Chevrolet Cavalier	1995289
96*	Slide	Del Wipe	1.75 X 2	86 Chevrolet Spectrum	94134825
97	Pod		2.25 X 3.25	86 Chevrolet Spectrum	94134821
98	Rocker	Headlt	7/8 X 1.25	86 Nissan Ma X ima SE	2598001L60
99	Rocker	Rear Defrost	5/8 X 1 5/8	86 Chevrolet Cavalier	14086670
100	Stalk	Del Wipe/Crs	4.75 X 1	86 Chevrolet Caprice	25031456
101*	Rocker	Headlt	.75 X 5	86 Nissan 300 ZX	2598017P01
102*	Pushbutton		1 X 1.25	86 Chevrolet Cavalier	14057590
103*	Paddle	Rear Wipe	2 X 1.5	86 Nissan 300ZX	2521017P15
104*	Paddle	Crs Control	2 X 1.5	86 Nissan 300ZX	2521501P09
105	Stalk	Del Wipe/Wash	.25 X 1.5	86 Chevrolet Cavalier	2556019P00
106*	Thumbwheel				1995290
107	Stalk	Del Wipe	5 X 1	86 Honda Civic CRX	2556019P00
108	Stalk	Headlt	5 X 1	86 Honda Civic CRX	2556019P00
109*	Knob		1.25 dia	86 Volvo 740 GLE	13233762
110*	Stalk	Wipe	7 X 1	86 Mercedes 300D	1245450424
111*	Stalk	Crs Control	6 X .5	86 Mercedes 300D	1245450924
112*	Stalk	Turn signal	5.5 X 1	86 BMW 635 CSI	61311377071
113*	Stalk	Crs Control	6 X 1	86 BMW 500	61311377979
114*	Pod			86 Subaru XT	83001LA351
115*	Paddle	Lights	2.5 X 1.5	85 Mazda 626	GA9766180K00
116*	Rotary	Del Wipe/Wash	1 7/8 X 1 1/8	86 Isuzu Impulse	8941204190
117*	Rotary	Headlt	1.25 X 1 1/8	86 Isuzu Impulse	8941204020
118*	Rocker	Headlt	1 3/8 X .25	86 Mercury Sable	E64Y11654A
119*	Thumbwheel	Panel Bright	1.5 X .25	86 Mercury Sable	E64Y11691A
120	Pushbutton	Rear Defrost	2 1/8 X 1.25	86 Mercury Sable	E64Y18C621A
121	Stalk	Del Wipe/Wash	5 X 7/8	86 Mercury Cougar XR7	E5SZ17A553B
122*	Stalk	Headlt	6 X .75	86 Mercury Cougar XR7	E5SZ13305A
123	Rocker	R. Wipe/Wash	5/8 X 1	83 Mercury Lyn X	E1FZ17A553C
124*	Combination	Del Wipe/Wash	3 X 1.5	86 Ford Tempo GL	E63Z17A553B
125	Pushbutton	Lights	1 X 3	86 Dodge Conquest	MB337938
127	Pushbutton	Headlts	2 X 1.5	86 Cadillac Seville	1635565
128*	Rocker	Wipe/Wash	1.5 X .25	Chrysler	
129*	Rocker	Wipe/Wash	5/8 X 1.75	Chrysler	
130*	Rocker	Trunk	1.5 X .25	Chrysler	
131	Pushbutton	Trunk	.5 X .5	Chrysler	
132	Rocker	Rear Defrost	1.5 X 1.25	Chrysler	

- Appendix D - Switches Tested

#	Switch Type	Function	"Size (W" X H")	Source	Model Number
133	Rocker	Rear Defrost	5/8 X 1 5/8	Chrysler	
134	Rocker	On/Off	1 X 1	Chrysler	
135*	Knob	On/Off	3/4 dia	Chrysler	
136	Rocker	On/Off	1.25 X 3/8	Chrysler	
138*	Toggle			Chrysler	
139	Toggle			Chrysler	
140*	Pushbutton		1/8 dia	Chrysler	
141*	Pushbutton	Open Rear	1/8 dia	Chrysler	
142	Stalk	Headlt	5.5 X 1	87 Subaru GL Hatch	83113GA370
143	Stalk	Wipe/Wash	5.25 X 1	87 Subaru GL Hatch	83113GA370
144*	Stalk	Headlt	5.5 X .75	87 Toyota Corolla SR5	8411219505
145	Stalk	Wipe/Wash	3 3/4 X .75	87 Toyota Corolla SR5	8465280006
146*	Rotary	Headlt	1.75 X 1.5	87 Dodge Colt	MB327203
147*	Rotary	Wipe/Wash	1.75 X 1.5	87 Dodge Colt	MB357876
148*	Rocker	Hazard	2.25 X 7/8	87 Audi 500	85594150901Z
149*	Rocker	Rear Defrost	2.25 X 7/8	87 Audi 500	
150*	Rocker	Headlt/P. Bright	2.25 X 1 7/8	87 Audi 500	855941531B/01Z
151	Paddle	Wash/Wipe	3 X 2.5	85 Mazda 626	GA9766170H00
152*	Paddle	Defrost/Hazard	3 X 2.5	85 Mazda 626	GA9766170H00
153	Slide	Panel Lights	1 1/8 X .5	86 Buick Somerset	25517587
154*	Pushbutton	Rear Defrost	1 1/8 X .5	86 Buick Somerset	22534143
155	Thumbwheel	Panel Bright	5/16 X 7/8	87 Audi 500	
156*	Stalk	Lights	5 X 5/8	86 Honda Civic CRX	2556019P00
158*	Stalk	Wipe/Wash/Crs	2.5 X 7/8	Chrysler	
159*	Combination	Wipe/Wash	2 X 3.5	LCI	
160*	Pushbutton	Hazard	.75 X .25	Ford Escort	
161	Push Surface	Square	3.5 X 3.5		
162*	Push Surface	Square	2.5 X 2.5		
163*	Push Surface	Square	2 X 2		
164	Push Surface	Square	1.25 X 1.25		
165	Push Surface	Square	.75 X .75		
166	Push Surface	Square	.5 X .5		
167	Push Surface	Rectangle	2 3/8 X 1.5		
168	Push Surface	Rectangle	1 X .5		
169	Push Surface	Triangle	1.25 X 1.08		
170*	Push Surface	Triangle	1 X .87		
171	Push Surface	Triangle	.75 X .65		
172*	Push Surface	Trapezoid	1.5X2		
173*	Push Surface	Trapezoid	1 1/8X1.5		
174*	Push Surface	Trapezoid	5/8X1		
175*	Push Surface	Arrow	3X1 3/8		
176	Push Surface	Arrow	2.5X1 1/8		
177*	Rotary	Headlt/P. Bright	2 X 1.75	87 Subaru GL Hatch	783011270
178*	Rotary	Wipe/Wash	2 X 1.75	87 Subaru GL Hatch	783021520
179*	Knob	Fan	1 5/8 dia	87 Ford Mustang	E6DZ18519-C
181*	Knob	Temp. Select	1 5/8 dia	87 Ford Mustang	E6DZ18519-A
182*	Slide	Int. Wipe	2.25 X .75	Subaru XT	
183	Slide	Panel Bright	2.25 X .75	Subaru XT	
184*	Pushbutton	Headlt/P. Bright	2.5 X 3	87 Chevrolet Beretta	
185*	Stalk	Headlt	1 1/8 X 5	83 Honda Civic Wagon	
186*	Thumbwheel	Panel Bright	1 3/8 X 1/4	87 Chevrolet Beretta	
187*	Rocker	Rear Wash	5/8 X 1 1/8	86 Chevrolet Cavalier	
188*	Pushbutton	Hazard	7/8 X .25	86 Cadillac Seville	
189	Thumbwheel	Panel Bright	1.25 X .25	86 Cadillac Seville	
190	Thumbwheel	Panel Bright	1.25 X .25	86 Cadillac Seville	
191	Pushbutton	Front Wash	1 X .5	86 Buick Somerset	
192*	Pushbutton	Turn Signal	1 1/8 X .25	85 Chevrolet Berlinetta	
193*	Pushbutton		1 X 3/8	86 Subaru XT	
194	Pushbutton	Crs Set/Reset	2.75 X 1.5	85 Mazda 929	
195*	Slide		3 X 2	85 Mazda 929	
196*	Rocker	Wipe/Wash	1 X 4.75	85 Mazda 929	
197*	Rocker	Headlts	1 X 4.75	85 Mazda 929	
198	Knob		1.5 dia	GC Electric	

#	Switch Type	Function	"Size (W"" X H"")	Source	Model Number
199	Knob		7/8 dia	GC Electric	
200*	Knob		1.5 X 3/8	GC Electric	
201	Knob		7/8 X 1.25	GC Electric	
202*	Knob		.5 X 2	GC Electric	
203	Knob		.75 dia	GC Electric	
204*	Knob		1 1/8 dia	GC Electric	
205*	Knob		5/8 dia	GC Electric	
206*	Knob		3/4 dia	GC Electric	
207	Rocker		5/16 X 7/8	GC Electric	
208*	Pushbutton	Foglts	2 X 1.25	86 Nissan 300ZX	
209*	Pushbutton	Rear Defrost	2 X 1.5	86 Nissan 300ZX	
210*	Thumbwheel	Rear Defrost	2.5 X 1	87 Chevrolet Beretta	
211*	Pushbutton	Hazard	2 X 1.25	86 Nissan 300ZX	
212*	Pushbutton	Beam Adjust	2 X 1.5	86 Nissan 300ZX	
213*	Thumbwheel	Rear Defrost	2.5 X .75	87 Chevrolet Beretta	
214*	Slide	Panel Bright	2 7/8 X 1.75	85 Mazda 929	
215*	Pushbutton	Wash	2.25 X 1.25	86 Chevrolet Spectrum	
216	Combination	Headlts	3 X 2	83 Citroen CX	
217*	Pushbutton	Rear Defrost	3.75 X 1.5	83 Citroen GSA	
218*	Pushbutton	Hazard	4 X 1.5	83 Citroen GSA	
219*	Pushbutton		3.75 X 1.5	83 Citroen GSA	
220*	Pushbutton		3.5 X 1.5	83 Citroen GSA	
221*	Rocker		1.5 X 2	85 Citroen BX	
222*	Rocker	Turn Signal	1.5 X 2	85 Citroen BX	
223	Rocker		5/8 X 1	87 Jaguar	
224*	Slide		2.25 X 1 1/8	87 Jaguar	
225*	Rocker		.75 X 1	87 Jaguar	
226*	Rocker	Fog Lights	.75 X 1	87 Jaguar	
227	Rocker	Hazard	.75 X 1	87 Jaguar	
228*	Rocker	Seat Heater	.75 X 1	87 Jaguar	
229	Rocker		1.25 X 1.25	87 Jaguar	
230*	Rotary	Headlts	2 X 3	87 Jaguar	
231	Lever	Crs Control	1.5 X 3	87 Jaguar	
232*	Pushbutton	Seat Adjust	2 5/8 X 2	87 Jaguar	
233*	Rocker	Turn Signal	2.5 X 1	83 Citroen CX	
234*	Pushbutton	Horn	1.5 X 1.5	83 Citroen BX	
235*	Slide	Wipe/Wash	1.5 X 3	83 Citroen BX	
236*	Combination	Wipe/Wash	3 X 2.5	83 Citroen CX	
237*	Rocker	Turn signal	2.25 X 1	83 Citroen CX	
238	Pushbutton	Hazard	3/8 X 3/4	83 Citroen CX	
239	Pushbutton	Hazard	1 X 1.25	85 Mazda 929	
240*	Push Surface		.75 X 5/8	85 Mazda 929	
241*	Push Surface	Rear Defrost	5/8 X 5/8	85 Mazda 929	
242*	Push Surface	Beam Adjust	5/8 X 7/8	85 Mazda 929	
243*	Pushbutton		7/8 X 1	83 Citroen GSA	
244*	Pushbutton	Foglts	7/8 X 1	83 Citroen GSA	
245*	Pushbutton	Oil	7/8 X 1	83 Citroen GSA	
246*	Pushbutton	Hazard	7/8 X 1	83 Citroen GSA	
247*	Pushbutton	Rear Defrost	7/8 X 1	83 Citroen GSA	
248*	Combination	Lights	1.5 X 4.5	83 Citroen BX	
249*	Combination	Lights	2.5 dia	83 Citroen GSA	
250*	Combination	Wipe/Wash	2.5 dia	83 Citroen GSA	
251*	Pushbutton	Wipe/Wash	3.5 X 4	Subaru XT	
252	Pushbutton	Lights	3.5 X 4	Subaru XT	
253*	Push Surface	Arrow	3 3/8 X1 7/8		
254*	Push Surface	Arrow	1.75X1 3/8		
255*	Push Surface	Arrow	1.51 1/4		
256*	Stalk	Crs Control	3 1/4X3/4		
257	Thumbwheel	Panel Bright	2.25 X 2	84 Ford Tempo	

* indicates switches which were not used by any participant throughout the experiment

APPENDIX E
PARTICIPANT RECRUITING INSTRUCTIONS

The following instructions were followed when recruiting participants by telephone. The instructions obtained important information about the participants to fulfill age groups and guarantee that they drove 1985 or newer cars. Also, using the recruiting instructions avoided the chance of omitting details (such as directions or phone numbers) so participants could easily find UMTRI and remember their appointments.

