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**WHAT DO DRIVERS SAY
THEY USE SPEEDOMETERS
AND TACHOMETERS FOR?**

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16. Abstract <p>Thirty-two licensed drivers (22 males and 10 females) were given a 72-question computer-controlled survey concerning speedometers and tachometers. All drove vehicles that had tachometers in them (25 had automatic transmissions, 7 had manual transmissions).</p> <p>Drivers reported they commonly used the tachometer to know when to shift, to protect the engine, to check idle speed, and to cross-check vehicle speed (if the speedometer is inaccurate or not working). The relative and absolute frequency with which various reasons were cited depended on how these questions were asked. Further, drivers noted that their usage depended very much on road noise, engine soundproofing, radio volume, trailer towing, and other moderating factors. Several drivers commented that the owner's manual did not provide adequate information on gear selection/shift points or normal engine idle speeds. It is suggested it may be desirable to present this information on clusters of the future.</p>					
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DISCLAIMER

The views in this report are solely those of Paul Green, the author, and not necessarily those of Ford Motor Company.

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INTRODUCTION

Cars are designed to move people and goods from place to place safely and efficiently. In the process of achieving that goal, drivers use the instrument panel displays to check if they have enough fuel to reach their destinations and if they are going at a safe speed. Furthermore, especially in cars with a manual transmission, it is also helpful to know the engine speed, so as to drive efficiently. It is therefore important that the displays associated with this information be both legible and understandable. Well designed displays help drivers make wise decisions about the information presented and minimize eyes-off-the-road time (and the chances of an accident).

While there is good information available on the understandability of fuel gauges (Green and Levine, 1982), the legibility of speedometers (Baines, Spicer, Galer, and Simmonds, 1981), and the legibility of displays in general (McCormick and Sanders, 1982; U.S. Department of Defense, 1981), the understandability of speedometers and tachometers has not been explored.

This report describes the first in a series of experiments concerning speedometers and tachometers. Given special emphasis in this series are what new features can be added to these displays to increase their utility. In this experiment drivers were asked what they used these displays for, when they did so, and why. (While on-the-road eye fixation recordings would have more directly examined these questions, there was neither time nor the funds to collect them.) In a follow-up experiment drivers will be shown several novel displays and be asked to explain what they show. In a third experiment, now in the planning stages, data will be collected on designs refined from the second study.

TEST PLAN

Test Participants

Thirty-two licensed drivers (22 males and 10 females) participated in this experiment. Only those who drove vehicles equipped with tachometers were tested. The participants ranged in age from 16-55 with a mean of 32. Of those tested only four had not gone to college, though a surprisingly large number were employed in occupations requiring little formal education (homemaker, sales, etc.). Except for a handful of University of Michigan employees, participants were recruited via an ad in the Ann Arbor News. Participants were paid \$10.00 to complete the half-hour survey. Five of the persons scheduled could not participate in the survey because they thought their odometer was the tachometer.

Participants drove a variety of vehicles. About half of them were foreign-made. The median age was about 4 years old, somewhat newer than the average car on the road today. Only five of the 32 vehicles had an automatic transmission. All vehicles are listed in appendix A.

Test Equipment and Materials

Data were collected by using two duplicate IBM personal computers (64K, one disk drive), each of which was operated independently by the experimenters. The program to conduct the survey (QTEST4) was written in BASIC by the author of this report. Its operation is described in the test activities section. The files containing the survey questions (TACH-Q) and their sequence (TACH-SEQ) were stored on a floppy disk. The development of this computer program and some associated analytic software was a significant aid to the conduct of the experiment. In previous studies and pilot versions of this experiment, paper and pencil

