

UMTRI-89-4

FURTHER ANALYSIS OF DRIVER PREFERENCES FOR SECONDARY CONTROLS

**Paul Green
Steve Goldstein**

FEBRUARY 1989

UMTRI **The University of Michigan
Transportation Research Institute**

Technical Report Documentation Page

1. Report No. UMTRI-89-4		2. Government Accession No.		3. Recipient's Catalog No.																																											
4. Title and Subtitle FURTHER ANALYSIS OF DRIVER PREFERENCES FOR SECONDARY CONTROLS				5. Report Date February 1989																																											
				6. Performing Organization Code 389822																																											
				8. Performing Organization Report No. UMTRI-89-4																																											
7. Author(s) Paul Green and Steve Goldstein																																															
9. Performing Organization Name and Address The University of Michigan Transportation Research Institute 2901 Baxter Road Ann Arbor, MI 48109-2150				10. Work Unit No. (TRAIS)																																											
				11. Contract or Grant No. DRDA-89-0086																																											
				13. Type of Report and Period Covered Final																																											
12. Sponsoring Agency Name and Address Chrysler Motors Corporation R&D Programs Administration 12000 Chrysler Drive Highland Park, MI 48288-1118				14. Sponsoring Agency Code 2000512																																											
15. Supplementary Notes																																															
16. Abstract <p>This report describes a further analysis of driver preferences for nine controls reported in Green, Kerst, Ottens, Goldstein, and Adams (1987). In that experiment 109 drivers sat in a mockup and placed switches for 24 functions (headlights on/off) where they wanted them. Preferences from 102 participants whose data were usable are shown below.</p> <table border="1"> <thead> <tr> <th>Function</th> <th colspan="2">Preferred Design(s) (statistically significant)</th> </tr> </thead> <tbody> <tr> <td>Beam Switch</td> <td>left stalk</td> <td>pull out</td> </tr> <tr> <td>Cruise On/Off</td> <td>hub</td> <td>rocker/push in</td> </tr> <tr> <td>Cruise Resume</td> <td>hub</td> <td>push surface, rocker, or pushbutton/push in,</td> </tr> <tr> <td>Cruise Set</td> <td>hub</td> <td>push surface or rocker/push in</td> </tr> <tr> <td>Front Wiper</td> <td>right stalk</td> <td>twist left or push up</td> </tr> <tr> <td></td> <td>left stalk</td> <td>twist left</td> </tr> <tr> <td>Front Washer</td> <td>right stalk</td> <td>push left or pull out</td> </tr> <tr> <td></td> <td>left stalk</td> <td>push right</td> </tr> <tr> <td>Lights On/Off</td> <td>left pod face</td> <td>push-pull sw/pull out</td> </tr> <tr> <td></td> <td></td> <td>pushbutton or rocker/push in</td> </tr> <tr> <td></td> <td>left stalk</td> <td>twist left</td> </tr> <tr> <td>Optical Horn</td> <td>left stalk</td> <td>pull out</td> </tr> <tr> <td>Panel Bright.</td> <td>low on IP</td> <td>knob or push-pull/twist in</td> </tr> </tbody> </table>						Function	Preferred Design(s) (statistically significant)		Beam Switch	left stalk	pull out	Cruise On/Off	hub	rocker/push in	Cruise Resume	hub	push surface, rocker, or pushbutton/push in,	Cruise Set	hub	push surface or rocker/push in	Front Wiper	right stalk	twist left or push up		left stalk	twist left	Front Washer	right stalk	push left or pull out		left stalk	push right	Lights On/Off	left pod face	push-pull sw/pull out			pushbutton or rocker/push in		left stalk	twist left	Optical Horn	left stalk	pull out	Panel Bright.	low on IP	knob or push-pull/twist in
Function	Preferred Design(s) (statistically significant)																																														
Beam Switch	left stalk	pull out																																													
Cruise On/Off	hub	rocker/push in																																													
Cruise Resume	hub	push surface, rocker, or pushbutton/push in,																																													
Cruise Set	hub	push surface or rocker/push in																																													
Front Wiper	right stalk	twist left or push up																																													
	left stalk	twist left																																													
Front Washer	right stalk	push left or pull out																																													
	left stalk	push right																																													
Lights On/Off	left pod face	push-pull sw/pull out																																													
		pushbutton or rocker/push in																																													
	left stalk	twist left																																													
Optical Horn	left stalk	pull out																																													
Panel Bright.	low on IP	knob or push-pull/twist in																																													
17. Key Words Human factors, ergonomics, human engineering, instrument panels, automobiles, cars, engineering psychology, preferences			18. Distribution Statement																																												
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 56																																											
				22. Price																																											

Reproduction of completed page authorized

TABLE OF CONTENTS

ABSTRACT	i
TABLE OF CONTENTS	iii
LIST OF FIGURES	v
LIST OF TABLES	vii
EXECUTIVE SUMMARY	ix
PREFACE	xi
INTRODUCTION	1
Background	1
Population Stereotypes for Control Motion	3
Black, Woodson, and Selby (1977)	5
Mourant, Moussa-Hamouda, and Howard (1977)	5
Elsholtz and Bortfeld (1977)	9
Jack (1985)	9
Summary	12
DATA SOURCE	13
RESULTS AND DISCUSSION	15
Pooling of Zones	15
Where Do People Want Controls Located?	16
Beam Select	20
Cruise On	22
Cruise Resume	24
Cruise Set	26
Front Washer	28
Front Wiper	30
Headlights On/Off	32
Optical Horn	34
Panel Brightness	36
CONCLUSIONS	39
REFERENCES	43

/

- Table of Contents -

LIST OF FIGURES

1. Warrick's Principle	4
2. Gear Model	4
3. Pulley Model	4
4. Controls Compared by Mourant, et al. (1977)	7
5. Performance Times for the Wiper	8
6. Test Locations and Bump/Dimple Results from Jack (1985)	11
7. Commonly Cited Pooled Zones	16

- *List of Figures* -

LIST OF TABLES

1. Control Expectancies (in %) from Black, Woodson, and Selby (1977)	6
2. Performance for Using Stalk-Mounted Controls	8
3. Control Use Errors Reported by Elsholz and Bortfeld (1978)	10
4. List of Functions Tested	13
5. Description of Pooled Zones	15
6. Chi-Squared Tests of Differences Between Pooled Zones (Original Data)	17
7. Chi-Squared Tests of Differences Between Pooled Zones (Censored Data)	17
8. Summary of Preferences	40

- *List of Tables* -

EXECUTIVE SUMMARY

Green, Paul and Goldstein, Steve (1989) Further Analysis of Driver Preferences for Secondary Controls (Technical Report UMTRI-89-4). Ann Arbor: Michigan: The University of Michigan Transportation Research Institute, February.

This report is one of several studies being carried out at the University of Michigan Transportation Research Institute for Chrysler. The purpose of the studies is to provide Chrysler with information to design controls and displays that are easy to use, which is what customers want. This particular report contains additional analyses of driver preferences for 9 of the 24 secondary controls (wiper, lights, etc.) collected in a previous experiment (Green, Kerst, Ottens, Goldstein, and Adams (1987), Driver Preferences for Secondary Controls, technical report UMTRI-87-47).

In that experiment (often referred to as Potatohead I) 109 drivers (ages 18 to 78) sat in a mockup of a 1985 Chrysler Laser. Its interior had been modified to include surfaces for pod controls (a sports car of the 90's). Those surfaces were covered with VELCRO (R). Surrounding the driver were panels on which 255 unique switches (stalk controls, pushbuttons, rocker switches, etc.) were mounted. In many cases, several copies of each switch were provided.

Drivers selected the switches they thought should be used for 24 functions (headlights on/off, rear defrost, etc.). They also placed the controls where they wanted them and said how they should operate. Subsequently, they operated a driving simulator and, while doing so, simulated using each of the switches they had installed. Based on that experience, drivers were given a chance to revise their preferences for switch location, type, and method of operation.

That report clearly identified location preferences for various functions and provided univariate analyses of preferences for switch types and method of operation. The report did not include bivariate combinations or contain statistical tests. That was not part of the original charter.

The additional analyses provided here examine the following question: For secondary controls in small cars, what is the relationship between the switch type, location, and preferred method of operation? Specifically, when both the function and zone are fixed, which types of switches do drivers prefer and how do they want them to operate? It also examines the statistical significance of differences in preferences.

- Executive Summary -

For only two functions (beam switching, optical horn) did more than half of those tested agree on where they preferred to have a control located. For the other seven functions, typically only about one-third agreed.

With regard to switches and their method of operation, there were only three instances (beam switching, optical horn, cruise on/off) where statistical tests led to identifying a single switch and motion as being preferred. This is a reflection of the diversity of views that drivers have.

Shown in the table that follows is a summary of the driver preferences. Where multiple preferences are shown, there were no statistically significant differences among them.

Function	Significant Preferences	
-----	-----	
Beam Switching	left stalk	pull out
Cruise On/Off	hub	rocker/push in
Cruise Resume	hub	push surface/push in
		rocker/push in
		pushbutton/push in
Cruise Set	hub	push surface/push in
		rocker/push in
Front Wiper	right stalk	twist left
		push up
	left stalk	twist left
Front Washer	right stalk	push left
		pull out
	left stalk	push right
Headlights On/Off	left pod face	push-pull sw/pull out
		pushbutton/push in
		rocker/push in
	left stalk	twist left
Optical Horn	left stalk	pull out
Panel Brightness	low on IP	knob/twist in
		push-pull sw/twist in

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. The program 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.

To satisfy customer demands, Chrysler wants to design vehicles with controls that are easy to use. To achieve that goal, designers and engineers need to know what properties of controls make them easy to use and what customers want.

A previous UMTRI report (Green, Kerst, Ottens, Goldstein, and Adams, 1987) describes where drivers prefer to have switches for various secondary controls (wiper, lights, etc.) located, what types of switches (rocker, knob, etc.) drivers prefer for each function and how drivers want those switches to operate. However, that report lists only method of operation preferences for each function, not for specific function-switch-location combinations. (It says how people want a wiper switch to operate in general, but does not, for example, give method of operation preferences for when the switch is a stalk control on the left side.) Those analyses, requested subsequent to the initial agreement, are described in this report for 9 of the 24 functions.

It is assumed that readers of this report have read the previous report carefully and have a copy on hand for a side-by-side comparison of the initial totals with the further analysis provided here.

- *Preface* -

INTRODUCTION

Background

This report concerns the design of secondary controls such as the windshield wiper switch, the headlights on/off switch, and so forth. Customers want those controls to be easy to use. In order 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.

There were three reports in the 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, methods of operation, and labeling were recorded for 31 secondary controls, thus cataloging contemporary design practice.

The third report in the series (Green, Kerst, Ottens, Goldstein, and Adams, 1987) identifies driver preferences for secondary controls. A total of 109 drivers sat in a mockup of a sports car with a "pod-like" instrument panel covered with Velcro. While a transmission shift level was not provided, the configuration of the car led drivers to believe it would be mounted on the transmission hump.

- Introduction -

Drivers designed a future car's interior by placing switches they preferred for 24 functions where they wanted them. There were 255 switch designs (stalk controls, pushbuttons, etc.) to choose among. Drivers also identified the motion they preferred to use to operate each control and provided comments. When the design was complete, drivers operated a driving simulator and, at the same time, reached for and touched each control when asked to do so by an experimenter.

The results were grouped by control in the Green, et al. 1987 report with each control having four pages associated with it. The first page contained text describing preferences. Accompanying the text 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.

The research described here addresses the question: For secondary controls in small cars, what is the relationship between the switch type, location, and the preferred method of operation. Nine functions examined in the previous experiment are considered: beam flash (optical horn), beam select, cruise on/off, cruise resume, cruise set, front wiper, front washer, headlights on/off, and panel brightness.

Specifically, for those nine functions, if the location of the function is fixed, what kinds of switches did drivers want and how did drivers prefer those switches to be operated for each location? For example, in the previous experiment the preferred location for the cruise control resume was on the right steering wheel spoke. When cruise resume was located there, what kind of switch did drivers prefer and how did they prefer it operate?

Finally, the authors would like to alert readers to another report that will soon appear. As part of a continuation of this project, driver preferences for secondary control locations will be obtained for a mockup with a column-mounted shift lever. In the previous experiment it was implied the shift lever was floor-mounted.