- Appendix E- Participant Recruiting Instructions

PARTICIPANT RECRUTING INSTRUCTIONS

One of the responsibilities of the experimenters in this experiment is to recruit subjects. One way to recruit participants is to call them on the telephone. The following points and dialogue should be followed when contacting subjects by phone.

1. First, get the phone number of the prospective subject. (Use the lists in the folder labeled , "Subjects.")

2. Please be sure to examine the name on the list(s) that you are using to see if there is any past indication this individual has been contacted before.

3. Check the Subject Age List, which is behind the door of Room 341, to make sure that you know what age categories still have available openings.

4. Dial the person's phone number and begin your opening conversation somewhat like the following:

Hello, may I speak with Mr./Ms._____, please?

Hi, Mr./Ms._____. My name is _____ and I am calling you from the University of Michigan Transportation Research Institute, about participating in a study of automobile instrument panel controls.

This study concerns how instrument panel controls should be designed for future cars. It takes about an hour and a half, and you will be paid $15.00 for participating.
NOTE: If you are looking for individuals within certain age categories (see the Subject Age List), conclude the above opening statement by mentioning the car and age restrictions. For example, you may state:

Currently, we are looking for participants from the age groups of _____ years to _____ years old and who also drive a car which is an '85 or newer model. (Make sure it is the car they drive most often.)

Do you qualify and would you like to participate?

If he or she says YES, then continue. If NO is the answer, then politely say,

O.K. Thank you for your time. Bye!

IMPORTANT: If NO was the answer, please note this on the subject list, so that others will not call him or her again.

If YES was the answer, then continue in this manner.....

Great!
This study takes place in our laboratory. Afterwards, we will go out to your car in the parking lot to compare the way your controls work, to the way you set up your car in the laboratory.

Lets get the following information.....

I have the following time slots open _____. Which would you prefer? _____.

Now get the following information and record it on the appointment sheet. Also, ask the subject to get a pencil and paper to take down important information, such as the appointment date and directions.

NOTE: Be sure to consult the Subject Appointment Sheet. Also, please ask the participant in what age category he/she belongs. The age categories are 18-29, 30-54 and 55-up. You should word your question like the following:

Our age categories for this study are 18-29 years, 30-54, and 55 and up. We need to know in which age category you belong.

Can you tell me the make, model and year of your car?
Make sure it is '85 or newer.

If for some reason you have to cancel or will be delayed in arriving, please call us at 764-4158.

Be sure to record in the appropriate appointment date and time slot:

- **Full name**
- **Phone number**

When you have all of this information, please ask the subject if he/she knows how to get to our building.

Do you know how to get here?

If they do not, then try to direct the subject as best you can. (Hint: Try to determine a main street that they are familiar with, such as Washtenaw, Huron Pkwy, or Plymouth Rd. A map of Ann Arbor is available, just in case things get complicated).

Once you get to the main floor of the building, please go to the elevators. Go to the 3rd floor, and down the left-most hallway to room 341. State that you are here as a subject for the controls study.

Now that you have all the information that you need, and your recruited subject has all that he/she needs, ask the subject if he/she has any questions.

Do you have questions?

If the subject has no further questions, then politely remind hem/her that we will meet on the designated day and time, in room 341, at the UMTRI building. Then say good bye.

Ok....then we will see you on _____ (date) at _____ (time) in room 341 at the UM Transportation Research Institute. Bye!

APPENDIX F
INSTRUCTIONS TO PARTICIPANTS

This appendix contains the text of the experimental instructions used in this study. Text in bold face is meant to be read to the participant. Text in normal print is a paraphrase of what should be said to the participant. Text in italics is instructions to the experimenter. The instructions provided a standard explanation of the experiment and a consistent order in which it was executed throughout the study for all participants. The study progressed as follows: Obtaining biographical information, Explaining the study to the participant, Collecting preference data, Performing the driving simulation, Collecting driver background and anthropometric data, Paying the participant, and Gathering data from the participant's car

INSTRUCTIONS TO PARTICIPANTS

THE UNIVERSITY OF MICHIGAN
TRANSPORTATION RESEARCH INSTITUTE
HUMAN FACTORS DIVISION

DRIVER PREFERENCES FOR SECONDARY CONTROLS
INSTRUCTIONS FOR
EXPERIMENTERS AND PARTICIPANTS

********* BEFORE THE EXPERIMENT BEGINS ********

1. Make sure the Mac is on and you are in the Potato Head 2 folder. Double click the Potato Head 2 stack to start the program. Output files and names are created automatically. Fill in as much of the biographical information as you can before the participant arrives.

2. Make sure the Commodore computer is on and the driving simulation program is running (SIM 9.1) and ready for a 10 minute run (instructions are next to the Commodore computer). Use the file "DATA" for the road pattern input. Turn on lamps to be used during driving.

3. Make sure the camera control box, camera, and monitor are turned on (turn the equipment on in that order, turn off in reverse order). Videotape the black board with the subject info for 10-20 seconds BEFORE the subject arrives. Also you can photograph the board at this time so that you can photograph the interior of the car immediately after the subject leaves.

4. Make sure there are blank copies of all of the forms (Consent, Biographical, Backup Data Collection) on hand along with a Support Voucher (for paying participants).

5. Make sure you have money to pay participants. (If you need more, ask Flora or Paul Olson.)

6. Complete as much of the Biographical form as you can before the participant arrives (participant number, phone, sex, experimenter, date, time, etc.). Also print the participant's name on the Support Voucher and related information on the Master Participant List.

7. Set up anthropometer to measure standing height. This way you only have to take it apart as you go along, instead of putting it together. Also get out the part for measuring hand length and index finger width.

******** WHEN THE PARTICIPANT ARRIVES *********
(GENERAL INFORMATION)

ARE YOU ___ ? *(Use their name.)* **HELLO, MY NAME IS ___ AND I AM ONE OF THE EXPERIMENTERS WORKING ON THE INSTRUMENT PANEL STUDY.** *(Don't say test.)* **BEFORE WE GET GOING, I WOULD LIKE**

TO NOTE THIS EXPERIMENT TAKES APPROXIMATELY 1.5 HOURS AND YOU WILL BE PAID 15 DOLLARS FOR YOUR TIME. IF YOU WOULD LIKE TO VISIT THE REST ROOM, NOW WOULD BE A GOOD TIME TO DO SO. I SHOULD ALSO NOTE THAT SMOKING IS PROHIBITED IN THIS BUILDING.

Take them into the long lab and sit them down across the table from you near the mockup. **THE PURPOSE OF THIS EXPERIMENT IS TO DETERMINE WHAT KINDS OF SWITCHES PEOPLE PREFER FOR CONTROLLING THE HEADLIGHTS, WINDSHIELD WIPER, AND SO FORTH. THE RESULTS OF THIS EXPERIMENT WILL BE USED TO SELECT CONTROLS FOR FUTURE CARS. SINCE YOU WILL BE DRIVING THOSE CARS, YOUR OPINION IS IMPORTANT.**

BEFORE WE GET TO THAT, THERE IS SOME PAPERWORK TO COMPLETE. FIRST, YOU NEED TO SIGN THIS OFFICIAL CONSENT FORM THE UNIVERSITY REQUIRES US TO GIVE YOU. YOU SHOULD READ IT IF YOU WANT, BUT IT BASICALLY REPEATS IN WRITING WHAT I JUST SAID. *Have the participant sign the consent form.*

NEXT, WE NEED TO KNOW A LITTLE MORE ABOUT YOU. *You should fill out the biographical form, so the information is legible. You should already have their name recorded.* **WHAT IS YOUR HOME ADDRESS?** *Be sure to get their zip code. If the participant is a student, just get their local address, not their permanent address.*

You should already have their home phone.

WHAT DO YOU DO FOR A LIVING? *Focus on how they spend most of their time. If the person is retired, note that along with their former occupation. If the person is a student, also list their major and level (junior, Ph.D. candidate, etc.) as well. If the person is a student with a part time job, ignore the job. Later classify them into technical or nontechnical.*

HOW MUCH EDUCATION HAVE YOU HAD? *If they say they graduated from college ask,* **WHERE DID YOU GRADUATE FROM AND WHAT WAS YOUR DEGREE?** *Compute the number of years of schooling. Count undergraduate work as four years unless they say something to the contrary.*

****** PHYSICAL INFORMATION ******

Record if they are male or female.

ARE YOU RIGHTHANDED, LEFTHANDED, OR AMBIDEXTROUS?

DO YOU NORMALLY WEAR GLASSES OR CONTACTS WHEN DRIVING? ARE YOUR GLASSES BIFOCALS OR TRIFOCALS?

HOW OLD ARE YOU? *Some people, especially women, may be reluctant to give you their age. Tell them the information is used for statistical purposes only and you will not tell anyone their age. If they are still reluctant, start out by asking for their age decade* (**ARE YOU BETWEEN 41 AND 50?**) *and then go from there. If it takes some effort to pry it out, offer a positive comment to put them at ease if it seems reasonable.* (**GEE, YOU CERTAINLY DON'T LOOK ...**).

DO YOU HAVE ANY PHYSICAL DISABILITIES THAT MIGHT INTERFERE WITH USING CONTROLS? *If they say yes, ask them to describe them.*

********** DRIVING HABITS **********

ABOUT HOW MANY MILES DO YOU DRIVE IN A YEAR? *If they don't know, then ask them for a weekly average and multiply by 52. Tell them what it would work out to be.*

WHAT FRACTION OF YOU DRIVING IS AT NIGHT? (WITH YOUR HEADLIGHTS ON) PLEASE TRY TO THINK OF THIS IN TERMS OF YOUR DRIVING YEAR ROUND, SINCE THERE IS MORE DARKNESS IN WINTER THAN IN SUMMER.

Compute the number of miles driven per year at night.

TELL ME WHICH OF THE FOLLOWING KINDS OF VEHICLES YOU HAVE OPERATED...AIRCRAFT *(wait for them to say yes or no),* **POWER BOAT ... CONSTRUCTION EQUIPMENT ... MEDIUM OR HEAVY TRUCK, OR BUS ... INDUSTRIAL TRUCK ... SPECIALIZED MILITARY VEHICLE ... MOTORCYCLE OR MOTORBIKE ... SNOWMOBILE ... FLYING SAUCER.** *Count up the number of yes responses.*

>>>>>>>Ask the subject to sit in the car. **LET'S HEAD OVER TO THE CAR AND BEGIN. ADJUST THE SEAT SO YOU ARE COMFORTABLE AND FASTEN YOUR SAFETY BELT.**

WHEN YOU DRIVE, SHOW ME HOW YOU POSITION YOUR HANDS ON THE STEERING WHEEL. *Record the clock positions of each (or if they are even on the wheel at all). Also record any comments.*

****** PREFERENCE DATA COLLECTION ******

MAKE SURE THE VIDEO RECORDER CAMERA AND MICHROPHONES ARE ON!