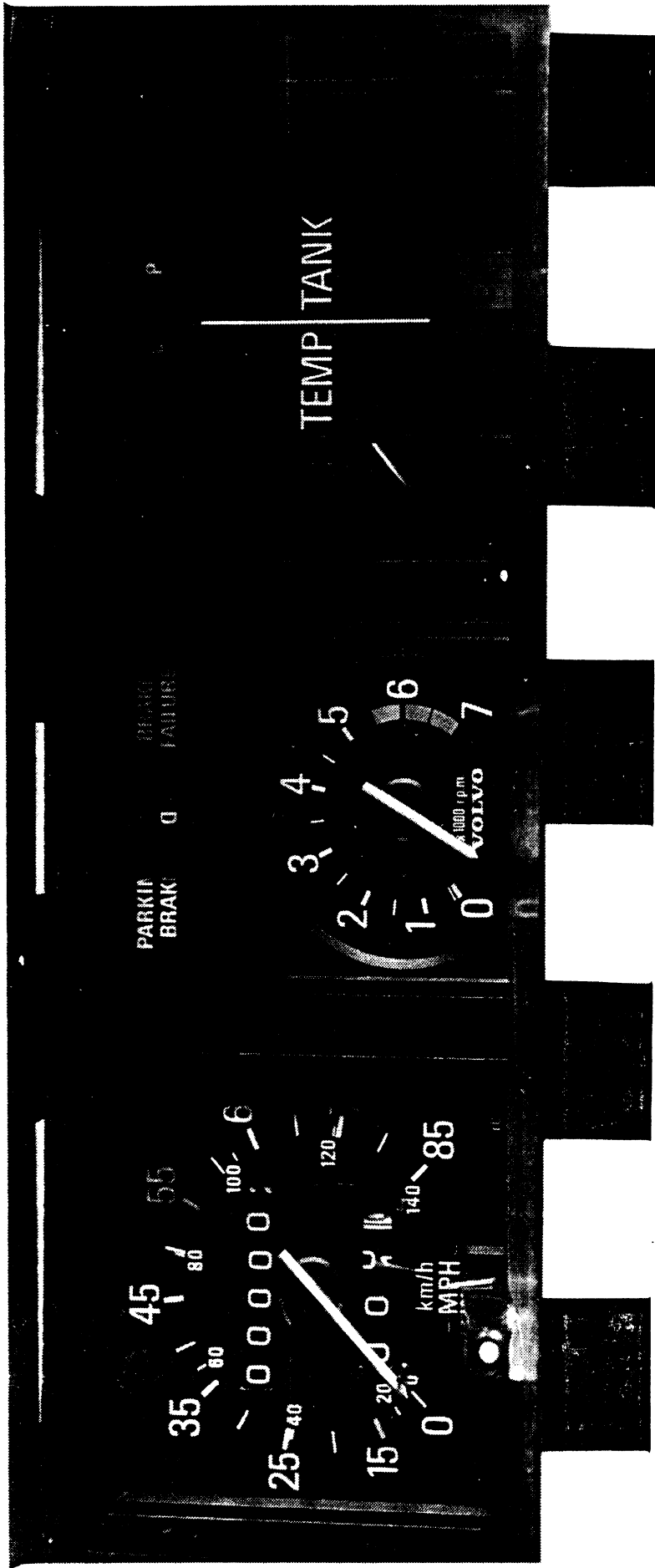
methods were used to collect responses. Not only did it take less time to type in responses than writing them down, but the computer output was easier to read and was more rapidly analyzed.

Towards the end of the test, participants were shown one of two clusters containing tachometers, either a 1979 Volvo or a cluster from a 1982 Saab 900 Turbo. The two clusters are shown in Figures 1 and 2. The tachometers in those clusters are somewhat similar in design. The centrally located Volvo tach goes from 0 - 7000 rpm with red band starting at 6000 rpm and a caution band from 5500 to 6000. The Saab tach is on the left and goes from 0-8000 rpm. The red band is from 6000-8000 rpm with a caution band from 5500 - 6000.

Test Activities and Their Sequence

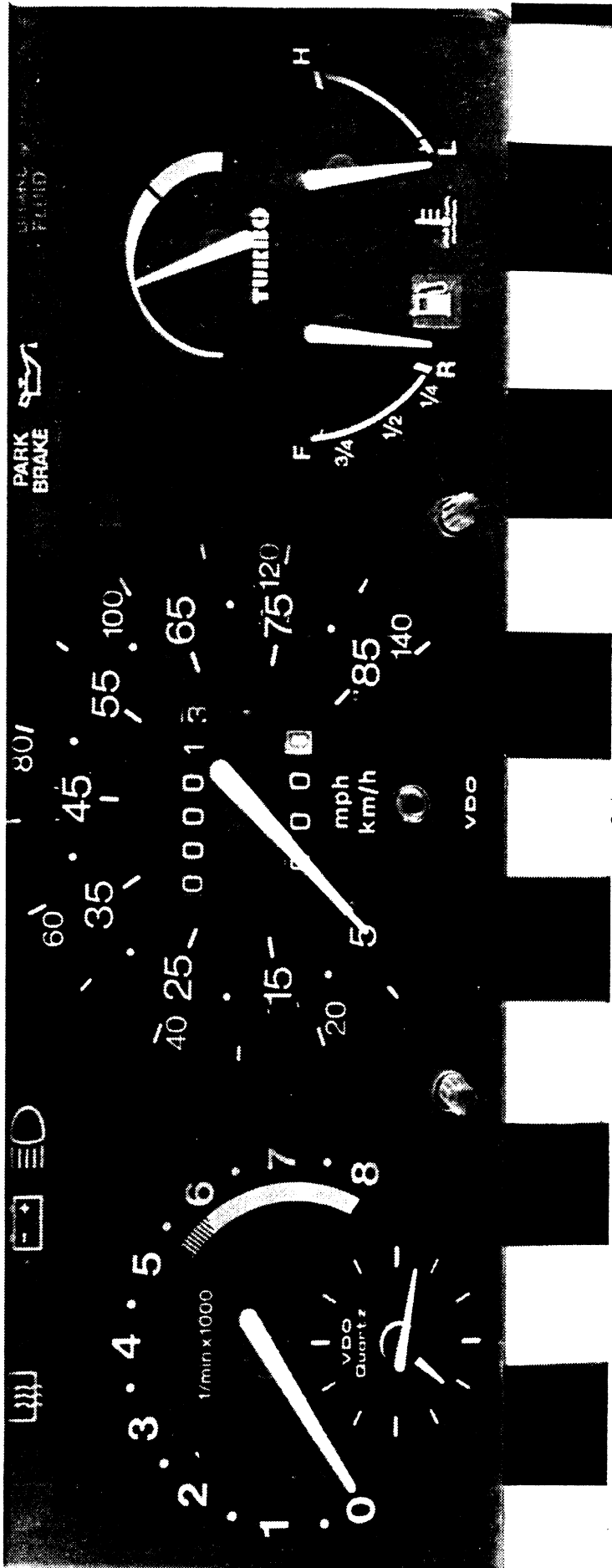
The experimenters tested participants individually. Tests were conducted in the experimenters' offices at the University of Michigan Transportation Research Institute. After the usual formalities of reading the instructions and signing the consent form, the experiment began. As prompted by the computer, the experimenter read the questions presented on the screen to each participant one question at a time. The participants could not see the computer screen. The experimenter entered the responses as the participants said them. At all times the experimenter had the option of terminating a response (and going on to the next question), replacing the previous response, or appending information to it.