Population Stereotypes for Control Motion

For controls, it is believed that there is a close correspondence between how drivers expect controls to move and what they might prefer. The decision about how to move a control so that a display or function changes in a particular way is based on several key principles (see Brebner and Sandow, 1976). It is not the authors' intent to provide a comprehensive review of the literature on which the principles are based. It should be sufficient to note that the literature is considerable. Readers interested in the literature should see Bradley, 1959; Loveless, 1962; and Simpson and Chan, 1988.

The key design principles are as follows:

1. Turn knobs clockwise to increase. An exception to this rule are hydraulic controls (e.g., faucets) which operate in the opposite manner (counterclockwise to increase fluid flow/open). This is because a right-hand thread is commonly used and a counterclockwise motion moves the valve head away from the stop (which opens the valve).
2. Up for increase (except for the U.K., where down is associated with increase). It appears this relationship is learned.
3. Collinearity - The end of a pointer should move in the same direction as the control associated with it. This rule is most appropriate for where linear pointer motions are associated with linear controls (e.g., slide switches).
4. Warrick's Principle - An indicator should move in the same direction as the nearest point on the associated knob. (See Figure 1.) In this rule the user thinks of turning the knob as turning a gear. If the scale is vertical, the scale is thought of as having a geared rack on the side adjacent to the knob. (See Figure 2.) If the display is a dial, it is thought of as a gear.
5. Pulley Model - When the separation of the knob and the associated display are great, the control and display are thought of as being connected by a pulley. According to Warrick's Principle, a coplanar knob and dial should turn in opposite directions (when they are close), but when far apart and the pulley model applies, they turn in the same direction. (See Figure 3.)

- Introduction -

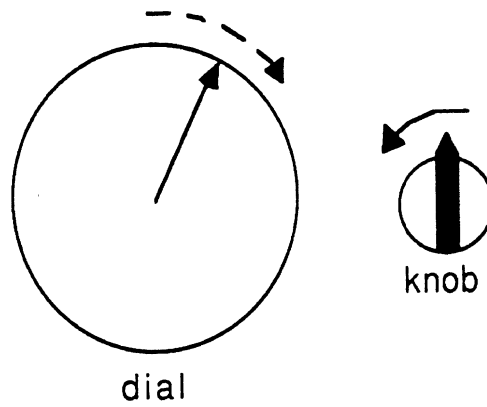


Figure 1. Warrick's Principle

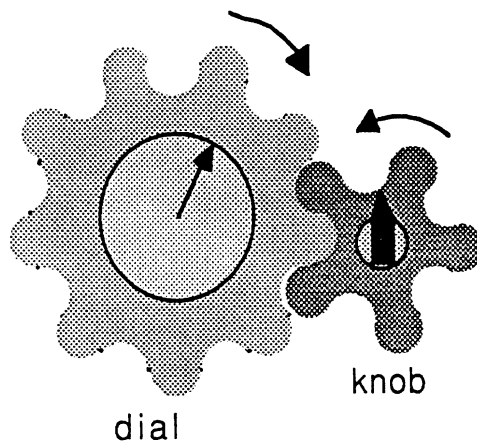


Figure 2. Gear Model

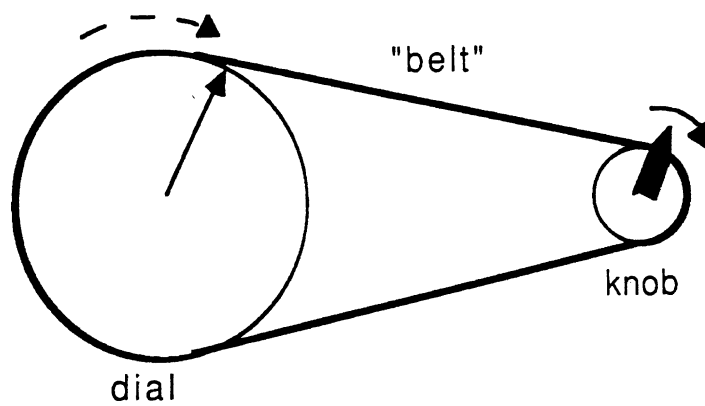


Figure 3. Pulley Model

Black, Woodson, and Selby (1977)

There are several studies in the automotive human factors literature that report experimental data on driver expectancies or performance when operating controls. Except for the Green, Kerst, Ottens, Goldstein, and Adams (1987) study on which the analysis described later is based, none of them directly addresses preferences.

In Black, et al. (1977) expectancies were obtained from 900 U.S. drivers for 10 controls, namely, washer, wiper, cruise, headlights (on/off), beam switching, hazard, fan, interior temperature, defrost, and radio volume. Drivers were shown pictures of six vehicles for which expectancies were obtained. Shown in Table 1 is a summary of some of those expectancies. (See Turner and Green, 1987, page 29 for the complete table.)

It is not clear how useful these data are. For example, almost 90% of the drivers expected the headlights on/off switch to be on the panel. When located there over 3/4 of the drivers expected it to be a knob that one pulled out to operate. This expectancy reflected a design practice common in the 70's, especially in GM and Ford cars. In Green, Ottens, and Adams (1987), just over 1/3 of the switches (of all types) were pulled by the driver to turn the lights on. Since expectancies reflect contemporary design practice, current driver expectancies for pull-push knobs for light switches are probably far less than in the 70's. Likewise, the fraction of drivers that prefer this type of switch is also likely to be much less now.

Mourant, Moussa-Hamouda, and Howard (1977)

In a laboratory experiment five stalks were mounted on the left side of a steering column in a mockup. The stalks differed in how the wiper and washer operated. Figure 4 shows the designs examined.

Five groups of 16 drivers operated the controls, with each group using only one stalk configuration. This task was conducted while drivers concurrently performed a simulated steering task. Where people looked and how they moved their hands were both videotaped and timed. Table 2 contains a summary of the results. In general drivers did better (took less time, looked away from the road less often) for control design that did not require fine grasping motions (the rotate designs). Information on preferences was not provided.

Table 1. Control Expectancies (in %) from Black, Woodson, and Selby (1977)

Control	Expected Location: Panel Stalk	----- If Column-Mounted -----			----- If Panel-Mounted -----		
		Where on column? Left Right	IDK*	What will it look like?	How will it operate?	What will it look like?	How will it operate?
Headlights (on/off)	89 11	35 0	55**	rotary switch lever rocker	30 rotate away 30 depress rocker 20 lever up 10 lever toward	round	78 pull out 49
High-Low Beam	0 100 (stalk test only)	51 --	39	lever rocker	65 lever toward 14 lever away 13 depress rocker 11 lever up		
Wiper	80 20	37 0	47	lever rotary switch rocker	31 rotate away 30 lever up 17 depress rocker 14 lever toward	round irregular round slider	26 rotate CW 49 14 slide right 14
Windshield Washer	74 26	33 7	51	end button lever rocker	34 push button in 32 lever toward 12	round irregular round slider	33 push in 51 12 rotate CW 14 12
Hazard	17 83	-- 73	--	pull/push or push/pull switch	pull out push in 82	NOT-IDK toggle irregular round	34 pull out 18 20 move up 18 13 move right 13
Cruise	0 100	46 --	37	end button rocker switch rotary switch	34 push button in 19 depress rocker 12 rotate away		

* NOT-IDK = None Of These, I Don't Know

** Many of the Column Location subtotals do not add up to 100%. It is not clear why.

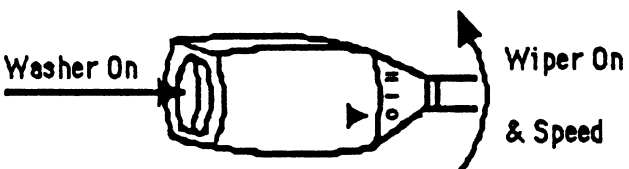
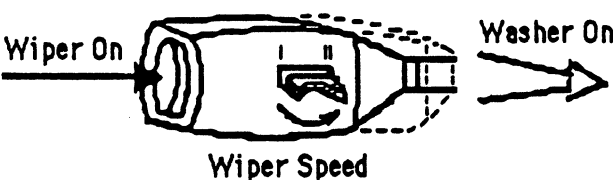
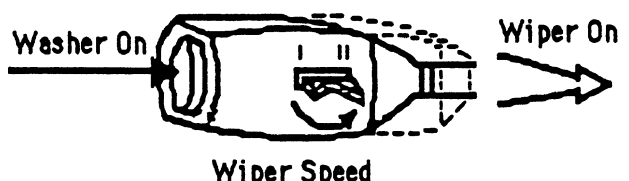
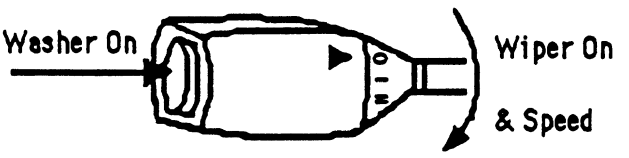
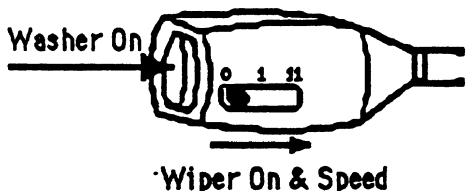
WIPER DESIGN	CONTROL
1.) Rotate Away	
2.) Button	
3.) Hand Switch	
4.) Rotate Toward	
5.) Slide Switch	

Figure 4. Controls Compared by Mourant et al. (1977)

- Introduction -

Table 2. Performance for Using Stalk-Mounted Controls

Experimental Group	Total Time -Wiper (sec)	Total Time -Washer (sec)	Looks/100 Responses -Wiper	Looks/100 Responses -Washer
Rotate Away	0.87	.81	4.5	3.0
Button	1.10	.84	27.5	9.0
Hand Switch	1.10	.99	13.5	12.0
Rotate Toward	0.85	.85	6.0	4.0
Slide Switch	1.19	.86	6.5	1.0

Figure 5 shows the contribution of component times to the total time to use the wiper function. Notice that the time to operate the control is half of the time measured. In this instance, the total time does not include the time to decide to use a control.

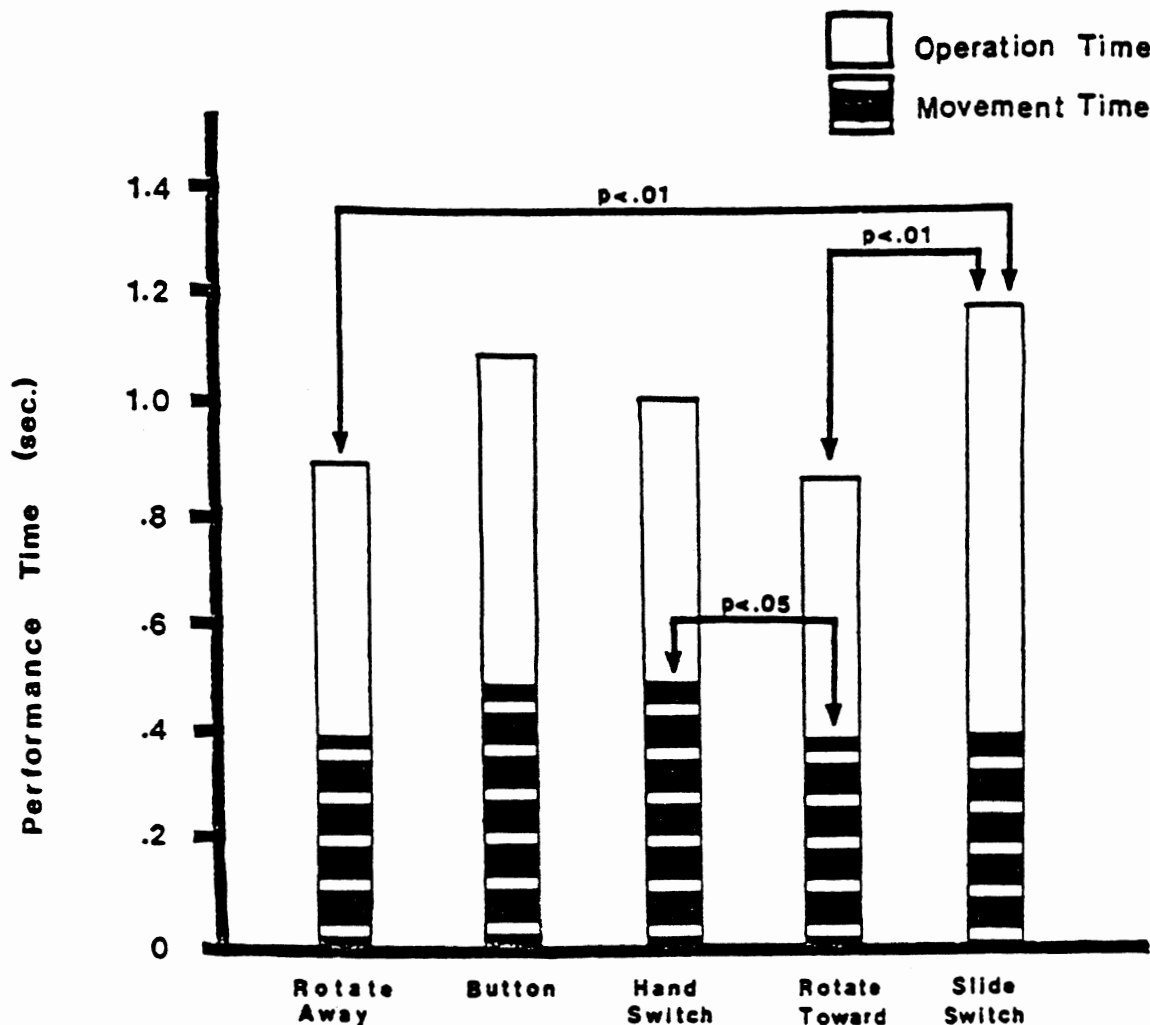


Figure 5. Performance Times for the Wiper

- Introduction -

Elsholtz and Bortfeld (1977)