TODAY WE ARE GOING TO DETERMINE WHERE YOU THINK A NUMBER OF CONTROLS, SUCH AS THE LIGHTS AND WIPER, SHOULD BE LOCATED. WE WILL ALSO FIND OUT WHAT KIND OF SWITCHES YOU PREFER FOR THESE FUNCTIONS. DON'T WORRY IF YOU DON'T KNOW MUCH ABOUT HOW SWITCHES WORK, IT DOESN'T MATTER. A GOOD DESIGN IS ONE WHICH IS EASY FOR YOU TO USE, SO **THERE IS NO RIGHT OR WRONG ANSWER.**

FROM A LARGE COLLECTION OF KNOBS, PUSH BUTTONS, AND STALK CONTROLS, **YOU WILL SELECT THE SWITCHES YOU PREFER AND PUT THEM ON THE INSTRUMENT PANEL OF A CAR.** *Point them out.* **THE SWITCHES HAVE VELCRO ON THE BACK, SO THEY SHOULD STICK FAIRLY EASILY TO THE VELCRO COVERED SURFACES IN THE CAR.** *Point out the velcro surfaces.*

AFTERWARDS, I WILL TURN ON THE DRIVING SIMULATOR AND SHOW YOU HOW TO OPERATE IT. ONCE YOU UNDERSTAND THAT, YOU WILL GO FOR A SHORT SIMULATED DRIVE AND **YOU'LL REACH FOR THE CONTROLS YOU PLACED ON THE INSTRUMENT PANEL.**

AFTERWARDS, YOU CAN CHANGE YOUR CHOICES FOR SWITCHES AND THEIR LOCATIONS .

Show the participant the alphabetical listing of labels. **IN THIS EXPERIMENT WE ARE INTERESTED IN 9 FUNCTIONS. THEY ARE:** *(Don't use the complete explanations if the subject understands the function.)*

<<<<THE **CRUISE CONTROL** SETS THE VEHICLE TO DRIVE AT A FIXED SPEED WHEN YOUR FOOT IS OFF THE ACCELERATOR. USUALLY THERE ARE SWITCHES TO TURN THE CRUISE SYSTEM **ON AND OFF**, AND SWITCHES TO **SET** THE DESIRED SPEED.

THE **DOME OR INTERIOR LIGHT**, THIS LIGHT, (point to it) ILLUMINATES THE PASSENGER COMPARTMENT.

THE **HAZARD SWITCH**, SOMETIMES CALLED THE FOUR-WAY FLASHER CAUSES ALL OF THE PARKING LIGHTS, BOTH FRONT AND REAR TO BLINK ON AND OFF. IF SOMETHING GOES WRONG WITH YOUR CAR AND YOU PULL OFF TO THE SIDE OF THE ROAD, YOU MIGHT TURN IT ON.

THE **HEADLIGHT SWITCH** IS USED TO TURN YOUR HEADLIGHTS, TAILLIGHTS, AND PARKING LIGHTS ON.

THE **IGNITION SWITCH**, WHICH REQUIRES A KEY, IS USED TO START YOUR CAR.

THE **PANEL BRIGHTNESS** ALLOWS YOU TO ADJUST THE BRIGHTNESS OF THE INSTRUMENT PANEL AT NIGHT. IT ONLY WORKS WHEN THE HEADLIGHTS OR PARKING LIGHTS ARE ON.

WINDSHIELD WIPERS

WINDSHIELD WASHER

DO YOU HAVE ANY QUESTIONS ABOUT WHAT ANY OF THESE FUNCTIONS ARE?

THE LOCATIONS AND SWITCH TYPES HAVE ALREADY BEEN SELECTED FOR SOME CONTROLS, IN PARTICULAR THE HORN, TURN SIGNALS, BEAM SELECT, AND BEAM FLASH. THE CONTROLS PROVIDED WERE CHOSEN BASED ON DATA FROM A PREVIOUS STUDY. HOWEVER, IF YOU'D LIKE TO COMBINE THESE WITH SOME OTHER FUNCTION(S), THAT'S OK. FOR EXAMPLE, YOU MAY PUT ANY OF THESE OTHER STALKS INTO THE LEFT SIDE OF THE STEERING COLUMN, IF YOU WANT TO, AS LONG AS YOU REMEMBER THAT IT STILL CONTROLS BEAM SELECT AND BEAM FLASH. *Point to the wooden stick to the left of the steering wheel.*

ON THIS PANEL ARE A LARGE NUMBER OF POSSIBLE SWITCHES THAT MIGHT BE USED FOR THESE FUNCTIONS. SOME OF THEM ARE ACTUALLY FOUND IN CARS NOW AND OTHERS ARE JUST PROPOSALS FOR FUTURE CARS. *(point to board)* **WE HAVE ROCKER SWITCHES** *(point to an example and show how it works)*, **TOGGLE SWITCHES** *(point and demonstrate for this and all other examples)*, **THUMB WHEELS, KNOBS, AND STALKS. ON THIS BOARD THERE ARE SLIDE SWITCHES. ON THIS BOARD THERE ARE PUSH SURFACES, PUSHBUTTONS, PADDLE SWITCHES, LEVERS, ROTARY SWITCHES, AND OTHERS. THERE ARE SEVERAL COPIES OF EACH SWITCH IN CASE YOU WANT TO USE THE SAME SWITCH DESIGN FOR SEVERAL FUNCTIONS, FOR EXAMPLE IF YOU WANTED THE HEADLIGHTS AND WIPER CONTROLS TO BE THE SAME TYPE OF KNOB.**
YOUR SELECTIONS ARE NOT RESTRICTED BY THE LABELLING ON THE SWITCHES. THAT IS, IF A SWITCH IS LABELED "HAZARD" BUT YOU WOULD LIKE TO USE IT FOR THE DOME LIGHT, THAT'S OK. IN ADDITION, IF YOU WOULD LIKE A CERTAIN SWITCH TO BE A DIFFERENT COLOR, THAT'S OK TOO, JUST TELL ME AND I'LL MAKE A NOTE OF IT.

IN ANY ORDER, YOU WILL SELECT A FUNCTION LABEL AND THINK ABOUT THE TYPE OF SWITCH YOU'D LIKE TO USE AND WHERE YOU THINK THE ASSOCIATED CONTROL BELONGS. NEXT YOU WILL SELECT A SWITCH OR A STALK AND PLACE IT IN THE LOCATION YOU CHOSE. CONTINUE TO THINK ABOUT THE SWITCHES AND LOCATIONS YOU'D LIKE FOR EACH FUNCTION AND THE REASONS FOR MAKING THESE CHOICES. YOU MAY CHANGE EITHER THE LOCATION OR TYPE OF A SWITCH AT ANYTIME. ALSO, IF YOU WOULD LIKE TO CHOOSE MULTIPLE SWITCHES FOR ONE FUNCTION, FOR EXAMPLE, TWO PUSHBUTTONS TO TURN SOMETHING ON AND OFF, THAT'S ALLOWED. WE ALSO WANT TO KNOW HOW YOU'D LIKE THE SWITCH TO OPERATE. YOU CAN MAKE SOMETHING UP OR USE IT EXACTLY AS THE SWITCH NOW OPERATES, JUST TELL ME AND I'LL MAKE A NOTE OF IT.

FOR EACH CHOICE, I WILL ASK YOU THE FOLLOWING. *(Put list in front of the subject).*

1. WHICH SWITCH DID YOU CHOOSE FOR THAT FUNCTION?

2. WHY DID YOU CHOOSE THAT SWITCH?

3. WHERE DO YOU WANT TO PUT THE SWITCH?

4. WHY DO YOU WANT TO PUT IT THERE?

5. HOW DO YOU WANT THE SWITCH TO OPERATE?

6. WHY DO YOU WANT THE SWITCH TO OPERATE IN THAT MANNER?

HERE ARE SOME OF THE POSIBLE REASONS YOU MIGHT HAVE FOR MAKING YOUR SELECTIONS. *(Place list in front of subject on board to the left of the list of questions.)* **PLEASE READ THROUGH THE LIST AND TELL ME WHEN YOU'RE FINISHED.** *Wait for subject to read list.* **WHEN I ASK YOU "WHY" YOU MADE A CHOICE I NEED YOU TO FIRST THINK OF YOUR OWN IDEA FOR A REASON, TELL ME, AND *THEN* LOOK ON THE LIST FOR SOMETHING THAT BEST MATCHES YOUR RESPONSE. TELL ME THE NUMBER NEXT TO THAT BLOCK OF REASONS. ALSO, IF YOU HAVE MORE THAN ONE REASON, TELL ME ALL OF THEM.**

INSTALLING THE STALKS IS A BIT TRICKY. IF YOU WANT A STALK ON THE LEFT OR RIGHT SIDE, INSERT THE SHAFT IN THIS DRILL CHUCK AND TURN IT TO TIGHTEN IT *(show them how to do this).*

BEFORE YOU BEGIN, I WOULD LIKE TO RE-EMPHASIZE THAT THE SWITCHES YOU SELECT ARE FOR A FULLY EQUIPPED CAR TO BE PRODUCED IN THE 1990's. IN MAKING YOUR DECISIONS ABOUT WHICH SWITCHES TO CHOOSE, TRY TO IMAGINE WHAT CARS WILL BE LIKE IN THE 1990's AND WHAT YOU WOULD EXPECT FROM THIS TYPE OF CAR. TRY TO MAINTAIN THIS PERSPECTIVE WHEN MAKING YOUR SELECTIONS. *Make sure that the computer program is ready, the zone chart is in front of you, you have a data sheet for comments next to you, and the switchboard is close to the subject.* **IF YOU HAVE NO FURTHER QUESTIONS, YOU MAY GO AHEAD AND BEGIN YOUR SELECTIONS.**

Enter into the computer the switch number, its name, location, method of operation, and any comments the subject may have.

The method of operation axes are relative to the instrument panel surface, not individual switch surfaces. Therefore if a subject places a push button switch on the door, the method of operation would be along the -Fy axis.

Repeat the process of selecting labels and switches until there are no more labels left. As they go through the process, offer encouragement. **(THAT'S FINE. OK. GOOD.)** *Encourage them indirectly to say why they chose a particular location or switch and enter those thoughts in the comments field for each switch. Avoid engaging in a discussion. As they tell you "why", encourage them to determine their own reasons before consulting the list. Once they give a reason in words, try to get them to classify their response according to the one-page list of reasons. When they give you a number, look in the long list (three-page) and try to best code their response. Only when unsure what they meant, give two or three choices from the long list as prompts and enter as many codes as are applicable. This seems to be more accurate than trying to figure out the codes later.*

If for some reason you lose the subject's data file (power outage, flood, famine, locusts, etc.) create a new file called S1A (for subject #1). Also you can use the paper stack-backups.

When they have placed all the labels and switches on the panel ask them the following. **WOULD YOU LIKE TO CHANGE ANY OF THE LOCATIONS OR SWITCH TYPES YOU HAVE CHOSEN? GO AHEAD.** *After they have completed their changes,* **remove the label board** *from in front of them. Do <u>not</u> save the data until after they have completed the driving simulation!!*

NEXT I WOULD LIKE TO SHOW YOU HOW OUR DRIVING SIMULATOR WORKS. ON THE SCREEN WILL APPEAR A SERIES OF SMALL BLOCKS THAT RESEMBLE ROAD EDGE MARKERS. THINK OF YOURSELF AS DRIVING ON A ONE LANE EXPRESSWAY RAMP AND THOSE MARKERS AS INDICATING THE SIDES OF THE ROAD. YOUR TASK IS TO DO THE BEST YOU CAN TO STEER DOWN THE CENTER OF THE ROAD. WHEN YOU ARE DOING A GOOD JOB STEERING, THE EDGE MARKERS CLOSEST TO YOU WILL DISAPPEAR IN THE CORNERS OF THE SCREEN *(point to the corners of the screen).* **TRY TO ANTICIPATE THE CURVES AND STEER THE SIMULATOR JUST AS YOU WOULD A REAL VEHICLE. TURNING THE WHEEL CLOCKWISE MAKES THE CAR GO TO THE RIGHT, COUNTERCLOCKWISE MAKES IT GO LEFT.**

LET'S BEGIN WITH A ONE-MINUTE PRACTICE RUN. *Turn on the lamps and turn off the overhead lights.* **READY? ... OK, HERE IT COMES.** *Start the driving simulator. If they have problems during the practice run, give them feedback right away* **(TURN TO THE RIGHT).** *Don't wait until the end of the trial.*

Repeat the trials until they understand how to steer and their performance stabilizes.

OK, NOW YOU SEEM TO HAVE IT. NEXT I AM GOING TO ASK YOU TO STEER AND AT THE SAME TIME, HAVE YOU PRETEND YOU ARE OPERATING THE INSTRUMENT PANEL CONTROLS. THE PURPOSE OF THIS TASK IS TO HELP YOU DETERMINE IF THE SWITCHES YOU SELECTED AND/OR THEIR LOCATIONS SHOULD BE CHANGED. WHEN I ASK YOU, REACH FOR THE CONTROL ON THE INSTRUMENT PANEL AND SHOW ME THE MOTION YOU WOULD MAKE TO OPERATE IT. TAKE YOUR TIME AND MAKE SURE THAT YOU DON'T NEGLECT TO STEER. I AM ONLY INTERESTED IN IDENTIFYING PROBLEMS IN LOCATING AND OPERATING CONTROLS, NOT THE TIME REQUIRED OR ERRORS MADE. IF YOU HAVE PROBLEMS, TELL ME ABOUT THEM AND I'LL NOTE THEM DOWN. AFTER THIS RUN IS OVER, YOU CAN GO BACK AND MAKE CHANGES.
Have a simulator survey sheet ready on a clipboard so you can write down any problems the subject may have. **READY? OK, HERE IT GOES.** *Stand by the driver's door and watch what they do. Read the requests off so that* ***5-10 seconds*** *elapses between when they finish showing you one request and you begin to read off the next one. Make sure they are on the road before you read a request. Make a note of those switches where the subject fumbles, forgets the location, or goes off the road.*

TURN ON THE IGNITION.

TURN ON YOUR HEADLIGHTS.

TURN ON THE WINDSHIELD WIPER.

TURN ON THE WINDSHIELD WASHER.

TURN UP THE PANEL BRIGHTNESS.

TURN ON THE CRUISE CONTROL

SET THE CRUISE CONTROL.

TURN ON THE DOME LIGHT.

TURN ON THE HAZARD SWITCH, THAT IS THE FOUR-WAY FLASHER.

At this point, stop the simulation. If the simulation has ended before the list is complete, restart it for a few more minutes.

THAT'S JUST FINE. I'M GOING TO TURN THE LIGHTS BACK ON, SO YOU MIGHT WANT TO COVER YOUR EYES. *Turn them on.* **I NOTICED YOU HAD SOME DIFFICULTY LOCATING/OPERATING THE _____ SWITCHES** *(list one at a time if many).* **WOULD YOU LIKE TO CHANGE EITHER THE LOCATIONS OR THE TYPES OF SWITCHES USED? OK, THEN PLEASE DO SO.** *Enter the revisions into the computer program. At this point save the data by hitting the "SAVE" button.*

DO YOU HAVE ANY FINAL COMMENTS? *Enter them into the computer.*

TURN OFF THE VIDEO RECORDER.

****** Participant Lifestyle Data ******

MAKE SURE VIDEO RECORDER AND MICROPHONES ARE OFF!!!!

THE NEXT SERIES OF STEPS INVOLVE FINDING OUT MORE ABOUT YOU, YOUR DRIVING HABITS, AND YOUR CAR. SOME PEOPLE THINK THAT THESE DIMENSIONS MAY BE RELATED TO THE SIZE OF SWITCHES PEOPLE WANT OR WHERE THEY WANT THEM. WE WANT TO SEE IF THIS IS TRUE.

PLEASE STEP OUT OF THE MOCKUP SO I CAN RECORD THE SEAT POSITION. *Record it on the data sheet.*

WHEN YOU DRIVE ON THE EXPRESSWAY AND TRAFFIC IS MOVING QUICKLY, DO YOU USUALLY DRIVE IN THE LEFT OR RIGHT LANE. *Record left or right.*

DO YOU PREFER CONVENTIONAL POINTER TYPE SPEEDOMETERS OR NUMERIC DISPLAYS? HERE ARE SOME EXAMPLES OF EACH. *Record conventional or numeric.*

IF A NEW GADGET COMES OUT, ARE YOU THE "FIRST ON YOUR BLOCK," THE LAST ON YOUR BLOCK," OR SOMEWHERE IN BETWEEN WHEN IT COMES TO BUYING ONE. *Record first, in between, or last.*

****** In-vehicle Measurements ******

Check their near visual acuity with the Orthorater.

NEXT WE'RE GOING TO TEST YOUR VISUAL ACUITY WITH THE ORTHORATER. IF YOU WEAR GLASSES OR CONTACTS WHEN DRIVING, PLEASE WEAR THEM WHILE WE INVESTIGATE YOUR NEAR VISUAL ACUITY. YOU WILL SEE 14 SETS OF DIAMOND SHAPES WITH A CIRCLE IN EACH CORNER. THREE CIRCLES ARE INCOMPLETE CIRCLES AND ONLY ONE IS COMPLETE. WHEN I PROMPT YOU FOR A NUMBER, PLEASE INDICATE THE LOCATION OF THE CLOSED CIRCLE (I.E. TOP, BOTTOM, LEFT, RIGHT).

Set up the orthorater with the dial set with #9 next to the amber light and the lever on the right side to the "near" setting and begin the test. **NOW, WE WILL CHECK YOUR NEAR VISION, SO LOOK INTO THE ORTHORATER AND I WILL ASK YOU FOR THE LOCATION OF THE CLOSED CIRCLE FOR THE DIAMOND NUMBERED 1.** *Give the subjects feedback on how well they are doing. GOOD!, NOW NUMBER TWO, etc. Continue to prompt subjects for numbers until they have missed two locations in a row, then stop the test. The subject's near visual acuity corresponds to the last correct response. Record their near visual acuity on the biographical form.*

NEXT WE NEED TO TAKE SOME MEASUREMENTS. PLEASE STAND UP STRAIGHT SO I CAN MEASURE YOUR HEIGHT. NOW, PLEASE SIT UP STRAIGHT ON THIS TABLE SO I CAN MEASURE YOUR UPPER BODY HEIGHT. NOW I NEED TO MEASURE YOUR SEATED EYE HEIGHT. *Make sure they are standing straight*

NEXT I NEED TO RECORD THE LENGTH FROM YOUR SHOULDER TO YOUR ELBOW. I AM GOING TO REST MY HAND ON YOUR RIGHT SHOULDER. HOLD YOUR UPPER ARM PARALLEL TO YOUR BODY WITH YOUR LOWER ARM PERPENDICULAR TO YOUR BODY. I ALSO NEED TO MEASURE THE LENGTH FROM YOUR ELBOW TO YOUR WRIST. *Take these measurements.*

NEXT I WANT TO RECORD YOUR HAND LENGTH. TURN YOUR HAND PALM UP AND I'LL MEASURE FROM YOUR WRIST TO THE END OF YOUR FINGERS.. *Show them. Measure from the crease in the wrist closest to the hand to the end of the middle finger, excluding fingernails. Make sure the hand is flat.*

NOW, I NEED TO MEASURE THE WIDTH OF THE INDEX FINGER ON YOUR DOMINANT HAND. *Measure the width of the joint closest to the fingernail.*

NEXT WILL YOU PLEASE STEP ON THE SCALE SO WE CAN RECORD YOUR WEIGHT. *If necessary, explain that weight is a representative measure of body size that we need in order to see if our subject pool accurately reflects the distribution of body sizes in the population.*

NOW IT'S TIME FOR YOU TO BE PAID. HERE IS $15.00 AS PROMISED. *Pay them, then give them the support voucher.* **PLEASE PRINT YOUR NAME, STREET ADDRESS, CITY, AND ZIP CODE ON THIS FORM ALONG WITH YOUR SOCIAL SECURITY NUMBER, THE**

UNIVERSITY REQUIRES ALL OF THIS INFORMATION. ALSO SIGN YOUR NAME HERE INDICATING THAT YOU WERE PAID.

******* Miscellaneous Questions ******

FINALLY, LET'S GO OUT TO YOUR CAR AND RECORD WHERE THE FUNCTIONS THAT I ASKED YOU ABOUT ARE LOCATED IN YOUR CAR. *Go outside, taking with you the forms, reference sheet, payment voucher, and money.*

THIS IS A ... *Record the year, make, model and body type. If they don't know what it is, ask to check their owner's manual if they have one, perhaps in the glove compartment.*

Record the size, shift type and locations, if it has pods and stalks, and the speedometer type. Also record the zones where the 9 functions are located, the switch types, and their method of operation.

THANK YOU FOR YOUR TIME!

Take pictures of the interior of the car after the subject leaves with the 35 mm camera. Afterwards, put all the switches back on the boards and get ready for the next subject.

APPENDIX G
PARTICIPANT CONSENT FORM

This appendix contains a copy of the consent form filled out by participants before the start of the experiment. The actual consent forms were printed on UMTRI letterhead stationery. The consent form briefly explained the events of the study and mentioned videotaping the experiment. All participants agreed to be videotaped, although they were not required to do so.

- Appendix G - Participant Consent Form

PARTICIPANT CONSENT FORM

Subject #_____

CONSENT FORM

PREFERENCES FOR CONTROLS, EXPERIMENT 2

The purpose of this experiment is to determine where controls such as the headlights and windshield wipers belong in future cars, and how they should operate. This information will be used to design cars that match your preferences.

While seated in a mock-up of a car, you will be shown a collection of knobs and buttons. From them, select a switch for each function, say where it belongs, how it should operate, and why. We will also ask a few questions about you, your car, and your driving habits. Then, we will take a few simple measurements of you (height, weight, arm length, etc.). Finally, we will collect information about the location of controls in your car by going out to the parking lot and looking at your car.

This experiment should take an hour and a half, for which you will be paid $15. You may withdraw from this experiment at any time.

To help understand how people make decisions, we would like to videotape a few participants in this experiment. Would you consent to being taped? (**yes/no** - *circle one*) Saying no carries no penalty.

I have read and understand these instructions.

_____	_____
Date	Participant's Signature
_____	_____
Experimenter (Witness)	Participant (please print)

(1/30/89)

- Appendix G - Participant Consent Form

APPENDIX H
PARTICIPANT BIOGRAPHICAL FORM

This appendix contains the text of the biographical form filled out by the experimenter before and after conducting the experiment. It gathered general information, (name, sex, age, handedness, education, etc.) as well as vehicle experience and driving lifestyles. The anthropometric measures were recorded on the biographical form as well. Finally, the form was taken to the participants' car to collect data regarding the controls and locations in their own vehicles.

PARTICIPANT BIOGRAPHICAL FORM

The University of Michigan
Transportation Research Institute
Human Factors Division
Dr. Paul Green, Project Director

Participant #_____

Experimenter_____
Date & Time _____

Driver Preferences for Secondary Controls, Experiment 2 Biographical Form

Please print.

GENERAL INFORMATION **********

1. Participant Name:_____

2. Address:_____

3. Home Phone:_____

4. Occupation: _____
(If retired, note former occupation; if student note major)

--->5. classify technical nontechnical (circle one)

6. Education: (circle highest level completed)

high school	some degree, where->	_____
trade/tech school	some degree, where->	_____
college	some degree, where->	_____
grad/prof school	some degree, where->	_____

7. Number of years of schooling: _____ (completed 7th grade=7)

PHYSICAL INFORMATION **********

8. Sex: male female (circle one)

9. Handedness: right left ambidextrous

10. Eyewear when driving: (circle one)

nothing glasses bifocals trifocals contacts

11. Age: _____

12. Any physical disabilities that will interfere with using controls?

no yes - describe->_____(13)

DRIVING HABITS **********

13. Total Miles Driven/Year: _____

14. What fraction is at night? Please make a year-round estimate. _____%

--->15. Compute miles driven at night _____

Which kinds of vehicles have you operated? (circle)

16. aircraft (airplane, helicopter, blimp) yes no
17. power boat yes no
18. construction equipment (backhoe, etc.) yes no

19. medium/heavy truck, bus (exclude pickup) yes no
20. farm machinery (combine, etc.) yes no
21. industrial truck (fork lift, etc.) yes no

22. specialized military vehicle (tank, etc.) yes no
23. motorcycle/motorbike yes no
24. snowmobile yes no

25. flying saucer yes no

26. -> Total number of kinds of vehicles operated _____

When you drive, where are your hands usually positioned?