In this experiment 30 German drivers operated the controls in either an Audi 100LS, a BMW 728, a Citroen CX2000, a Peugeot 640SL, or a Renault 30TS. Table 3 shows the numbers and types of errors drivers made. Preferences were not reported. In this experiment drivers consistently made mistakes in operating stalk-mounted controls. No explanation for this is given.

Jack (1985)

One experiment which fairly directly examined driver expectancies for control operation is a performance study reported in Jack (1985). In particular, this study was concerned with how orientation, labeling, and tactile coding of rocker switches influenced how likely drivers were to push them in various directions to turn functions on and off.

The first experiment involved 20 people who happened to be walking by the Ford Automotive Safety Office. An unlabeled rocker switch with both a bump (bulge) and a dimple (indentation) on its face was mounted in seven locations around the driver's seat of a late model car. Direction-of-motion stereotypes were obtained by asking each participant to operate each switch (e.g., "Turn this switch on"). Performance times were not recorded. Each person responded to 36 such requests in a random order (9 function/location combination x 4 directions). Figure 6 shows the percentage of respondents who selected the "bump" side of the switch for each configuration. (See the figure caption for a further explanation.)

These results confirm the linear direction-of-motion stereotypes reported in the human factors literature; moving a control forward, to the right, or up is associated with turning something on or increasing its value. (Curiously, in the United Kingdom, down is associated with on.) Particularly strong was the association of pushing the upper half of a rocker switch with both on and increase. This suggests that, where practical, rocker switches for raising something or turning it on should be vertically mounted and pushing the top half should turn the function on or increase it. Further, Jack's results show that adding a bump in the favored direction (when there was a stereotype), increased the strength of that stereotype.

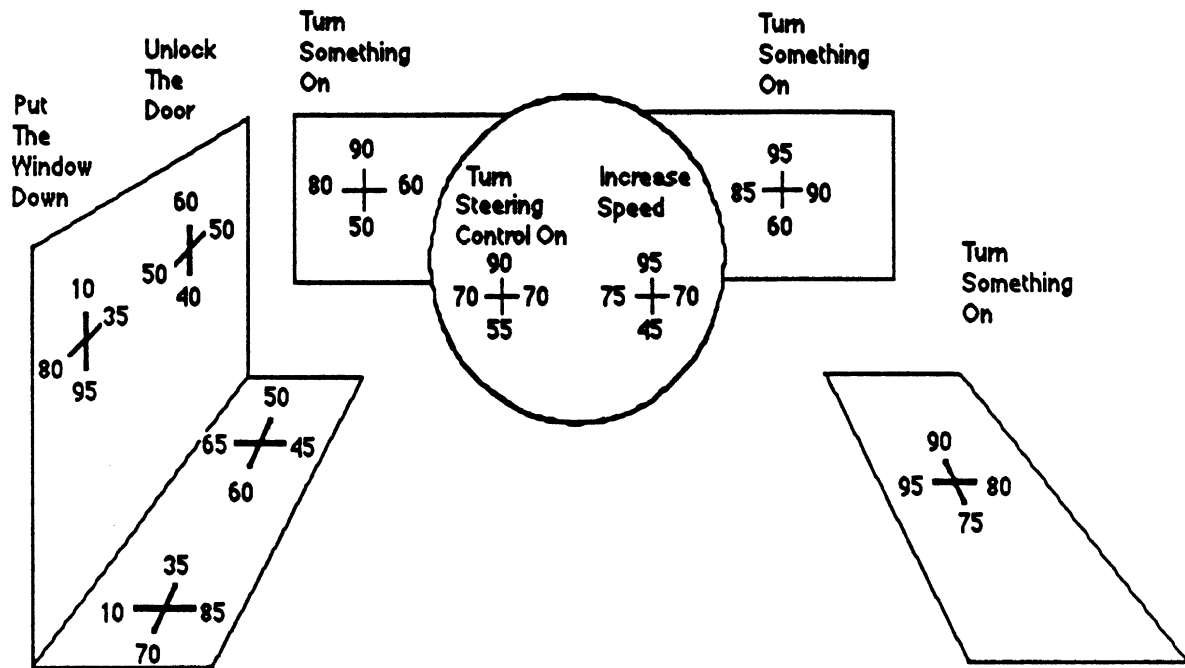
For the specific functions examined, these data show drivers were most likely to expect to lower a power window by pushing the bottom half of a vertically mounted rocker switch. For power door lock, the stereotype was to push the far side of a horizontally mounted switch to lock.

- Introduction -

Table 3. Control Use Errors Reported by Eisholtz & Bortfeld (1978).

<u>Function</u>	<u>Control</u>	<u>Location</u>	<u>To Operate</u>	<u>% Unable to Locate</u>	<u>% Wrong Direction to Operate</u>	<u>% Wrong Direction to Control Intensity</u>
Windshield Wiper	Stalk	Column: Right	Up	10	7	13
		Column: Right	Out	30	80	80
		Panel: Left		70	13	27
		Column: Left	In	63	77	77
		Column: Right	Up	7	10	63
Windshield Washer	Stalk	Column: Right	Right	10	20	23
				27	27	27
				3	13	13
		Column: Left	Up	53	63	63
Horn	Stalk Touch	Column: Right	Right	83	47	47
		Column: Control	Left	0	0	0
				13	0	0
				0	0	0
Turn Signal	Stalk	Panel: Left	In	77	3	3
		Column: Left	Up/Down	23	0	0
				17	0	0
				3	0	0
Parking Light	Stalk	Column: Right	Up/Down	37	0	0
		Panel: Left		27	0	3
		Static: Left	Up	57	10	17
		Static: Right	Right	53	77	77
Headlights On/Off	Stalk	Panel: Right	Out	73	3	10
		Panel: Left	Up	47	7	23
				60	0	10
High Beam	Stalk	Column: Left	Up/Down	43	3	23
			Down	17	80	90
		Panel: Right	Out	73	3	10
		Panel: Left	Up	43	7	17
Front Fog Light	Stalk Rocker			60	0	13
		Column: Left	Left	38	46	68
				10	14	31
				17	83	93
Rear Fog Light	Stalk Rocker	Panel: Right	Down	30	20	70
		Panel: Left		67	0	0
		Panel: Right	Up	70	27	57
		Panel: Left		63	0	50
Hazard Flasher	Stalk Rocker	Column: Left	Up	77	20	37
		Panel: Right		77	0	40
				77	0	30
				57	0	3
Parking Light	Stalk Rocker	Column: Left	Up/Down	27	0	0
		Column: Center		90	0	0

- Introduction -



Number represents percent pushing the Bump side.
(e.g. To put the window down when the switch was placed with the Bump side forward on the left armrest, 35% of the subjects pushed the switch's Bump side.)

Figure 6. Test Locations and Bump/Dimple Results from Jack (1985)

- Introduction -

Three other small experiments (typically involving 100 drivers but only one response each) were also completed. Jack found that adding the words "on" and "off" below a horizontal rocker switch (with a bump on it) increase the on-off direction-of-motion stereotype from 79 to 98%. However, when the distinction was a label on one face and serrations on the other, there was no clear stereotype as to which side was associated with "on." Finally, he found that for switches with one serrated and one flat face, the serrated face was more likely to be associated with on (59 vs 41%). (The right-left stereotype for on-off was about 65-35.)

Thus, the Jack data provide numerous results that are directly applicable to the placement of rocker switches in motor vehicles. However, most of the recommendations (but not the stereotype values), could have been predicted based on human engineering rules of thumb.

Summary

The literature provides considerable insight as to how people expect and prefer controls to operate. In general, people expect to turn functions on or increase their value by moving controls up, forward, clockwise, or to the right. When a display associated with a control is present, the relative location of one to the other and their separation will influence the direction-of-motion stereotype.

In addition, there have been several studies that have addressed stereotypes for specific automotive controls, particularly rocker switches and stalks. The rocker switch data are quite good and, because such expectancies are based on characteristics which change very slowly (e.g., the way wall switches operate), they are likely to be useful well into the future. However, the stereotypes for stalks are highly dependent upon the particular experiences of individual drivers and contemporary design practice.

The literature is weak not only with regard to stalk control stereotypes, but also with regard to the operation of any control or control placement that is specific to road vehicles (e.g., unique surfaces such as the sides of pods). Information on those preferences is contained in the analysis that follows.

DATA SOURCE

No new data were collected as part of the analysis that follows. The methods are described in detail in the initial preference experiment (Green, Kerst, Ottens, Goldstein, and Adams, 1987), commonly referred to as the Mr. Potatohead Experiment (or Potatohead I). As a refresher, usable preferences were obtained from 103 of 109 licensed drivers (ages 18-78) who sat inside a full-sized A to B pillar mockup of a 1985 Chrysler Laser. (The analysis here is based on the data from 102 "good" subjects, one fewer than the previous report.) The mockup interior was covered with Velcro and two drill chucks were mounted on the sides of the steering column to accept stalk controls.

Several Velcro panels of switches surrounded the driver. Mounted on the panels were 255 unique switch designs (stalks, rocker switches, pushbuttons, etc.). For many switches, there were several copies present, so the total number of switches was close to 1000. Switch designs of interest were an outgrowth of the survey of switches in 1986 cars (Green, Ottens, and Adams, 1987). Surface-mounted switches had bases on them to prevent switches from being placed closer together than is good human factors practice.

People were tested individually. In front of them were labels for each of the 24 functions of interest. (See Table 4.) In any order they desired, participants selected the switch they preferred for each function, and placed it where they thought it belonged. In addition, they also indicated how each switch should operate. For the climate controls, ignition, and radio functions, only the location was indicated. This process was initially done for a "horizontal" climate control, the existing Chrysler design, and was later repeated for a vertical climate control (from a Camaro Berlinetta).

Table 4. List of Functions Tested

- | | |
|----------------------------|----------------------------|
| 1. Auditory Horn | 13. Optical Horn |
| 2. Beam Select | 14. Panel Brightness |
| 3. Climate Control | 15. Power Door Lock |
| 4. Cruise Control On/Off | 16. Power Seat |
| 5. Cruise Control Resume | 17. Power Window |
| 6. Cruise Control Set | 18. Radio |
| 7. Dome Light | 19. Rear Defrost |
| 8. Front Washer | 20. Rear Windshield Washer |
| 9. Front Windshield Washer | 21. Rear Window Wiper |
| 10. Hazard Lights | 22. Steering Adjustment |
| 11. Headlights | 23. Suspension Adjust |
| 12. Ignition | 24. Turn Signal |

- Data Source -

After each participant had "designed" the entire instrument panel, the driving simulator was then started. The name of each control was read aloud and each participant pretended to operate each control while driving. Problems with locating or operating any control were recorded and drivers were given the chance to change any control. All selections were recorded on a computer.

RESULTS AND DISCUSSION

In the section that follows, it is assumed that the reader has a copy of the original report (Green, Kerst, Ottens, Goldstein, and Adams, 1987) open to its "Results" section. That will permit a side-by-side comparison of the initial figures with the additional analysis.

Pooling of Zones

For the analyses contained in this report the roughly 80 zones used to identify the location of controls were aggregated into 18 pooled zones. This is because there were too few responses to allow for distinctions using the original zones. This pooling is identical to that in the previous report. Shown in Table 5 are the original and pooled zones. Figure 7 shows the commonly cited pooled zones.

Table 5. Description of Pooled Zones

Zone # Range	Pooled Zone Description
=====	=====
Pod-Related	
1-3	Left Pod (side)
4-6	Left Pod (face)
7-9	Lower Center of Pod (face, below wheel)
10-12	Right Pod (face)
13-15	Right Pod (side)
16-17	Lower Center of Pod (underside)
18-20	Lower Dash Under Pods (face)
21-22	Lower Left Side of Driver's Seat
Column-Related	
24-25	Right Side of Steering Column
26	Left Stalk
27	Right Stalk
Console-Related	
31-36	Upper Section of Console (face)
41-52	Lower Section of Console (face)
53	Floor Console (between seats)
55-58	Driver's Door and Armrest
61-66	Forward Ceiling
71-78	Aft Ceiling (near dome light)
81-89	Steering Wheel

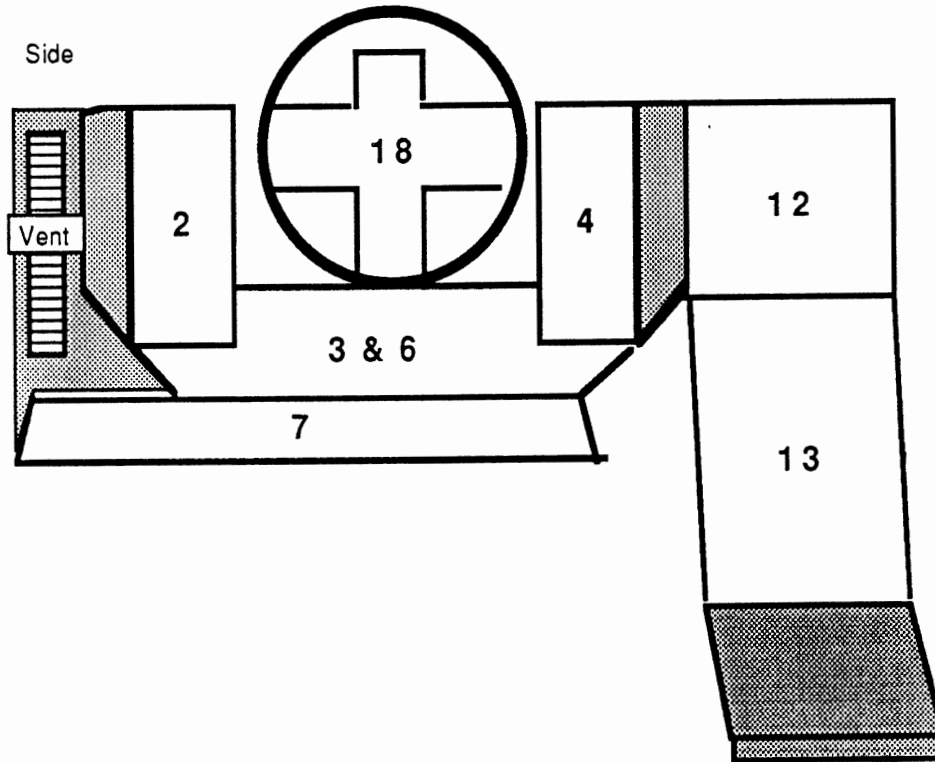


Figure 7. Commonly Cited Pooled Zones

Where Do People Want Controls Located?

Very little statistical analysis was carried out in conjunction with the previous experiment. Subsequently, the following question has arisen repeatedly, "Were there significant differences in driver preferences for the location of each function?"

That question could be answered using a Chi-Squared Test based upon the number of times each zone (or pooled zone) was selected by each driver. Readers may recall that drivers responded to each function twice, once for a horizontal climate control and once for a vertical control. Rarely did the climate control design matter. Hence, it would be inappropriate to use those pooled responses as they are not independent, a requirement of the Chi-Squared Test.

Therefore, the mean of the two responses (one per climate control design) was used instead. Those Chi-Squared Test results are shown in Table 6. Clearly, there were highly significant differences between zones for all of the controls examined.

- Results and Discussion -

Table 6. Chi-Squared Tests of Differences Between Pooled Zones (Original Data)

Function	df	Chi-Squared	probability
Beam Switching	6	184.59	.0001
Cruise On/Off	7	99.73	.0001
Cruise Resume	7	130.31	.0001
Cruise Set	7	132.20	.0001
Headlights On/Off	6	69.57	.0001
Optical Horn	7	164.20	.0001
Panel Brightness	7	116.51	.0001
Windshield Washer	7	73.94	.0001
Windshield Wiper	7	54.71	.0001

Unfortunately, this analysis also violates a major requirement of the Chi-Squared Test, which is to pool when the cell frequencies (the number of people picking each zone) are low. What is called "low" varies, some say 4 or less, others say 5, or even 10. But here, arbitrarily pooling all of the small cells doesn't make sense because they are fundamentally different responses. Therefore, all zones for which there were five responses or fewer were deleted and the Chi-Squared statistics recomputed. (See Table 7.) The only change in reported significance levels was a minor drop in one case. The actual significant levels are between the estimates in Tables 6 and 7. Thus, there were statistically significant differences in driver preferences for control locations.

Table 7. Chi-Squared Tests of Differences Between Pooled Zones (Censored Data)

Function	df	Chi-Square	probability
Beam Switching	4	120.15	.0001
Cruise On/Off	6	86.80	.0001
Cruise Resume	3	46.38	.0001
Cruise Set	3	45.36	.0001
Headlights On/Off	3	14.87	.0019
Optical Horn	4	82.21	.0001
Panel Brightness	3	27.57	.0001
Windshield Washer	6	39.44	.0001
Windshield Wiper	6	37.41	.0001

Designers also want to know if the differences between the top two or three preferred zones for each function are significant. While the underlying frequency distribution of choices of preferred zones is hypergeometric, it is reasonable to treat the categories being compared as binomial and compute the standard error as follows:

- Results and Discussion -

$$\text{Standard Error} = [(N1 * N2) / (N1 + N2)]^{1/2}$$

where:

N1 = number of people preferring one zone

N2 = number of people preferring a second zone

Examination of the data reveals that it is typical for the preferred zone to be desired by about 40% of those responding and the second choice by about 30%. Since approximately 100 people responded, that would make N1=40 and N2=30. In this instance that would lead to a standard error equal to the square root of 17.1, or about 4. (There are several instances in the data where N1 and N2 are less and the standard error is closer to 3.) Typically, differences of two standard deviations or more (here 6-8) are regarded as statistically significant. Hence, any instance with an 8-person difference (or 16 votes in the figures that follow) was regarded as significant ($p < .05$). In this experiment, the differences in preference between the top two most commonly zones for each function were statistically significant, except for the headlights. Those seeking additional information about where in each zone a control was desired should review Green, Kerst, Ottens, Goldstein, and Adams (1987).

In the section that follows, each of the nine functions of interest is described separately. Consistent with the previous report, the explanatory text appears on a left page, the associated figure on the right. To avoid clutter in the figures, data for any pooled zones associated with less than 5% of the responses are not shown.

Each illustration for each function consists of a series of tables linked to a drawing of the pooled zones. The numbers at the top of each table refer to the number of responses (out of 204) and the percentage of them favoring a particular pooled zone.

The tables show how often people in the experiment preferred a particular pooled zone-switch-motion combination for each function. Readers are reminded that each person responded twice, once for a horizontal climate control configuration and once for a vertical. The percentages in each table below refer to the number of people that wanted a particular control type-motion combination for a given zone. Again, differences in zone preferences of about 16 votes (8 people out of 102) are regarded as statistically significant.

Finally, all motions refer to a right-handed coordinate system of the instrument panel with plus x forward, plus y to the right, and plus z up. This is the same system used in the

- Results and Discussion -

previous report and maintains a consistency across the instrument panel. (See Green, Kerst, Ottens, Goldstein, and Adams, 1987, page 15.) These motions do not refer to the plane on which a control is mounted. What makes interpretation of the data tricky is that controls on the left side of the panel are operated with the left hand, not the right hand to which the coordinate system refers.

- Results and Discussion -

Beam Select

The most commonly preferred location for the beam select control was on the left stalk, a location preferred by 60.8% of those sampled. This was almost six times the second choice, on the face of the left pod. Given the two standard deviation rule of thumb (16 votes, 8 people), this difference in preference for location is clearly statistically significant, and practically significant as well.

With regard to control type, all of those selecting that location wanted a stalk control. Of those choosing a stalk in that location, over half (51.6% of the 124 responses) want to pull the stalk towards themselves while about half that number wanted to push it away (towards the instrument panel). This corresponds to 60 votes for out and 30 for in (or 30 drivers wanting out, 15 wanting in). Since this difference is greater than 8 people, the difference was statistically significant.

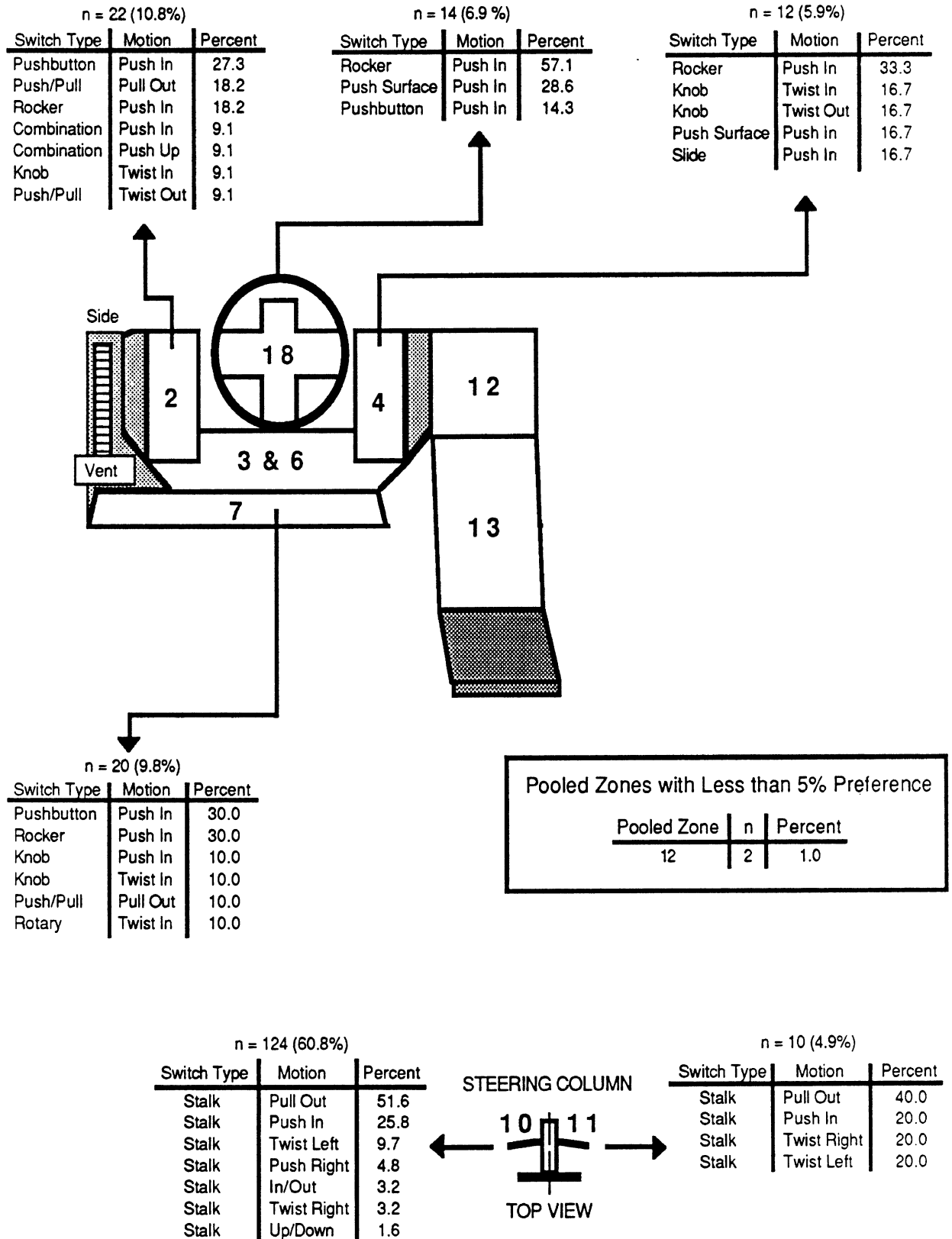
Readers should note that there is one strange response here, the 1.6% (both votes from one person, one of two from another) who wanted to move the stalk up or down for beam select. This motion is normally associated with the turn signal. This is not a coding error but a bizarre response.