27. Left hand: not on wheel ____ o'clock
28. Right hand: not on wheel ____ o'clock

Comment:_____

TURN ON VIDEO RECORDER AND MICROPHONE SETS!!!!!!

>>>>>>>>>> begin collecting preference data <<<<<<<<<

TURN OFF VIDEO RECORDER AND MICROPHONE SETS!!!!!

PARTICIPANT LIFESTYLE DATA **********

29. When you drive on the expressway and traffic is moving quickly, do you usually drive in the left or right lane?

left right

30. Do you prefer conventional pointer type displays or electronic displays for the speedometer?

conventional electronic

31. If a new gadget comes out, are you the "first on your block," "last on your block," or somewhere in between to buy one?

first in between last

IN-VEHICLE MEASUREMENTS **********

32. Fore-aft Seat Position _____

ANTHROPOMETRIC MEASUREMENTS
****

33. Corrected Near Visual Acuity (measure): 20/___

34. Standing Head Height: _____

35. Seated Head Height: _____

36. Seated Eye Height: _____

37. Shoulder--Elbow Length: _____

38. Elbow--Wrist Length: _____

39. Hand Length: _____

40. Index Finger Width: _____

41. Weight: _____

GO OUT TO THEIR CAR NOW **********

42. Car You Drive Most Often:_____
(include year, make, model)

43. Body Type (FARS code):

convertible (excludes sun-roof, t-bar)
2-door sedan, hardtop, coupe
3-door/2-door hatchback
4-door sedan, hardtop
5-door/4-door hatchback
station wagon
other automobile
unknown automobile type

44. Size: subcompact compact medium large

45. Shift: manual automatic

46. Shift Location: floor column other

47. Does the car have pods? yes no

48. Are there stalk controls used for other than turn signal, gear shift, or column tilt?
yes no

49. Does the car have a moving pointer or numeric speedometer?
pointer numeric

Existing controls

	zone	sw type	op code	# pos	LABELS
50. cruise on/off					
51. cruise set					
52. dome light					
53. front washer					
54. front wiper					
55. hazard					
56. headlights					
57. ignition					
58. panel bright					

COMMENTS **********

APPENDIX I
SAMPLE CLUSTER DESIGNS

This appendix contains photographs of both a typical cluster design and a "futuristic" cluster design. In Figure 27, Subject 29 chose a somewhat typical layout, but preferred not to use stalks. The cruise control functions were both on the steering wheel; on the left spoke a rocker switch controlled on/off, and on the right, pushbuttons were used for cruise set/resume. Although not shown in the photo the dome light switch was a rocker on the front center ceiling. The windshield washer and wiper were controlled by a knob located on the lower left panel (this not a common selection). The hazard was a rocker placed on the lower right panel. Headlights and panel brightness were activated by a push-pull switch on the lower left panel.

A futuristic design (shown in Figure 28) was proposed by Subject 18, who put all controls on the steering wheel spokes. The cruise control on/off and set were both controlled by pushbuttons on the left spoke. The windshield washer and wiper utilized a combination switch on the right spoke Slide switches on the center spoke operated the dome light, hazard switch, headlights, and panel brightness.

Figure 27. A typical instrument panel design.

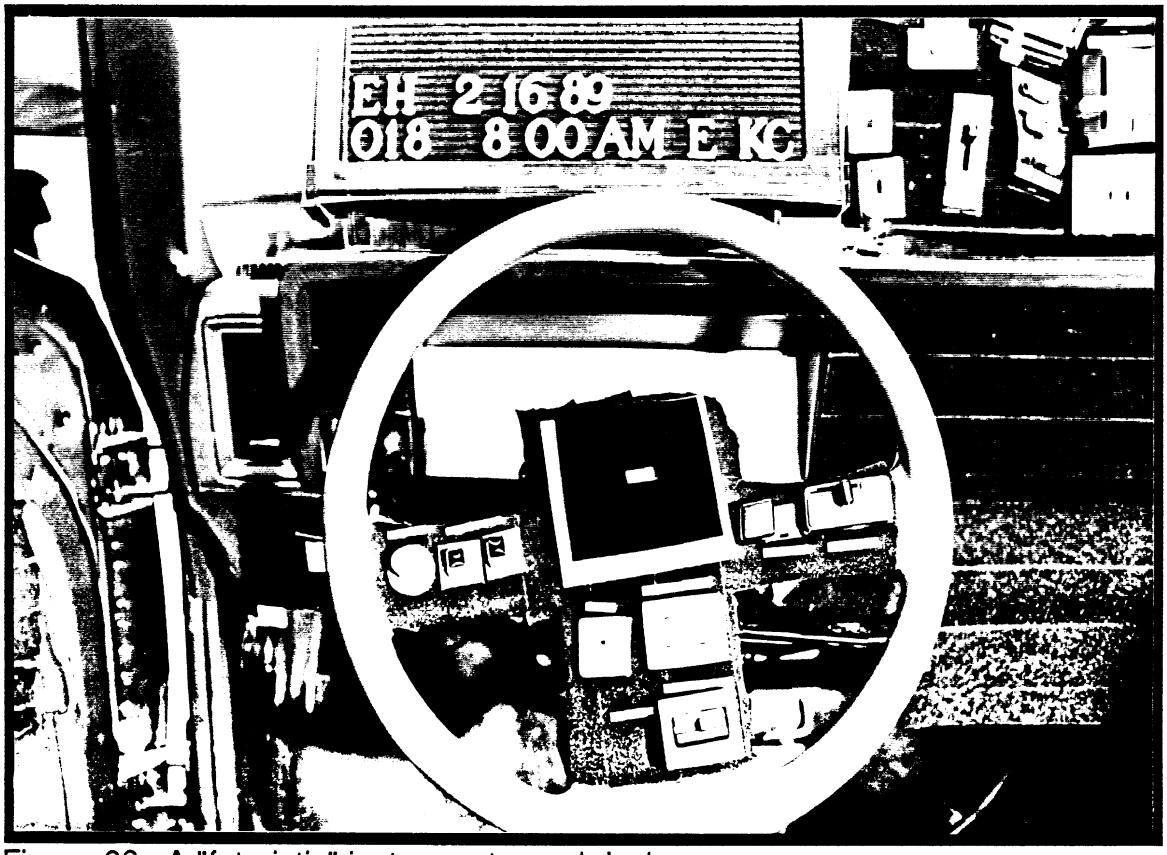


Figure 28. A "futuristic" instrument panel design.

APPENDIX J
DIALOG WITH A TYPICAL PARTICIPANT

This appendix contains a transcript of a session with a subject, which is intended to show a typical interaction between a subject and the experimenter. This particular session took place on March 6th, 1989 at 10:30 am with subject number 42. The dialogue was edited very minimally to help clarify the interaction, such as removal of a few "Umms" and "O.K.s.".

Anything in parentheses was not actually said, and may describe the actions of the speaker or what the speaker was talking or thinking about.

A series of dots (...) denotes a pause, where the speaker may have been thinking noisily (um,ah,uh) or quietly (long pause).

A series of dashes (---) denotes a sudden change (mid-sentence) in what the speaker is saying.

DIALOG WITH A TYPICAL PARTICIPANT

Sample Experimenter-Subject Dialogue

Exp. O.K. I think you understand that we are going to have you choose controls that you want for some different functions. The functions are listed on that board directly in front of you. There is a little list to the right with labels....We want to know what kind of switches and locations you want for these functions. There is no right or wrong answer for any of these. As you can see, there is a large collection of switches and knobs here.

Sub Someone really hit the hardware store and electrical shops--wow!

Exp. (Laughter from Exp.) Yeah, there's a lot of them and they all have velcro on the back too so you can stick them to the instrument panel of the car....After you make all your choices I'm going to turn on our driving simulator and show you how to use it, and then I will tell you do so some things and you can see whether you like your locations and switches and you can change anything you want at any time including after the driving simulator....The nine functions we are interested in are headlamps on and off, dome light, panel brightness, cruise set, cruise on and off, front washer, front wiper, hazard switch and ignition. For the ignition we are mainly interested in where you want it unless you have some other suggestions for anything else....Do you have any questions about any of those functions?

Sub None

Exp. O.K....Locations and switch types have already been chosen for the horn which is in the center of the steering wheel and for the turn signal and the beam select and beam flash which are on the left stalk. If you would like to ... oh-- Those were... chosen based on data from a previous study, if you would like to change ... the left stalk, like put one of these other stalks in, there's quite a few right here, ... you can, as long as the up and down and the forward and back are still turn signal and beam select and beam flash but you can make them twist or slide or push or other things....

Sub Let me think for just a second.

Exp. You don't have to .... (choose one now)

Sub The key is location. ... You're secondarily interested in--well, let me say it again. Did you want me to select one of these (stalks)?

Exp. Oh, no.

Sub O.K.

Exp. That's only if you want to. I'm just going to continue telling you some preliminary information.

Sub Yeah

Exp. O.K.... Here we have some rocker switches, thumbwheels, knobs, different sizes (pointing to the switches). In front of you to the right there are slide switches of all different shapes and sizes, and on the board--the vertical board to your right--there are some push surfaces and some pushbuttons, and then on the board sitting next to you there are some push/pull switches, paddle switches and some other miscellaneous things including an ignition switch if you want to change the location of the present one. Um... also you don't have to choose something based on labeling, if you want to choose something that says washer/wiper, and

say that its the lights, you can do that, that's fine.... Also, if you want to change the color of a switch, just tell me.... You can choose those functions in any order you like, to place them where you want and choose your switches.... You can choose multiple switches for one function, such as two pushbuttons to turn something on and off--that's o.k. Then we also want to know how you want a switch to operate, so you have to---I'm going to ask you that. So, I'm going to give you this little list of questions that I'm going to ask you (places list in front of subject). Every time you choose one-- one of these functions to talk about-- I'm going to ask you all these questions about each one.... That would be- "which switch did you choose?" (pointing to the list) Each switch has a number on the back and I'm going to ask you why you want that switch and where do you want to put it? You are just going to put it somewhere and I'll record the location and then I will ask you why you want it there. Then I'll ask you how you want the switch to operate, you will just tell me what you want it to do and then I will ask you why you want it to work that way. And then here is the list of some of the reasons you may have for making some of your selections (places list in front of subject) so right now I would like you to just read through the list to make yourself a little familiar with it and tell me when you're finished reading that.

Sub O.K.
(typing in background at this point)

Sub O.K.

Exp. O.K.... When I ask you why you made a choice, you are going to first think of your own idea for a reason and then tell me and I'll probably be able to figure out what you mean, because we have to assign codes to it so we know...

Sub Uh huh.

Exp. Every one, you know...

Sub O.k.

Exp. will say different things and mean the same thing.... So, I may know what you are talking about, but if I don't, I may ask you to look on this list and find what best matches your reason; and then I want you to tell me the number next to that block of reasons; and also, if you have more than one reason, tell me all of them....If you want to install a stalk on the left or right side, I can show you how to do it....

Sub Yeah.

Exp. Before you begin, I'd like to emphasize that the switches you select are for a fully-equipped car to be produced in the 1990's. In making your decisions about which switches to choose, try to imagine what cars will be like then and what you would expect from this type of car. Try to maintain this perspective when making your selections. If you have no further questions, go ahead and start making your selections.

Sub O.K.

Exp. In any order you want.

Sub That's fine.

Exp. O.K. ... O.K.

Sub Well, I'm going for the headlights, on and off switch first.... I guess I'm going to get stuck with push/pull. It is a fail-safe kind of thing for me. Do I ... label these or just put them down?

Exp. ... If you would like to put the labels on, that's fine. That might make it a little easier.

Sub Lets see, I've got number 24.

Exp. O.K.

Sub Push-pull.

Exp. O.k. you can probably just put the label right down there and then you know you have done it and you...

Sub O.K.

Exp. ... know where it is.