Thus, according to these data, drivers preferred the left stalk to be used for beam select and they wanted to pull it towards themselves to operate it. The preferences for location, switch type, and method of operation were all significantly different from alternatives.

- Results and Discussion -

Beam Select

(204 Total Observations)



- Results and Discussion -

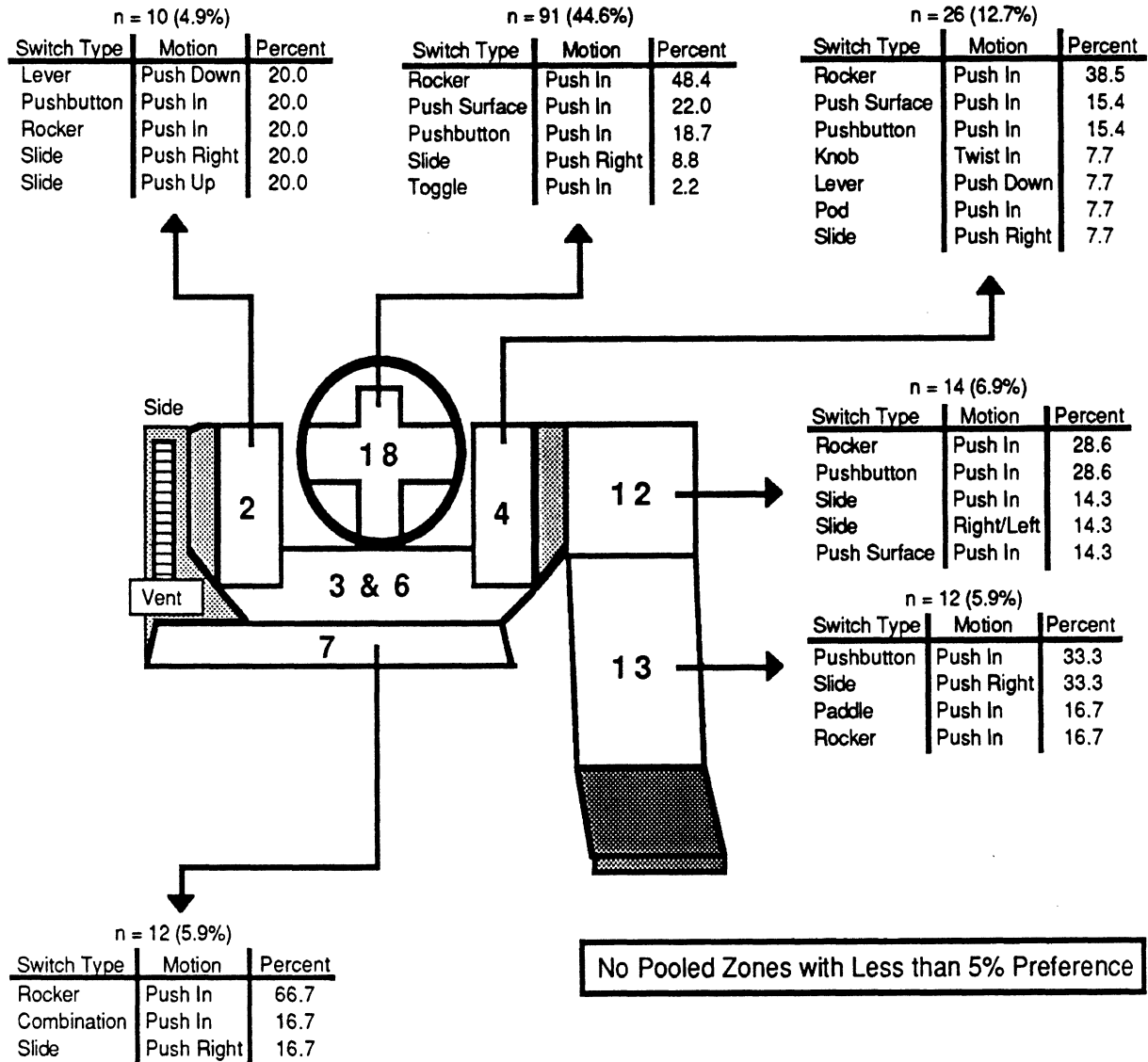
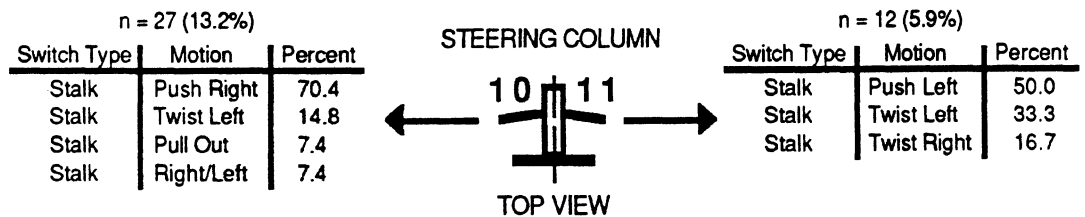
Cruise On

Almost half of those tested (44.6%) wanted the cruise on function located somewhere on the steering wheel hub. The preference for this location over the second choice (left stalk, 13.2%) was clearly significant. The favored design (significantly so) was to push in a rocker switch (48.4%), with almost all of those preferring this location wanting to use a push in motion for a switch for this function (all but 8.8%). For the left stalk location, there was clear preference for a switch type and motion ($.704 \times .132 \times 102 = 9$ people) but this was significantly less than those preferring to push in a rocker switch ($.446 \times .484 \times 102 = 22$ people).

- Results and Discussion -

Cruise On

(204 Total Observations)



- Results and Discussion -

Cruise Resume

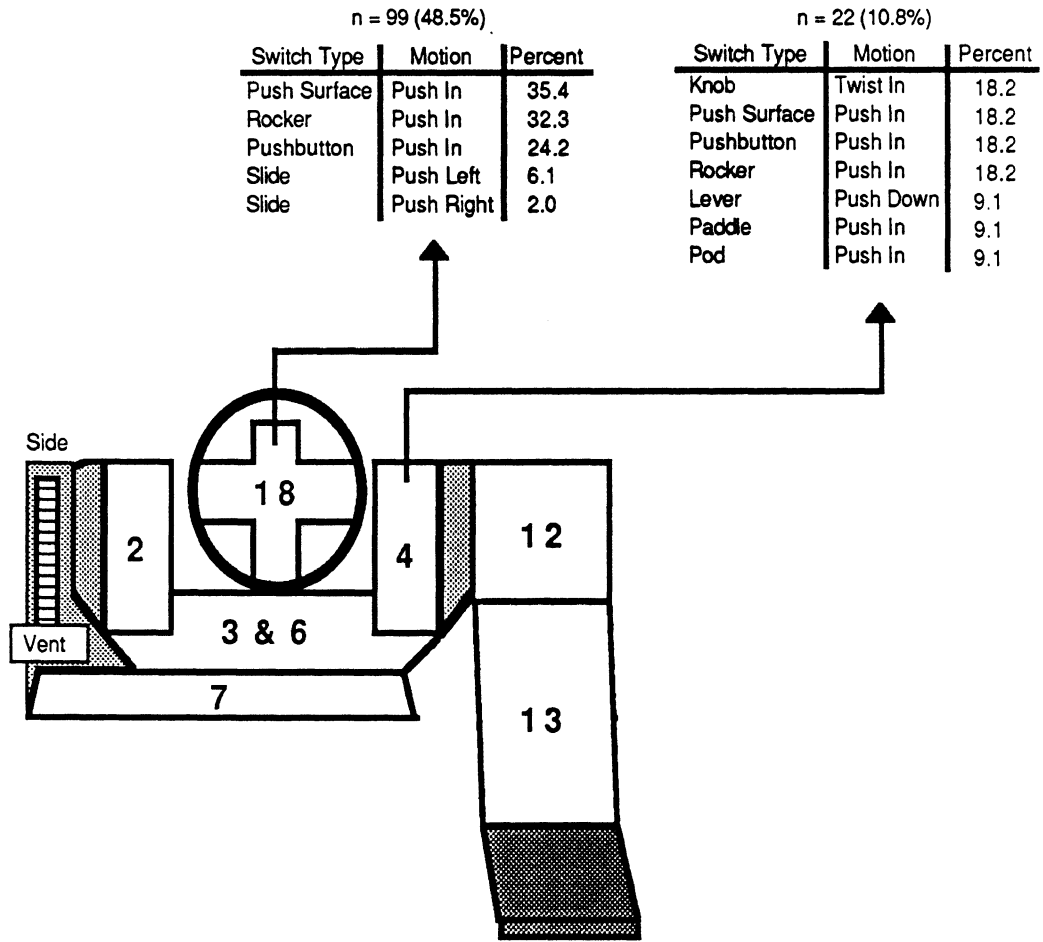
The pattern for the cruise resume function is similar to that for the cruise on, although there was less variety in the commonly chosen locations. Again, almost half (48.5%) preferred to have the switch for this function on the steering wheel hub. This choice was preferred by over 3:1 over the second choice, the left stalk, a location used in some current Chrysler products. This difference was significant (>16 votes). The right stalk, where the cruise control is located in some foreign cars, was preferred by only about 1 out of 10 drivers.

With regard to switch type, the preference was for a push surface, not a rocker switch (35.4 vs 32.3%). This difference (17 vs. 15 plus people) was not statistically significant. (There was also not a significant difference between the first choice, a push surface, and the third choice, a pushbutton.) Good human factors practice dictates that adjacent switches, especially if they are close together and operated without looking at them, should be of different types so they can be distinguished by touch. This principle suggests that a push surface may be most appropriate.