Sub I put it at the left, easy to reach, not blocked by anything, ... that's my primary consideration. I suspect there is a secondary consideration in that I'm used to seeing switches down there.

Exp. O.K. (typing) O.K.... When you chose that switch you said that it was a fail-safe switch.

Sub Yeah, to me ... if I want to, without even looking, pull it all the way out, the switch is now on. I've got the headlights and I can manipulate a push-pull switch very easily without having to give it any thought or a look and ---anything further on that before I go to another one? (typing in background)

Exp. ... Yeah, I just need to know how you want it to work. (typing)

Sub O.K. All the way out is on, all the way in is off. There can be an intermediate point for control of the driving lights, things of that sort.

Exp. (typing) O.K. And I just wanted to know also why you want it to work that way.

Sub You know, without looking at it, I guess we are talking about, ... feedback.

Exp. Uh huh.

Sub And it-- a push-pull --is ... contrasted with say ... a slide switch where you've got to use a thumb or a finger and a certain delicacy of motion. With this you just grab it with the hand, pull it out, push it back.

Exp. O.K.

Sub It's just a nice, sturdy, positive feedback kind of a switch.

Exp. (typing) O.K. You can go on to the next one.

Sub O.k. We are going to do the dome light.

Exp. O.K.

Sub We picked a number 41 -- pushbutton.

Exp. O.K. And why do you want that switch?

Sub I want to be able to just reach back-- click, click. It's a fairly large switch. (typing) I'll know when it's on or it's off very easily and ... either the lights come on or they don't, I see illumination or I don't, large so that I can locate it easily, pushbutton so there is no intricate motions involved and also locating it out of the way. (typing) Oh, there was a secondary issue. It has a contrast with some of the other pushbutton switches; it seems to have a nice look to it.

Exp. O.K. (typing)

Sub And so there was a secondary consideration in terms of look, a certain sleekness and modernity to it. O.K. What have we forgotten here?

Exp. (typing)... I just need to-- oh, let's see-- I need to know-- let's see where you put it. Kind of with the dome light?

Sub Uh huh.

Exp. O.K. so that's.....and you said that....(typing while thinking aloud.)

Sub Well, I will tell you right now that if I don't end up using space right here, later on I'll move it up to here.

Exp. O.K.

Sub But for the moment I've got it out of the way.

Exp. O.K. So you want it there. You mentioned something about you could reach it easily.

Sub Yeah, I can go back like this and find it.

Exp. Is there any other reason you want it there?

Sub No, other than what I just mentioned; it is out of the way.

Exp. O.K.

Sub Rarely use a manually manipulated dome light-- I personally. The only lights I normally use for internal illumination are switched on by a door opening.

Exp. O.K. (typing) And the last thing is, I want to know how you want it to work.

Sub O.K. Strictly on/off ya know. Punch it once, it's on--punch it once, it's off.
(typing)

Exp. O.K. Why do you want it to work that way?

Sub Simplicity, used to it, no I'm not. I guess I'm not use to it, push-pull or ... a pushbutton, come to think of it. I'm used to a slide switch. Strictly simplicity.

Exp. O.K.

Sub O.K. Panel brightness. O.K. We've selected ... --I think that's a 105.

Exp. Yep, why do you want that switch for the panel brightness?

Sub O.K. it's a ... thumbwheel rheostat ... approach to varying the panel brightness. I can slap it up here and be able to reach it without looking at it and I can dial in the amount of brightness I want strictly by just manipulating the thumbwheel. (typing) That location is one that I'm used to and works well for me. It is out of the way, can actually be even further under the dash if the velcro is there. So it is an out of the way location, no conflicts but still easily reached and manipulated while driving.

Exp. O.K. (typing)

Exp. So-- one of the reasons you like the location-- you say it's easy to use while you're driving?

Sub Yeah, that would be primary, secondary is familiarity with that particular location.

Exp. O.K. (typing) O.K. And when you say that you are familiar with that location, is it that way in your car? Or because it's usually that way?

Sub Yeah, it's that way in the car I drove over today. Anything further on that one?
(typing)

Exp. ... I just need to know how you want it to work.

Sub Thumbwheel rheostat.

Exp. O.K. So which way do you want it to be brighter and which way dimmer?

Sub (laughs) -- How to describe this? Why don't we just say clockwise - brightens, counterclockwise - dims.
(typing)

Exp. O.K. and then I just want to know why you want it to work that way.

Sub Past experience.

Exp. O.K. (typing) O.K. you can go on to the next one now.

Sub O.K. Cruise control on/off. I'm going to use a number 2 rocker switch.
(typing in background)

Sub On is-- I don't know whether it matters or not.

Exp. O.K. First of all I want to know why you want that switch.

Sub O.K. I want to be able to manipulate it with my thumb, while driving-- just drop my hands down a little bit and flick it back and forth with my thumb. (Exp. typing) The rocker allows me to know on or off without looking at it, you know, although the pressing down on the left always turns it on as an example. Pressing right always turns it off or vice versa which ever way it is. (typing) Positive feedback in other words.
(typing)

Exp. And which way ... (do you want to turn it on?)-- let's see. O.K.

Sub If I've got a choice, on would be pressing the right hand portion of the rocker.

Exp. O.K. (typing) O.K. And why do you want to put it there on that side of the steering wheel? You mentioned that you want to be able to use it with your thumb while you're driving.

Sub Yeah, strictly ... because the Escort that I drive has them like that and I find that convenient.
(typing in background)

Exp. O.K. (typing) O.K. and you said that you want to push on the right side for on and left side for off.
(typing)

Exp. And why do you want it to work that way?

Sub Once again, it was the positive feedback ... without being--without having to look at the switch while driving down the road, I know that flicking my thumb all the way over to the

farthest point and going down has got it on and if I want to turn it off, just move the thumb over a little bit without looking, positive feedback tells me what I've done.
(typing all the while in the background)

Exp. O.K. You can go to the next switch.

Sub O.K. Now we'll do the cruise set and ... did I give you a number off of that switch?

Exp. Yeah, it was a number 2.

Sub I want to match color wise, design-wise; I guess we're going to have to match it with pushbutton number 20.

Exp. O.K. And why do you want that switch?

Sub O.K. I presume that anytime I want to-- you know I've gotten up to a particular speed, I'm on with cruise control, all I do is hit the button, I've now triggered cruise control to operate at-- to hold me at that particular speed. If I ever cut off cruise control- OK, and then come back reset to a particular speed, I just hit the button again. I don't ever have to go on/off/on/off. All I have to do is just trigger. I like the pushbutton approach, once again I can drop my hand down slightly, hit the button without ever looking at it and set my speed. (typing in background) There is an aspect of pushbuttons. I'm not familiar with push surface switches. Are they--would they give me a positive detent or click or something of that sort?

Exp. Well, if you want it to work that way, you can say that that's how you want it to work. We just provided it as a way of having some sort of shape or different kind of switch than is normal.

Sub Well, I'm curious for the moment.... Would this be a flush mounted switch or is that a choice of my own?

Exp. No, that's a choice of your own.

Sub That's strictly for future reference. I still think that I'm going to go with what I've got here.

Exp. O.K. And I have to ask you why you wanted to put it on the right hand side of the steering wheel.

Sub Ah...

Exp. For some of the same reasons as the cruise on/off?

Sub It's strictly familiarity, yeah. Strictly familiarity, I had the arrangement in the past and it works for me.

Exp. O.K. (typing) O.K. And you said briefly how you wanted it to work. You want to accelerate with the floor accelerator until you get to the right speed and then press it and that makes you stay there.

Sub Right.

Exp. O.K.
(typing)

Exp. O.K. And why do you want it to work that way? For the cruise set--just to press it in and have it stay?

Sub Simplicity, and positive (feedback) uh, just for simplicity sake.

Exp. O.K.

Sub No unusual movements required or anything of that sort, just sudden pressure with the thumb and that's got it set.

Exp. O.K. ... What's the next thing you want to work on?

Sub I'd like to get the ignition switch moved off the steering column. Is that O.K.?

Exp. Yep.

Sub Are they going to allow me to do that?

Exp. Uh huh.

Sub I know why they've got it on the column but for my ease and convenience I'd prefer to have it, since I'm right handed, over on the right side and where I don't have to come down behind the wheel.

Exp. O.K. There's a little key next to you, ... on that board (pointing).

Sub Where?

Exp. See it? It should be sitting there.

Sub Oh yeah.

Exp. There it is. (Subject places ignition switch.) That's where you want it?

Sub Yeah.

Exp. O.K. And you said partly because you are right handed.

Sub Right, correct.

Exp. And what else, what other reason do you have for wanting it there?

Sub Awkwardness in reaching behind the steering wheel.
(typing in background)

Exp. Alrighty. ... Is there-- what's the next thing you want to do? All we want to know about is the location for that one.

Sub For the next one?

Exp. Uh huh.

Sub Well let's see.

Exp. I meant for the ignition. That's all we want.

Sub O.K. Wiper and washer are pretty important Let me think for a minute. These are all the switches I've got to mess with- these (pointing).

Exp. Uh huh.

Sub I'm going to do washer and wiper. O.K., washer--I guess we'll go with a push surface, that would be number 165.

Exp. O.K. Is this for the wiper or the washer?

Sub For the washer. As I visualize it, all I have to do is push it like I'd push a calculator button.

Exp. O.K.

Sub I'll get a positive, I've forgotten what you call it, not detail, but click that indicates that I have successfully-- no, I take that back, I don't need that for this. All I've got to do is push it, it's going to squirt, I see it squirt. As long as I'm holding it down, it is going to continue to squirt, as soon as I let off, a spring kicks it back up into the off position. I've got it over on the right where I can hopefully find it. It's going to be raised above the surface, it's not flush with the mounting surface, but raised a little bit so that once again, I can hit it with a thumb coming down off the steering wheel while I'm still watching the traffic through my dirty windshield. I've chosen-- I'm trying to maintain some degree of design continuity between the other switches that I have. I gave some thought just in passing to getting away from the push/pull switch and the headlamp and going to a push switch something like these or like the washer switch and found it difficult to break away from the concept of push-pull for me personally. O.K. back to the washer.

Exp. O.K. Did you tell me why you wanted to have it in that place?

Sub Yeah, so I can just come right down off the steering wheel while I am still watching traffic and get that thing without ever having to look for it, I'll be able to reach it with my thumb just by feel.
(typing in background) Now as long as this is *my* car and I'm doing it *my* way with *my* controls, let's see-- I'd like another one the same size (pulls a switch off the board). I don't know if it is the same size or not- 165... (compares it to the other switch). Let's see-- 165, yeah, another 165 for my wipers. The concept here-- I don't like the wiper control systems that I typically encounter on cars where-- and I'm assuming that I've got variable speed wipers. Seems to me I end up always having to drop my eyes down to look at the controls in order to adjust them, so I'd like this one which is strictly a push surface switch with click type feedback. I click it once and on to a low speed wiping action, click it again, slightly more but still intermittent. Click it again, a higher rate intermittent operation. Perhaps click it again, and I'm into the highest rate of intermittent operation, click it once more and then to continue slow speed, click it again and it continues high speed. Let me think that through, if I do that how do I drop back down again? Hit the top of this surface switch- push surface switch- push the top, I go up, push the bottom, I go down in sequence.

Exp. O.K. (typing)

Sub I'd like to have something like that. O.K. what else do we need? So we are at the right and down so once again I drop my hand off the steering wheel and I can slide right across the washer to the wipers. I'm presuming of course, anytime I hit the washer button my wipers will automatically come on. It's down to the right because I'm right handed. It's in that location so I don't have to look for it, I can do it by feel, come right back up again to the steering wheel.

Exp. O.K. ... Can you just repeat how you'd like the wiper to work? You want to push the top part of the switch to go faster and the bottom part of the switch to go slower?

Sub Yeah, exactly.
(typing)

Exp. Is that a kind of continuous motion, or is it a click, or as long as you push it it will get faster?