- Results and Discussion -

Cruise Resume

(204 Total Observations)



Pooled Zones with Less than 5% Preference

Pooled Zone	n	Percent
2	8	3.9
7	4	2.0
12	8	3.9
13	8	3.9

n = 31 (15.2%)			n = 24 (11.8%)		
Switch Type	Motion	Percent	Switch Type	Motion	Percent
Stalk	Push Right	48.4	Stalk	Twist Right	33.3
Stalk	Push In	12.9	Stalk	Twist Left	25.0
Stalk	Twist Right	12.9	Stalk	Pull Out	16.7
Stalk	Twist Left	12.9	Stalk	Push Left	16.7
Stalk	Pull Out	6.5	Stalk	Push Up	8.3
Stalk	Push Left	6.5			

STEERING COLUMN



TOP VIEW

- Results and Discussion -

Cruise Set

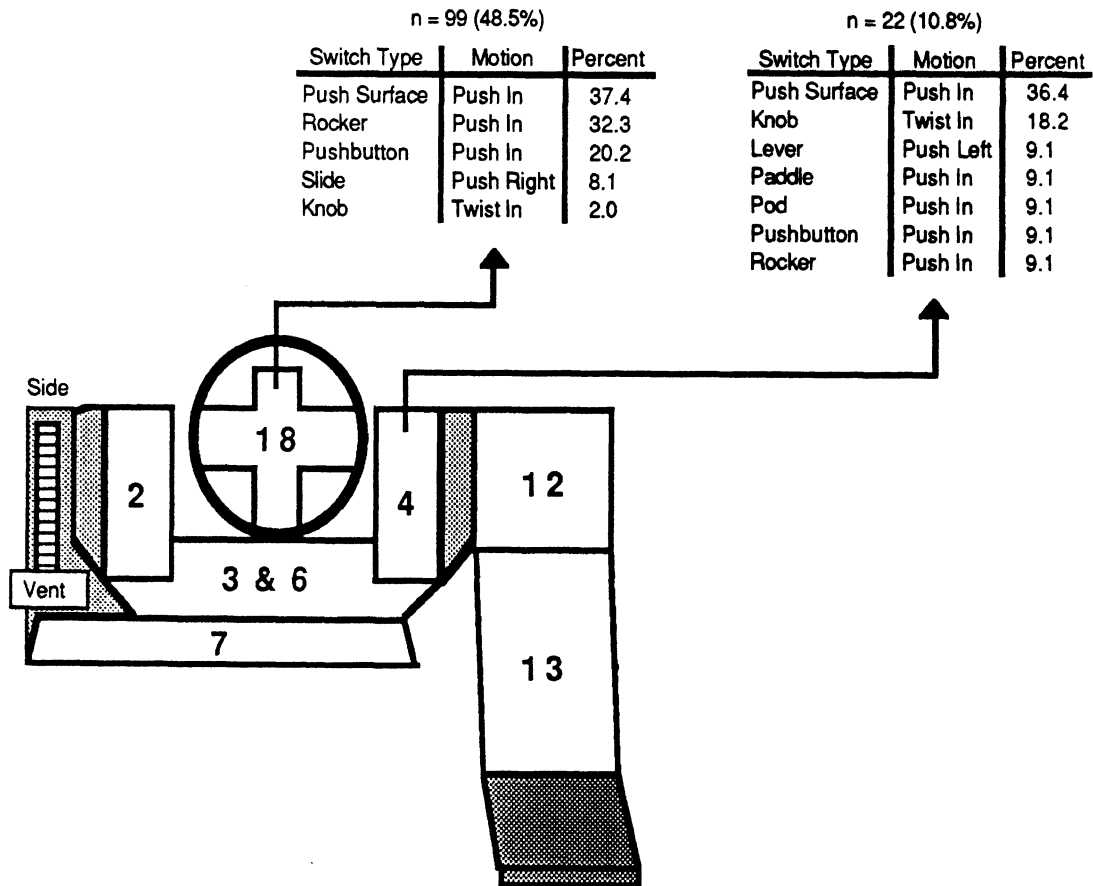
The data for cruise set are almost identical to those for cruise resume with aggregate data suggesting that only one person changed their mind as to where they wanted the function. Thus, the preferred zone was on the steering wheel hub (48.5% of the responses) and that location was preferred 3 to 1 over the left stalk, the second choice.

Drivers preferred a push surface over a rocker switch (37.4 vs. 32.3%). That difference was not significant according to the rule of thumb. Unlike the resume function, there was a significant difference, but barely, between the first and third preferences for switch type (push surface vs. pushbutton).

- Results and Discussion -

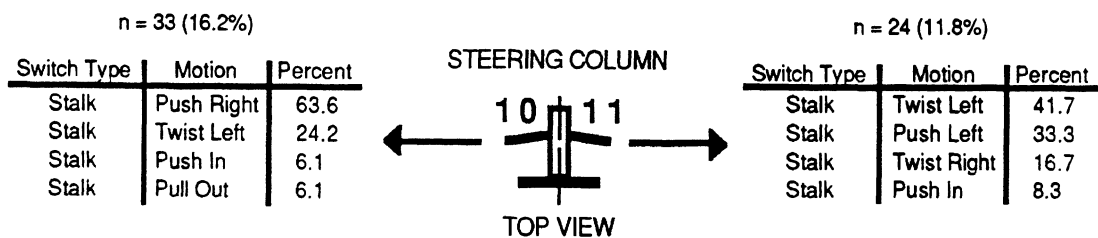
Cruise Set

(204 Total Observations)



Pooled Zones with Less than 5% Preference

Pooled Zone	n	Percent
2	6	2.9
7	4	2.0
12	8	3.9
13	8	3.9



- Results and Discussion -

Front Washer

Drivers preferred the front washer function to be located on the right stalk. The number of drivers preferring this design (33) was greater than those favoring the second choice (17), the left stalk. This difference was statistically significant. There were several other locations that were almost as popular as the second choice, specifically the face of the right pod (16 people), and the face of the left pod (13 people).

For the right stalk location, pushing the stalk to the left was favored by 45.5% wanting that design ($.455 \times 33 = 15$ people) while the leading choice for the right stalk (push right) was favored by 11 people ($17 \times .647$). This difference is not statistically significant. There was also not a significant difference between pushing the right stalk left or pulling it towards the driver.

For the pod locations, a slide switch was favored for the right side and rocker switch for the left.

- Results and Discussion -

Front Washer

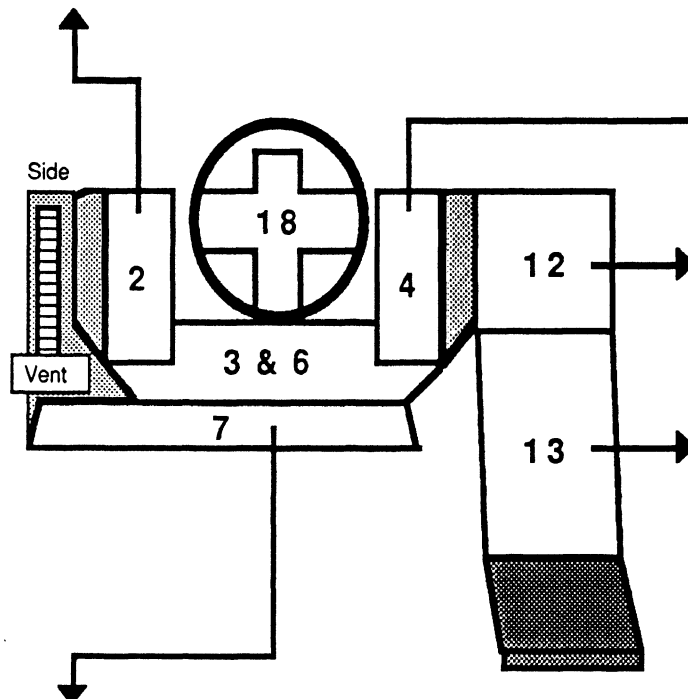
(204 Total Observations)

n = 26 (12.7%)

Switch Type	Motion	Percent
Rocker	Push In	34.6
Combination	Push In	23.1
Knob	Push In	7.7
Push Surface	Push In	7.7
Pushbutton	Push In	7.7
Slide	Push In	7.7
Thumbwheel	Push In	7.7
Paddle	Push Up	3.8

n = 36 (17.6%)

Switch Type	Motion	Percent
Slide	Push In	33.3
Combination	Push In	11.1
Knob	Push In	11.1
Push Surface	Push In	11.1
Pushbutton	Push In	11.1
Push Surface	Push Left	5.6
Rocker	Push In	5.6
Slide	Push Left	5.6
Slide	Push Up	2.8
Slide	Push Down	2.8



n = 12 (5.9%)

Switch Type	Motion	Percent
Pushbutton	Push In	50.0
Knob	Push In	33.3
Knob	In/Out	16.7

n = 12 (5.9%)

Switch Type	Motion	Percent
Pushbutton	Push In	33.3
Combination	Push In	16.7
Knob	Push In	16.7
Push Surface	Push In	16.7
Slide	Push Right	16.7

n = 14 (6.9%)

Switch Type	Motion	Percent
Knob	Twist Out	28.6
Rocker	Push In	28.6
Combination	Push In	14.3
Push Surface	Push In	14.3
Pushbutton	Push In	14.3

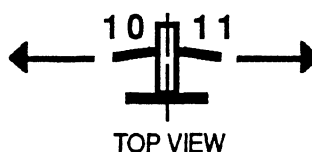
Pooled Zones with Less than 5% Preference

Pooled Zone	n	Percent
3	2	1.0
18	2	1.0

n = 34 (16.7%)

Switch Type	Motion	Percent
Stalk	Push Right	64.7
Stalk	Pull Out	11.8
Stalk	Push In	5.9
Stalk	Push Left	5.9
Stalk	Twist Right	5.9
Stalk	Twist Left	5.9

STEERING COLUMN



n = 66 (32.4%)

Switch Type	Motion	Percent
Stalk	Push Left	45.5
Stalk	Pull Out	36.4
Stalk	Twist Right	6.1
Stalk	Push In	3.0
Stalk	Push Up	3.0
Stalk	In/Out	3.0
Stalk	Multiple	3.0

- Results and Discussion -

Front Wiper

Drivers preferred to have the windshield wiper switch on the right stalk (32.4%). The preference for this location is significantly greater than that of the two second choices, the face of the right pod (17.6%) and the left stalk (16.7%). This does present something of a dilemma for designers as the preferred location is preferred by less than 1/3 of the population. As an indication of the diversity of opinion, one driver wanted the wiper switch on the steering wheel hub.

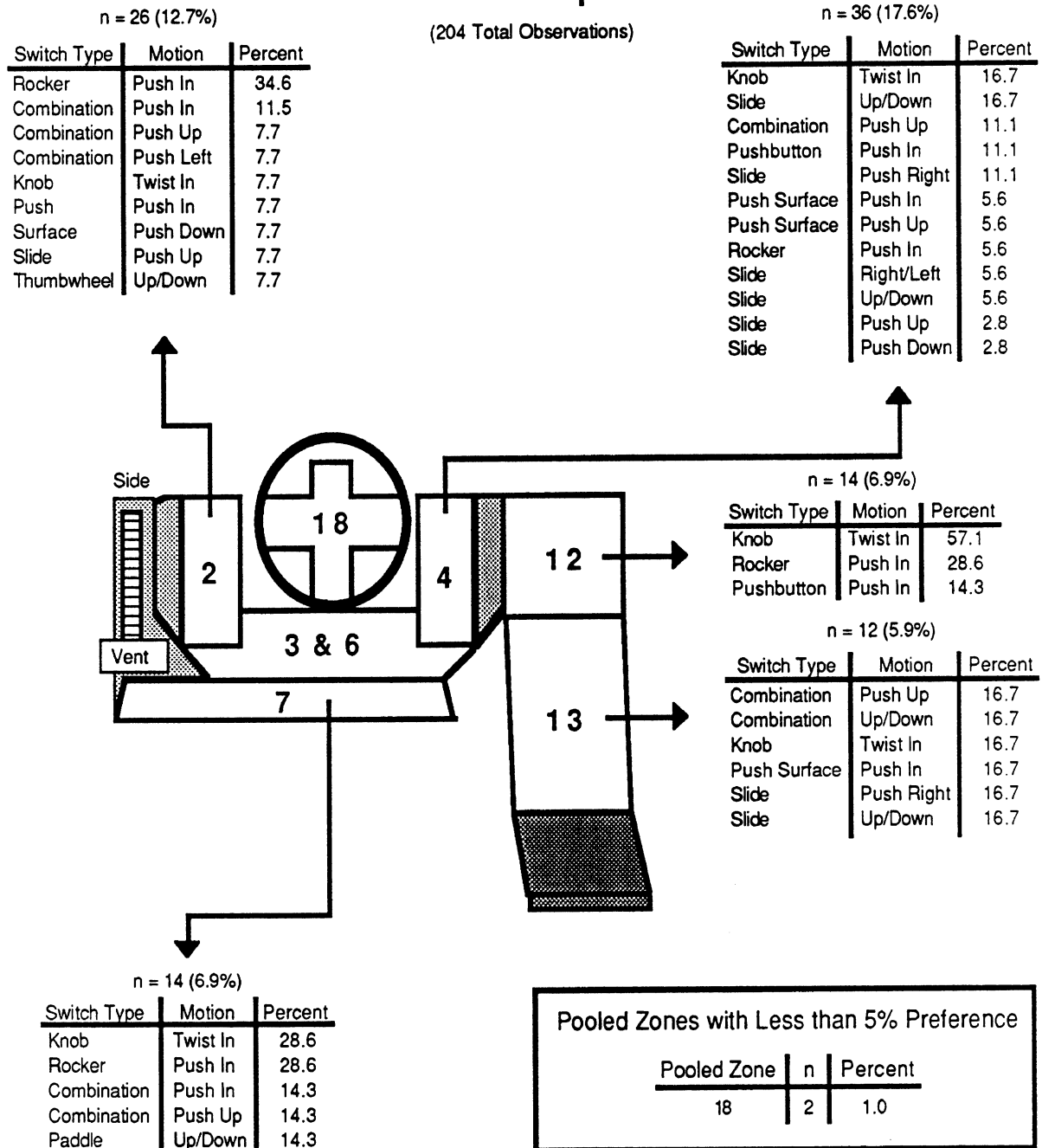
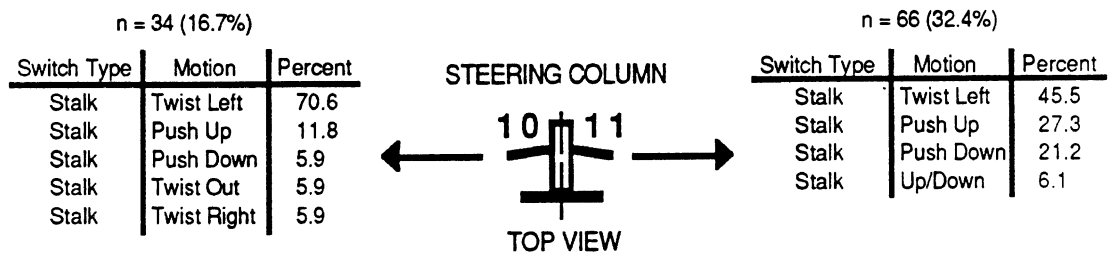
With regard to switch type, 45.5% of those choosing the right stalk said they would want to twist the stalk left (following the right-hand rule, to the driver's door). Another 27.3% argued for push up. This difference is not statistically significant. (As noted early, the rule of thumb is that differences in opinion of 8 drivers are statistically significant. Here the difference corresponds to $.455 \times 33 = 15$ drivers versus $.273 \times 33 = 9$ drivers.) Further, the number preferring push up was not significantly different from push down.