Sub I want click feedback. I'm visualizing that it operates in this fashion. My thumb comes down, I reach the top portion of the push surface, push it once there is a click. Now I'm into a very slow intermittent wipe. Click it again, faster intermittence, click it again even faster, click it

again even faster intermittent operation. Four levels of intermittent operation. Click it again, continuous but slow wiping, click it once more high speed continuous wiping. Then if I drop the thumb down to the bottom portion of the switch I can get quick action and drop down through all those levels of wiping action. Fast, to slow continuous, to high speed intermittence, slightly less intermittence and click, click down to the lower speed.

Exp. O.K. Why do you want it to work that way?

Sub I-- from previous experience a) find the controls that we do have awkward where you have to use the left hand to come over to a wand as an example and then rotate some portion of that wand in order to reach a particular action whether it's intermittent or high speed or continuous. So a) I want it on the right, I don't want it on a wand, I want it somewhere where I can reach it and work it without really looking at it or thinking about it with only the motion of the thumb at this point in time. I don't have to twist.

Exp. O.K. ...

Sub Twist with the wrist bent as you typically do on a wand.

Exp. O.K. I want to go back to the washer for a minute. You said that you wanted it to operate by pushing it in and it squirts as long as you hold it down. Why do you want it to work that way?

Sub I don't like the kind that you just hit it and it goes on, it gives you one squirt and automatically starts wiping. I want to be able to control the amount of fluid onto that windshield and if necessary keep the fluid flowing while the wiper is operating.

(typing)

Sub It would also be nice of course, if they could come up with some sort of a moveable nozzle, so if I push harder, as well as longer, it moves the jet around on the windshield.

Exp. That would be nice.

Sub That would be lovely. O.K. where are we at?

Exp. ... I think you have to do the hazard switch.

Sub O.K. The hazard switch is used infrequently. When you do need it though, it's been my experience that on some cars, the pressure of the emergency may make it difficult for you to find the switch and manipulate it. I can't recall but in the past there have been cars that have the damn thing up here on the steering column underneath the wheel. The one that I love is always down and to the right and so-- Wow, here's an accident or something, and Wham and I'm down and I hit it. So I'm going to be down to the right next to the ignition switch but in-board of it so when my hand actually drops, that's the place it goes. No hunting, no searching. It has got to be a click just like that, it's on. I don't want to have to worry about manipulating anything other than hitting the surface again. I love the push surface concept, maintain continuity. I'm not trying to distinguish by-- perhaps I should be, I suppose-- trying to change-- let's see. Let me see, I don't have that option really. I'm talking to myself saying, "Gee, what if I hit this switch and it turns out to be the washer?". I want to drop down here. I really need to have some sort of different feel to it. Guess I'm limited to changing the shape of the switch but at the same time all I want to do is push. I'd like to have one that is circular. I don't (have one), so I'll pick one that is triangular. Let's see-- Is that efficient? - no - it is not good, it is not good. Might miss - I will have to go over to push button. I really want circular versus square. I would want a bigger button than the one we've got here but I'm stuck with it, so number 21.

Exp. O.K. Why do you want that switch?

Sub O.K. I want it to have a different feel than the square switches above. Lets pretend as well that it's as big as the end of my thumb so I don't miss it easily. So it's big and I can hit it and push it and that's all I have to do is with one motion I am down and pushing and it's on. Positive click.

(typing)

Sub I'm trying to maintain continuity in terms of looks at the same time. Trying to have it blend in with the other switches from an appearance stand point. O.K. Now what have we missed?

Exp. Nothing. I just need to ask you some questions about why you want the hazard switch there, which you told me something. I'm just trying to get everything typed in.

Sub Yeah, I wanted it where all I've got to do is drop my hand down, my right hand, since I'm right handed, down from the steering wheel and it's there.

(typing)

Exp. Also you mentioned that you didn't like where they are in most cars now?

Sub ....Yeah.

Exp. O.K. And also how do you want it to work?

Sub Strictly a push-- positive click.

Exp. Then push it again to turn it off?

Sub Yes.

Exp. And why do you want it to work that way?

Sub Positive feedback and simplicity of operation.

Exp. I think we've got everything now. Now I'm just going to turn on the driving simulator and let you see if you like everything. (removes board in front of the subject) I'm going to turn off the lights after I get the simulator set up. O.K. You're just going to steer this steering wheel. This black spot in the middle is your car. You want to keep it in the middle so you want to steer to the right. O.K. there you go. O.K. Just try to keep your car in the middle of the road. Pretend you're driving down a one-lane expressway ramp or down the center lane of the highway.

Sub Oh my. (has difficulty steering)

Exp. It is kind of hard.

Sub Oh...This little sucker is not exactly--- but o.k.

Exp. You don't have to keep it exactly in the middle, I mean, it is probably a little easier if you don't move the steering wheel around so much. Just keep it going steady. Do you think you are comfortable enough with it now to start operating some of your controls?

Sub Yeah, I reckon.

Exp. O.K. Why don't you turn on your headlights.

Sub O.K.

Exp. Alright, now I want you to turn on your windshield wiper.

Sub O.K.

Exp. Now operate your washer.

Sub Click.

Exp. Turn up your panel brightness now.

Sub O.K. Whoops, I hit something. Dial, dial, dial, dial, dial.

Exp. O.K. Now turn on your cruise control.

Sub Click.

Exp. Now you're at the speed you want to go so is that it? (Is it set?- Subject combined the on/off with the set function for the Cruise Control.)

Exp. O.K. Now turn on your dome light.

Sub Click

Exp. O.K. Turn on your hazard switch.

Sub Click

Exp. O.K. Good. (turns off the driving simulator) Is there anything that you didn't feel comfortable with when you were ... (driving)

Sub The only problem I had was the rheostat for panel brightness. That was a little awkward. I hit something, I hit the wand. I not only hit that wand, I destroyed it.

Exp. That's O.K.. We can fix it.

Sub But that is a valid criticism of its location (the panel brightness). Where I put that sucker, my hand is going to hit a wand. There is no doubt about it.

Exp. Well, it (the wand) will probably be there, don't worry about it. Would you like to change anything?

Sub Yeah, if I've got an opportunity to change, that panel brightness switch gets moved--as long as there is going to be a wand here I've got to move it. And since it's a non-- to me it's normally a non-critical item-- but I'm right handed-- I guess I've got plenty of space. I'm going to put the sucker right over here. Way off to the left, out of the way, reachable, I like the rheostat concept. Same choice of switch, just relocated in order to prevent conflict and relocated to my right hand side where I'm more adept.
(typing)

Exp. O.K. Is there anything else you would like to change?

Sub No, everything else felt good.

Exp. O.K.

Sub Oh no, I'm sorry. Now that I'm sure that I don't have an overload, I'd just as soon move this switch for the dome light down to here. That would be an easier location. (down to the dash)

Exp. O.K. You gave us reasons for putting it in the place you had it before--it can be reached easily, it is out of the way, and you don't use it very often. Is that basically the same?

Sub Same, same, yeah.

Exp. O.K. Is there anything else you want to change?

Sub That's it.

Exp. O.K. I think that you are done and you can get out of the car.

Sub It was a great drive, I really enjoyed the trip. Gee, I hope it was a Ford, but it sure doesn't look like it is.

Exp. What, this car? It's a Chrysler.

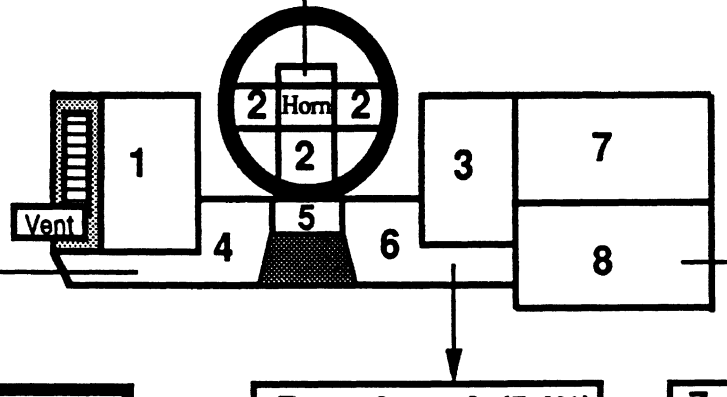
APPENDIX K
DRIVER PREFERENCES VS. THE ACTUAL CONTROLS IN THEIR OWN VEHICLES

This appendix contains diagrams showing the actual switch/motion by pooled zone found in the participants vehicles for each of the functions studied. The diagrams follow the same format as those for preferred switch/motion by pooled zone found in the results sections. Direct comparisons between the driver preferences and controls in drivers actual cars can be made to show relationships and the effect of familiarity or expectation on driver preferences.

Cruise Control On/Off

Actual locations, switches, and motions found in participants' vehicles
(n = 37 total observations*)

Zone: 2 n = 16 (43.2%)		
Switch	**Motion**	**%**
pushbutton	push in	37.8
rocker	push in	5.4

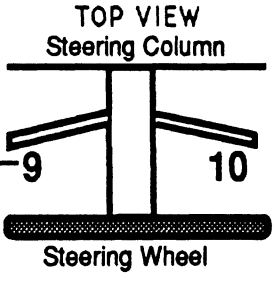


Zone: 4 n = 4 (10.8%)		
Switch	**Motion**	**%**
pushbutton	push in	10.8

Zone: 6 n = 2 (5.4%)		
Switch	**Motion**	**%**
pushbutton	push in	5.4

Zone: 8 n = 2 (5.4%)		
Switch	**Motion**	**%**
pushbutton	push in	5.4

Zone: 9 n = 11 (29.7%)		
Switch	**Motion**	**%**
stalk	push right	27.0
stalk	push up-down	2.7



Pooled Zones with less than 5% Preference		
Zone	**n**	**%**
10	1	2.7

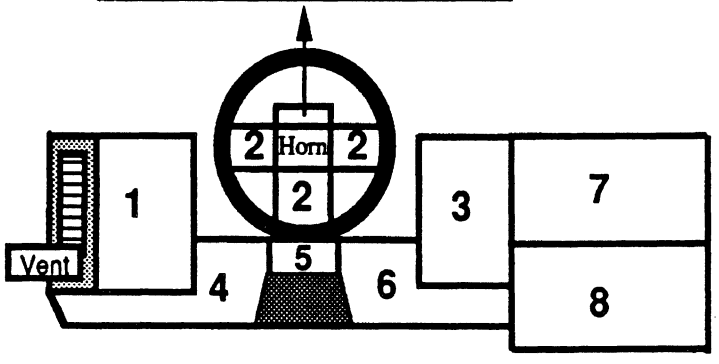
other locations not shown:	3
other switches not listed:	3

* Note: Only 37 of the 54 participants had cruise control in their vehicle

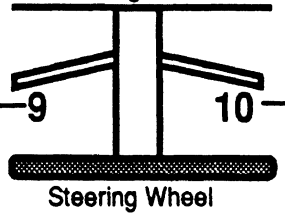
Cruise Control Set

Actual locations, switches, and methods for functions in participants' vehicles
(n = 37 total observations*)

Zone: 2 n = 23 (62.2%)		
Switch	**Motion**	**%**
pushbutton	push in	54.1
rocker	push in	5.4
paddle	push in	2.7



TOP VIEW
Steering Column



Steering Wheel

Zone: 9 n = 11 (29.7%)		
Switch	**Motion**	**%**
stalk	push in	24.3
stalk	push r - l	2.7
stalk	twist +/- y	2.7

Zone: 10 n = 2 (5.4%)		
Switch	**Motion**	**%**
stalk	twist r & l	2.7
stalk	push left	2.7

other locations not shown:	3
other switches not listed:	2

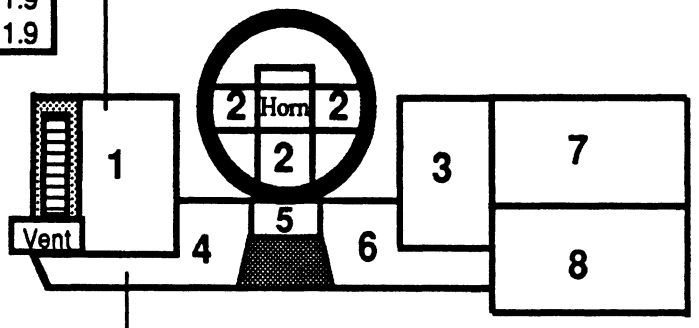
Pooled Zones with less than 5% Preference		
Zone	**n**	**%**
11	1	2.7