Human factors design practice would argue for using push up since the wiper must sometimes be operated quickly. Using MTM (a system of predetermined times, see Niebel, 1976) one could analyze the motions required to operate a control. It is clear that to twist a stalk requires an additional positioning motion and a grasp, so the twist motion should take longer than push up. This situation is an interesting dilemma for designers in that the design preferred by drivers is not significantly better than the second choice, but the second choice is better in terms of good human factors design practice.

If some of the second choice preferences were to be explored, there was a strong preference (70.6% of those favor a left stalk) for the twist left motion. This number (12 people) is only slightly less than those preferring to twist a right stalk up (14 people) but more than those preferring to push it up (9). As mentioned above, the authors have reservations about using a twist motion for the wiper function. For mounting on the face of the right pod, there was no consensus as which type of switch was preferred or its motion. For example 17.6% wanted to twist in a knob and the same fraction wanted to move a slide switch up and down.

- Results and Discussion -

Front Wiper



Headlights On/Off

For the headlight switch, the preferred location was on the face of the left pod (31.4%), which was not significantly different from the second choice, on the left stalk (28.4%). Only a few cars currently have the on/off switch on the left stalk. (Beam select, however, is often found there.)

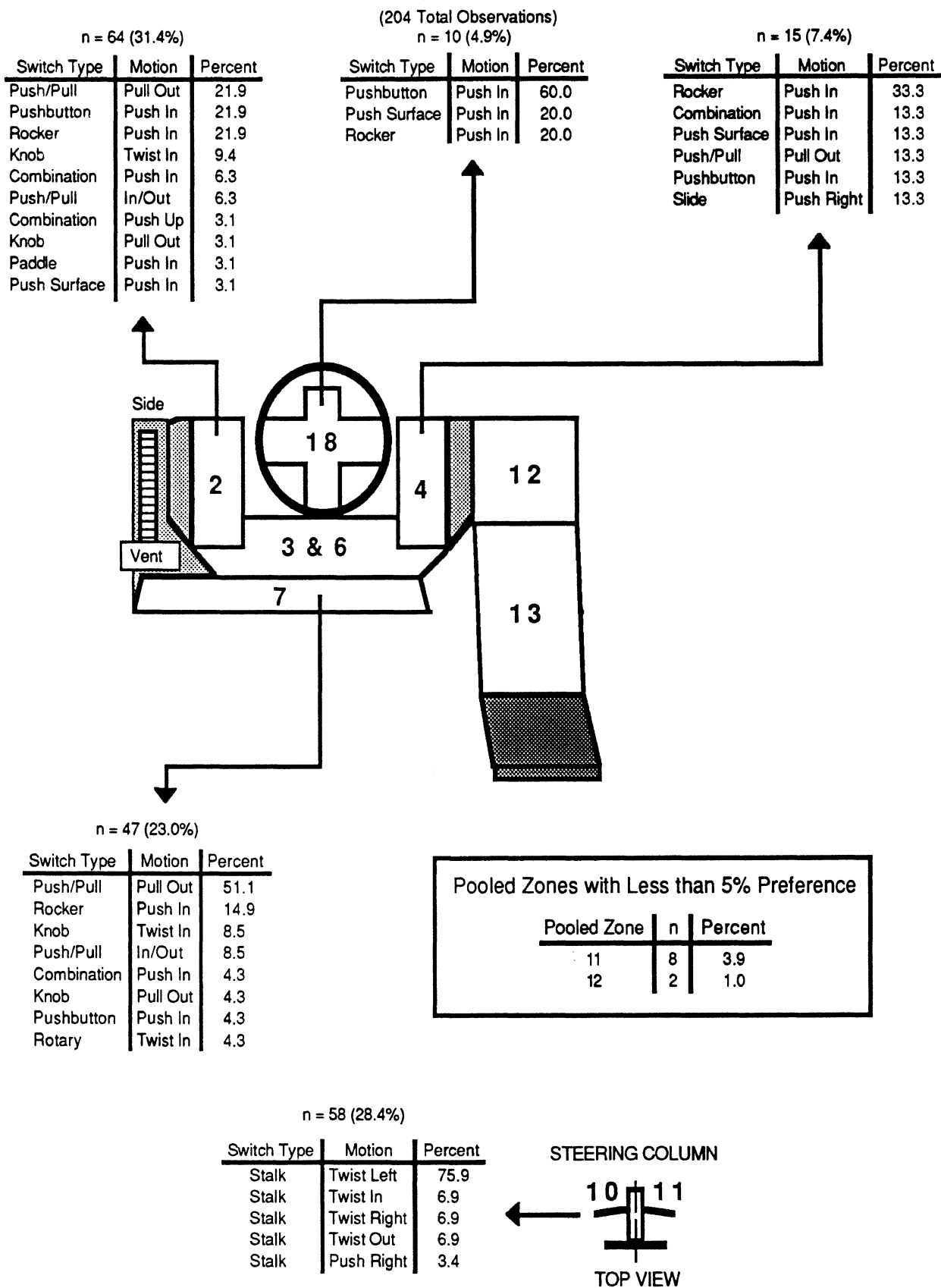
For the left pod, three switch-motion combinations were chosen equally often (21.9% of the 32 drivers, or 7 of the 102 sampled), pull out a pull/push switch, push in a button, or push in a rocker switch. This number is less than favoring twisting a stalk left (75.9% of 29 drivers, or 22 people). Again, this presents a dilemma for designers. Should a control be located where drivers are most likely to prefer it but where there is disagreement as to the switch type and method of operation? Or, should it be located where it is preferred less often, but where there is agreement as to the type of switch and method of operation.

The authors would argue that the twisting motion should not be used because it violates good human factors practice as described previously. The authors would also argue against the pull on design because that design is error-prone. In particular, with pull-on type light switches, drivers often pull the switch part way out, turning only the parking lights and panel lights on, when they mean to turn their headlights on (Green, Allen, Appalucci, and Conroy, 1972). The position of the switch (a change in depth) provides only weak cues as to its position and the panel illumination level is misleading.

Finally, the authors should note there were a few strange responses, in particular a few people that wanted to push in a paddle switch. These responses were doubled checked and were not coding errors.

- Results and Discussion -

Headlights On/Off



- Results and Discussion -

Optical Horn

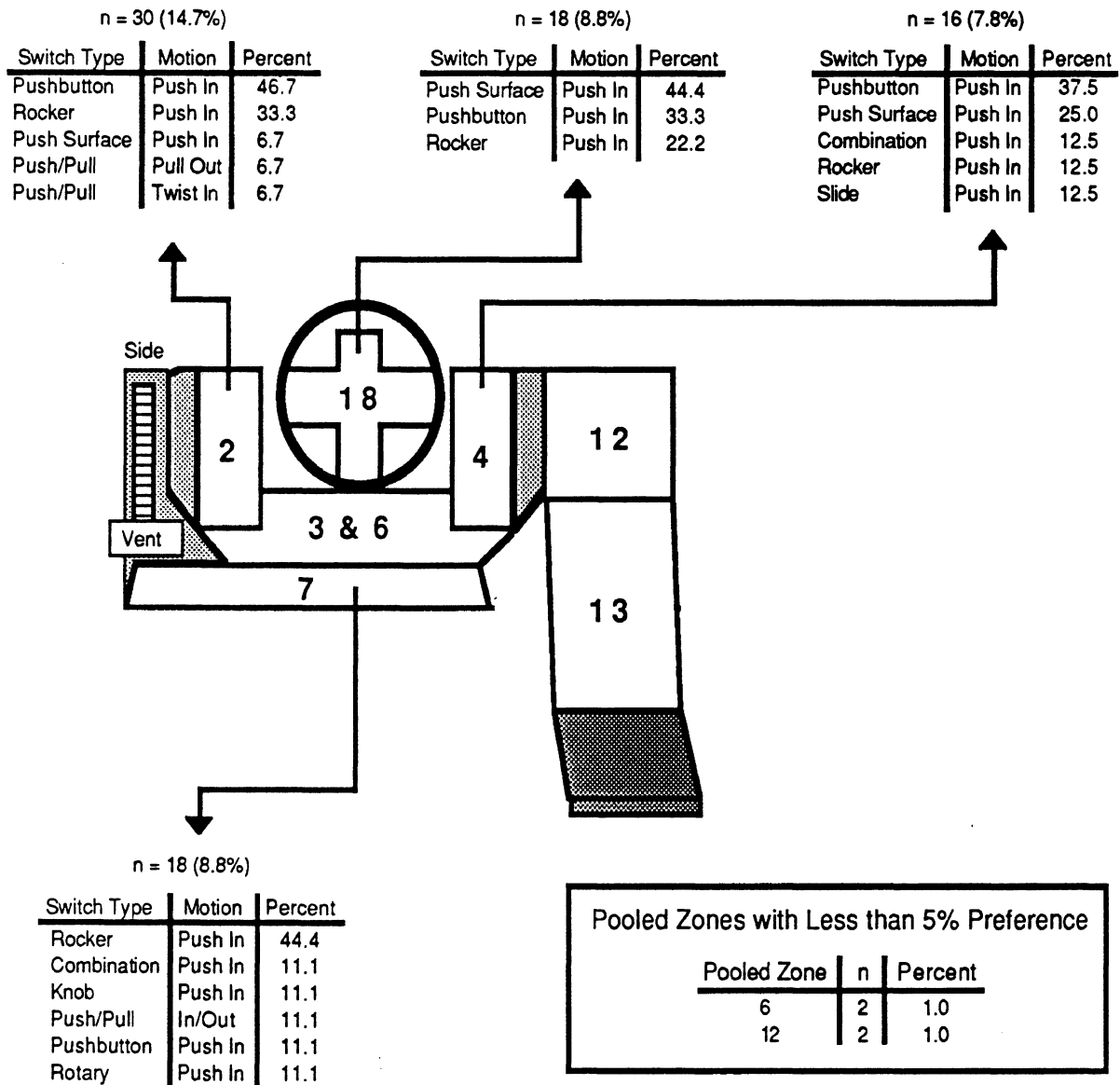
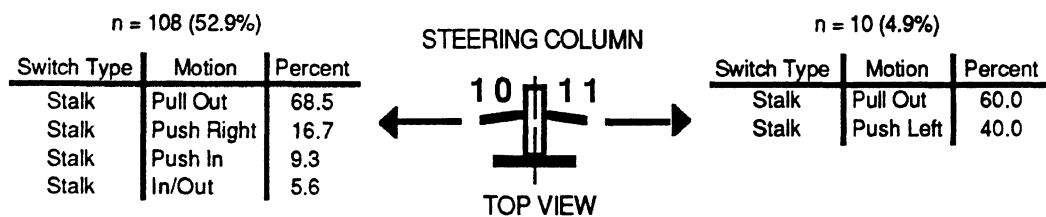
For the optical horn function (beam flashing), just over half of the drivers (52.9%) preferred to have the function on the left stalk. This is a surprisingly low number considering the extent to which that function is found on the left stalk in contemporary cars. The preference for this location is significantly greater than the second choice, a pushbutton on the face of the left pod, favored by only 14.7% of the sample.

For the left stalk location, pulling the stalk out (towards the driver) was preferred by 68.5% of those wanting this location ($.685 \times 54 = 37$ drivers). This number was significantly greater than any of the alternatives.

- Results and Discussion -

Optical Horn

(204 Total Observations)



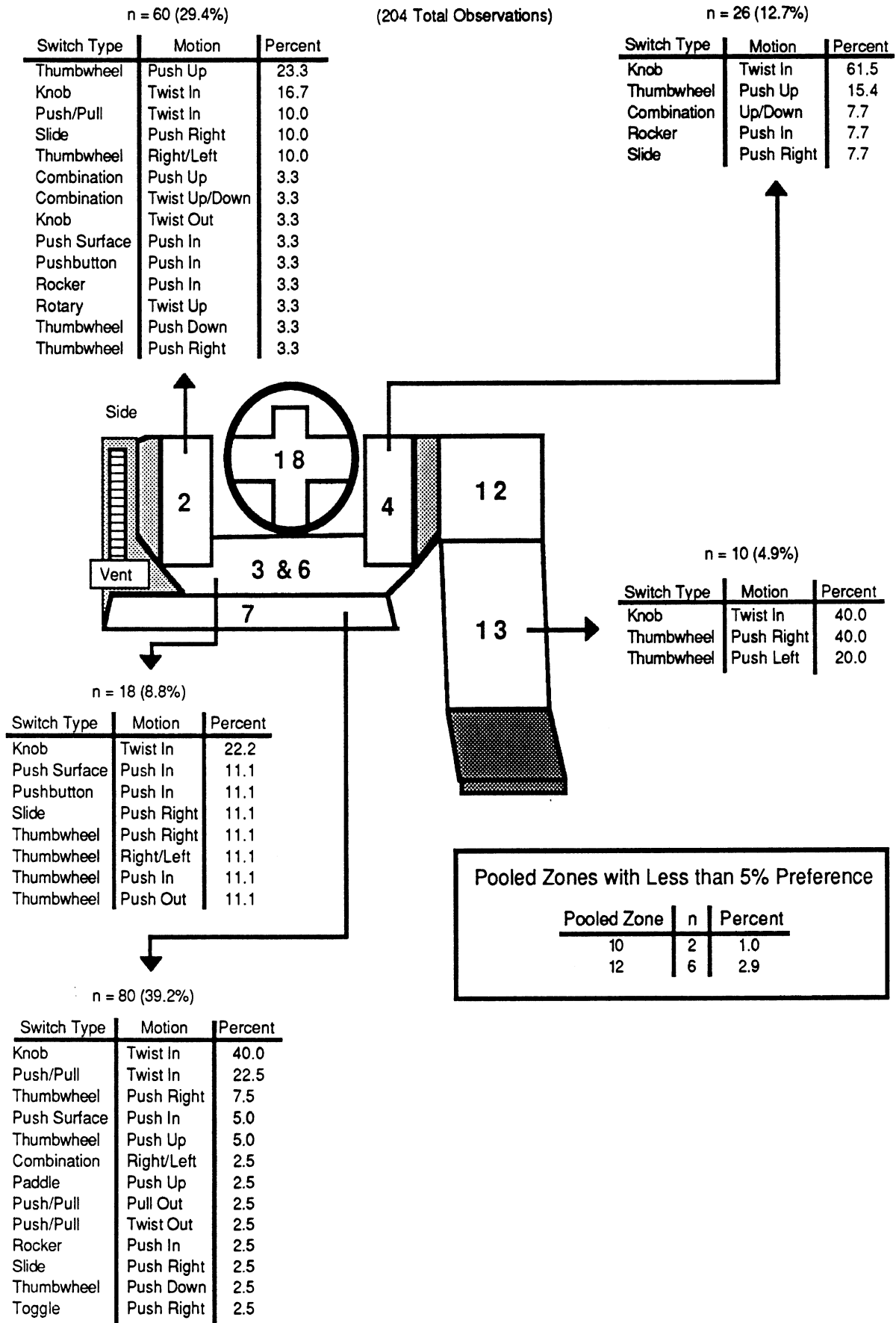
- Results and Discussion -

Panel Brightness

For panel brightness, 39.2% of the participants in the experiment wanted the panel brightness switch on the lowest part of the face of the instrument panel. This was significantly greater than the second choice, the face of the left pod (29.4%)

As for switch type, a plain knob was preferred (by 40.0% of those wanting it on the panel), and a push-pull knob that also rotated was desired by others (22.5%). Thus, almost 2/3 of those selecting that zone wanted a rotary control of some sort (twist in) versus 7.5% that wanted a thumbwheel. Good human factors practice dictates that this control should not be combined with the headlights on/off switch since moving the control to adjust the headlights often changes the panel brightness, a minor but undesired error.

Panel Brightness



- *Results and Discussion* -

CONCLUSIONS

Overall, there was great diversity in where drivers preferred to have various controls, how they wanted them to operate, and what types of switches they wanted. (See Table 8.) While there were significant differences in preferences for zones for every function, for only two of the nine functions did more than half of the participants agree on the preferred location for a control. However, while often a minority opinion (typically held by a third of those responding), there usually was a location that was significantly preferred over alternatives for each function. Furthermore, there were often significant differences in preferences for switch type and method of operation. They are summarized in the table on the next page. Where more than one location or switch/motion combination is given for each function, the differences among those listed are not significant. In those instances they are shown with the preferred zone listed first and, within zones, with the preferred switch first.

Note that for only three out of the nine controls tested (beam switching, cruise on/off, optical horn) is there agreement on a single location, switch type, and method of operation. For the other functions there are no clear-cut single preferences.

Obviously, when there is a clear preference for a control, it should be considered as a design option. But, a strong preference does not necessarily indicate a good solution, but one that people are used to and have come to accept. Unfortunately, this can discourage innovation as people often prefer designs with which they have had experience. A good designer should "lead" the public and not just follow current fashion. On the other hand, a new configuration, even one that performance-based research suggests is better, may not be acceptable simply because it departs from what people are accustomed.

The experience argument may explain why there was no overwhelming preference for pod controls, a very contemporary design. In brief, few drivers had driven cars with pod controls (though they did use them during the test). To counteract that bias in future studies, more extensive operational experience with new designs should be provided than was done here.

What should designers do when there is no clear preference for a particular control design? In all cases, but particularly here, good human factors practice should be considered when designing controls. The designer's goal is to make vehicles safe and easy to operate. (See Turner and Green, 1987 for a lengthy discussion). To give an example, one of those principles is that controls should be labelled. In several instances drivers preferred that stalk controls be used for functions. A weakness of stalk controls is that they provide minimal space for labeling, so labels are often small and difficult to read.

- Conclusions -

Table 8. Summary of Preferences

Function -----	Significant Preferences -----
Beam Switching	where: left stalk sw/motion: stalk/pull out
Cruise On/Off	where: hub sw/motion: rocker/push in
Cruise Resume	where: hub sw/motion: push surface/push in rocker/push in pushbutton/push in
Cruise Set	where: hub sw/motion: push surface/push in rocker/push in
Front Wiper	where: right stalk sw/motion: stalk/twist left stalk/push up - or - where: left stalk sw/motion: stalk/twist left
Front Washer	where: right stalk sw/motion: stalk/push left stalk/pull out - or - where: left stalk sw/motion: stalk/push right
Headlights On/Off	where: face of left pod sw/motion: push-pull sw/pull out pushbutton/push in rocker/push in - or - where: left stalk sw/motion: stalk/twist left
Optical Horn	where: left stalk sw/motion: stalk/pull out
Panel Brightness	where: lowest part of face of IP sw/motion: knob/twist in push-pull sw/twist in

- Conclusions -

Another human factors principle is to minimize the time to use controls. This argues for not using a twisting motion to operate a stalk control. To twist a stalk a driver must look at the stalk to guide their hand to it. This means they are not looking at the road ahead. Operating a stalk with a sweeping hand motion (to push or pull it) is less visually demanding and takes less time, and would therefore be much safer. Maximizing safety is clearly of interest to the automakers. (Chrysler's current advertising talks about the "customer's right to a safe vehicle.")

In summary, this report provides useful insights into how vehicles should be designed to suit the driving public. The report identifies the types of switches drivers preferred, where they wanted them, and how they should operate for several functions. The evidence is based on a reasonable sample that was collected in a carefully controlled experiment. But, customer preferences are only one aspect of the control selection decisions and this report needs to be viewed from that perspective.

Some may have hoped that this experiment would answer all questions about which switches should be used for which functions and where they should be located. It does not. That is not because the test was poorly executed, but rather there is no predominating opinion that drivers have for each function. This report does very clearly lay out the options that designers should consider. The authors expect that figures in this report will give designers the immediate sense of driver preferences just as the figures in the previous report did, and that they will be posted in the Chrysler studios.

- *Conclusions* -

REFERENCES

- Black, T.L., Woodson, W.E., and Selby, P.H. (1977). Development of Recommendations to Improve Controls Operability (report DOT-HS-803-456). Washington, D.C.: U.S. Department of Transportation.
- Bradley, J.V. (1959). Direction-of-Knob-Turn Stereotypes, Journal of Applied Psychology, 43(1), 21-24.
- Brebner, J. and Sandow, B. (1976). Direction-of-Turn Stereotypes-Conflict and Concord, Applied Ergonomics, 7(1), 34-36.
- Elsholz, J. and Bortfeld, M. (1978). Investigation into the Identification and Interpretation of Automotive Indicators and Controls (SAE paper 780340). Warrendale, PA: Society of Automotive Engineers.
- Green, P. Allen, B., Appalucci, L, and Conroy, P. (1972). Design of a New Dashboard for the Ford Pinto-Human Factors Considerations (unpublished technical report), Philadelphia, PA: Drexel University.
- Green, P. Kerst, J., Ottens, D., Goldstein, S., and Adams, S. (1987). Driver Preferences for Secondary Controls (technical report UMTRI-87-47). Ann Arbor, MI: The University of Michigan Transportation Research Institute, October.
- Green, P., Ottens, D., and Adams, S. (1987). Secondary Controls in Domestic 1986 Model Year Cars (technical report UMTRI-87-21). Ann Arbor, MI: The University of Michigan Transportation Research Institute, October.
- Jack, D.D. (1985). Rocker Switch Tactile Coding and Direction of Motion Stereotypes, Proceedings of the Human Factors Society-29th Annual Meeting, 437-441.
- Loveless, N.E. (1962) Direction-of-Motion Stereotypes: A Review, Ergonomics, April, 5(1), 355-383.
- Mourant, R.R., Moussa-Hamouda, E., and Howard, J.M. (1977). Human Factors Requirements for Fingertip Reach Controls (report DOT-HS-803 267). Washington, D.C.: U.S. Department of Transportation.
- Niebel, B.W. (1976). Motion and Time Study (6th ed.). Homewood, IL: Irwin.
- Okada, Y., Tsuda, H., and Kurata, H. (1985). Development of a Non-Rotating Steering Wheel-Switch (SAE paper 852290). Warrendale, PA: Society of Automotive Engineers.

- References -

Simpson, G.C. and Chan, W.L. (1988). The Derivation of Population Stereotypes for Mining Machines and Some Reservations on the General Applicability of Published Stereotypes, Ergonomics, 31(3), 327-335.

Turner, C.H. and Green, P. (1987). Human Factors Research on Automobile Secondary Controls (technical report UMTRI-87-20). Ann Arbor, MI: The University of Michigan Transportation Research Institute, October.