* Note: Only 37 of the 54 participants had cruise control in their vehicle

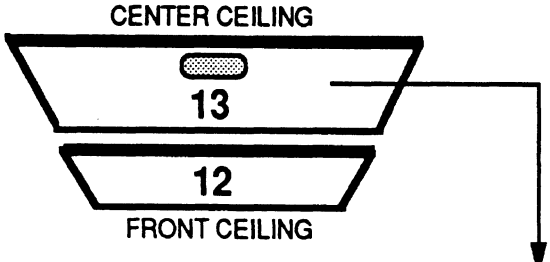
Dome Light

Actual locations, switches, and methods for functions in participants' vehicles
(n = 54 total observations)

Zone: 1 n = 8 (14.8%)		
Switch	**Motion**	**%**
push-pull	twist - x	3.7
push-pull	push up	1.9
slide	push up	1.9
slide	push up-dn	1.9
slide	push right	1.9
thumbwheel	push up	1.9
thumbwheel	multi-twist	1.9



Zone: 4 n = 21 (38.9%)		
Switch	**Motion**	**%**
push-pull	twist - x	13.0
thumbwheel	push up	11.1
knob	twist +x	3.7
knob	twist -x	3.7
push-pull	twist +x	1.9
push-pull	twist +/- x	1.9
thumbwheel	push right	1.9



Zone: 13 n = 22 (40.7%)		
Switch	**Motion**	**%**
slide	push in & out	33.3
slide	push right-left	3.7
slide	push left	1.9
slide	push out	1.9

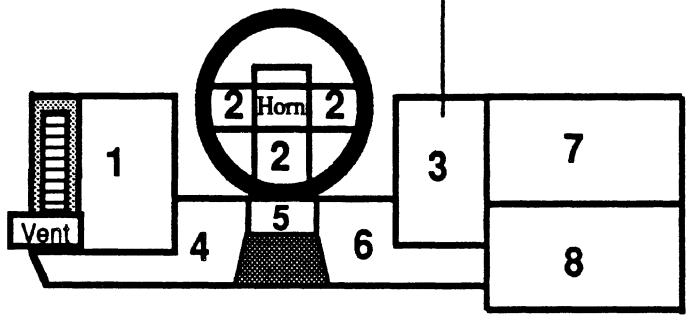
other locations not shown: 1

Pooled Zones with less than 5% Preference		
Zone	**n**	**%**
8	1	1.9
12	1	1.9

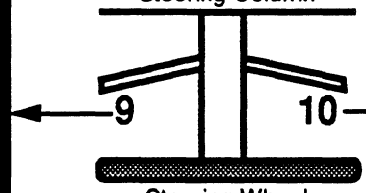
Front Windshield Washer

Actual locations, switches, and methods for functions in participants' vehicles
(n = 54 total observations)

Zone: 3 n = 5 (9.3%)		
Switch	**Motion**	**%**
pushbutton	push in	7.4
knob	push in	1.9



TOP VIEW
Steering Column



Steering Wheel

Zone: 9 n = 27 (50.0%)		
Switch	**Motion**	**%**
stalk	push right	29.6
stalk	pull out	13.0
stalk	push in	7.4

Zone: 10 n = 19 (35.2%)		
Switch	**Motion**	**%**
stalk	pull out	25.9
stalk	push left	7.4
stalk	push in	1.9

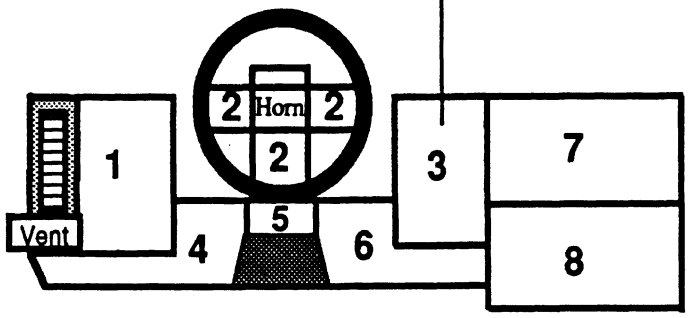
other locations not shown: 1

Pooled Zones with less than 5% Preference		
Zone	**n**	**%**
4	1	1.9
7	1	1.9

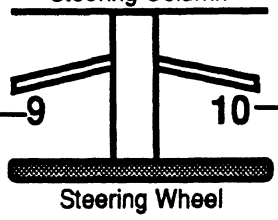
Front Windshield Wiper

Actual locations, switches, and methods for functions in participants' vehicles
(n = 54 total observations)

Zone: 3 n = 5 (9.3%)		
Switch	**Motion**	**%**
slide	push up & down	7.4
knob	twist +/- x	1.9



TOP VIEW
Steering Column



Steering Wheel

Zone: 9 n = 27 (50.0%)		
Switch	**Motion**	**%**
stalk	twist +/- y	38.9
stalk	push up-down	9.3
stalk	twist -y	1.9

Zone: 10 n = 19 (35.2)		
Switch	**Motion**	**%**
stalk	twist +/- y	27.8
stalk	push up & down	7.4

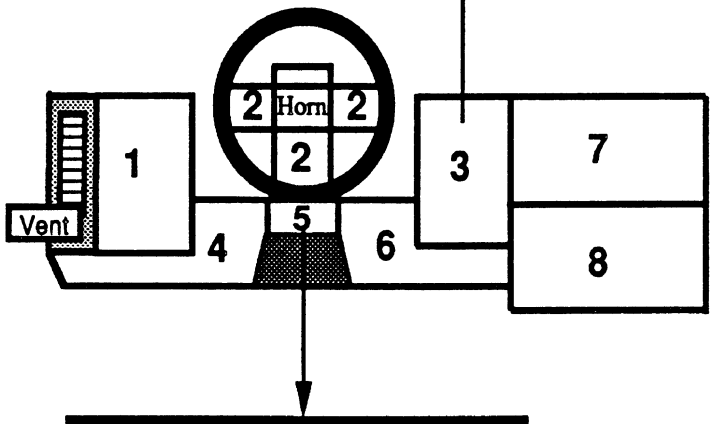
other locations not shown: 1

Pooled Zones with less than 5% Preference		
Zone	**n**	**%**
4	1	1.9
7	1	1.9

Hazard

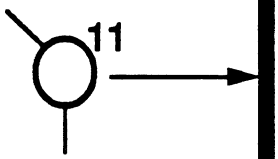
Actual locations, switches, and methods for functions in participants' vehicles
(n = 54 total observations)

Zone: 3 n = 6 (11.1%)		
Switch	**Motion**	**%**
pushbutton	push in	5.6
rocker	push in	3.7
paddle	push in	1.9



Zone: 5 n = 17 (31.5%)		
Switch	**Motion**	**%**
slide	push right-left	11.1
slide	push left	1.9
pushbutton	push down	9.3
rocker	push down	9.3

STEEIRING COLUMN
CROSS-SECTION



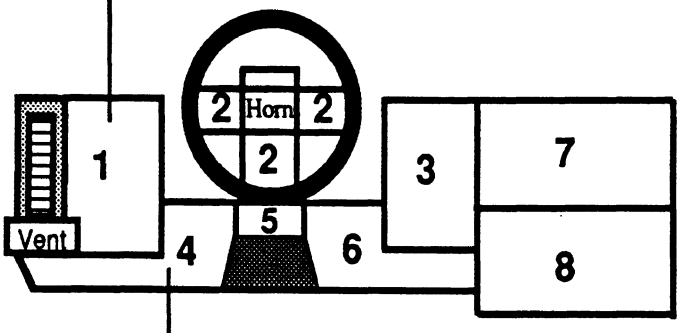
Zone: 11 n = 28 (51.9%)		
Switch	**Motion**	**%**
push-pull	push right-left	22.2
push-pull	push in/pull out	9.3
push-pull	push up-down	3.7
pushbutton	push left	3.7
pushbutton	push up-down	1.9
pushbutton	push in	1.9
knob	twist +/- y	5.6
slide	push left	3.9

Pooled Zones with less than 5% Preference		
Zone	**n**	**%**
1	1	1.9
7	2	3.7

Headlights On/Off

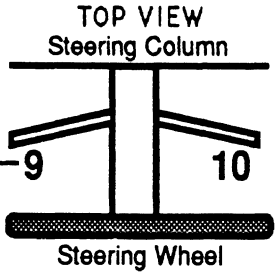
Actual locations, switches, and methods for functions in participants' vehicles
(n = 54 total observations)

Zone: 1 n = 16 (29.6%)		
Switch	**Motion**	**%**
knob	twist +/- x	11.1
pushbutton	push in	7.4
push-pull	push in/pull out	5.6
paddle	push in	1.9
rocker	push in	1.9
slide	push up-down	1.9



Zone: 4 n = 18 (33.3%)		
Switch	**Motion**	**%**
push-pull	push in & out	22.2
rocker	push in	3.7
knob	pull out	3.7
knob	push in & out	3.7

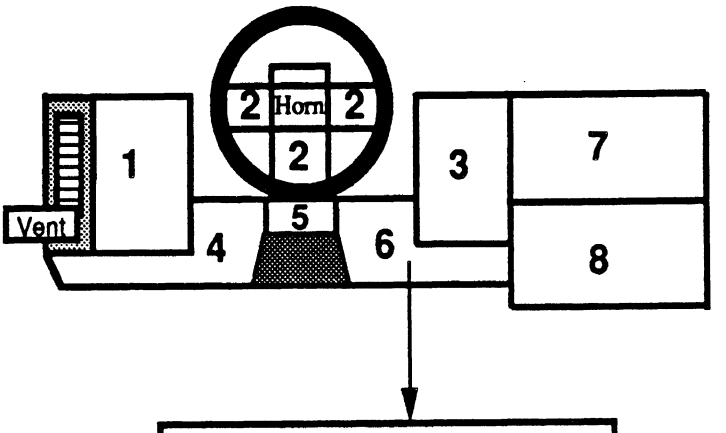
Zone: 9 n = 19 (35.2%)		
Switch	**Motion**	**%**
stalk	twist + & - y	35.2



other locations not shown: 1

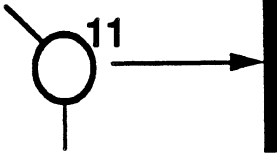
Ignition

Actual locations, switches, and methods for functions in participants' vehicles
(n = 54 total observations)



Zone: 6 n = 14 (25.9%)		
Switch	**Motion**	**%**
key	twist +/- y	25.9

STEEIRING COLUMN
CROSS-SECTION



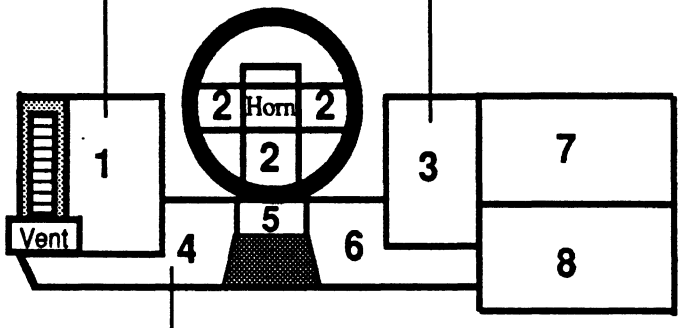
Zone: 11 n = 40 (74.0%)		
Switch	**Motion .**	**%**
key	twist +/- x	74.0

Panel Brightness

Actual locations, switches, and methods for functions in participants' vehicles
(n = 54 total observations)

Zone: 1 n = 11 (20.4%)		
Switch	**Motion**	**%**
thumbwheel	push up -down	5.6
thumbwheel	multi twist	1.9
push-pull	twist +/- x	5.6
slide	push up-down	3.7
slide	push right-left	1.9
knob	twist +/- x	1.9

Zone: 3 n = 5 (9.3%)		
Switch	**Motion**	**%**
knob	twist +/- x	7.4
slide	push up-down	1.9



Zone: 4 n = 36 (66.7%)		
Switch	**Motion**	**%**
knob	twist +/- x	29.6
push-pull	twist +/- x	22.2
thumbwheel	push up-down	13.0
thumbwheel	push right-left	1.9

other locations not shown: 1