The survey consisted of 72 questions, not all of which each participant answered. The survey was organized in several discrete parts. The first section concerned initial biographical data (name, vehicle, etc.), asked how it came to pass their vehicle had a



VOLVO 1979 (1 in. scale)

Figure 1. 1979 Volvo cluster.



SAAB 900 TURBO
1980-82
 (1 in. scale)

Figure 2. 1982 Saab turbo cluster.

tachometer, and if they ever used it. Based on the response to that question (tachometer user, non-user), slightly different sets of questions were then presented. Those questions addressed when they did (or might) use it, why they might (or not) do so, and how often and accurately they read it. There were similar questions concerning the speedometer. In subsequent common sections, participants were asked to define associated terms (for example, torque), answer true/false questions about the meaning of the red line, and a second set of check questions concerning frequency and instances of use. Finally, general comments were elicited and additional biographical data was obtained (occupation, education, age).

The survey questions and a guide to their sequence are contained in appendix B, except for four questions built into the control program (experimenter's name, participants' name and number, and experimenter's closing comments).

RESULTS AND DISCUSSION

Questions concerning the tachometer and summaries of the answers follow. The questions have been regrouped so that similar questions are listed together. Topics covered include how a tachometer came to be installed in the participant's vehicle; where, why, and what people report they use the tach for; the use of engine sounds as a shift cue; how precisely the tach is read; how often it is read; understanding of markings and terminology; responses to marketing questions; and questions concerning the speedometer.

Several questions were targeted to subgroups of the sample (tach users or nonusers) and consequently there were few responses. For others, where participants gave reasons why they did something or when

they did it, the tallies may exceed the number of people tested, because several participants gave multiple responses.

Tachometer Installation

The first few questions concerned the source of the tachometer in their cars. Most drivers said their car came with it. About 80% of those tested said they used it. Of those who did not, half were driving cars with automatic transmissions.

When you bought the car...[question 5]

Responses	# Choosing
a) did it come with a tachometer	26
b) did you order it as an option	3
c) did you add it later	<u>3</u>
Total	32

Who installed it? [question 6]

Responses	# Choosing
I did	2
my brother	1

Do you ever use it? [question 7]

Car Transmission Type	Yes	No
manual	24	3
automatic	<u>1</u>	<u>4</u>
Total	25	7

When and Why is the Tachometer Used?

By and large drivers reported they use the tach to help them select gears (about 1/3 of the responses, depending on the question), with the second most popular reason being to avoid over-revving the engine. They reported their use of the tachometer for shifting was influenced by how much engine masking noise (from traffic or the radio) was present and if they were towing a trailer. Neither the speedometer nor the tachometer in most production vehicles provide any direct information as to when to shift. (In fact, when asked for comments, several subjects complained about that information not being included in the owner's manual.) A few subjects reported they also used the tachometer to cross-check their speed.

When given specific instances as to when they might use a tach, participants adopted some of those as additional to reasons they had initially cited. Particularly noteworthy was that almost all drivers said they would use the tach to check idle speed (when given that as a use) but few had initially volunteered it.

When do you use the tachometer? [question 11]
 What for and why? [question 12]
 (only tach users responded to these questions)

Response	# Times Mentioned
When shifting	
to know when to shift	5
avoid over-revving the engine	5
protect transmission	2
can't hear engine (traffic or radio masks)	2
mileage/fuel economy	1
protect transmission	2
monitor engine	2
avoid lugging	1
not clear why	1
All times	
when going long distance-- fuel economy	1
when towing a trailer	1
to identify problems with car	2
check engine behavior	
unspecified	2
idle	5
lugging	2
protect engine/avoid over-rev	3
check speed (incl. broken speed)	4
when racing/horsing around	2
out of habit, no specific reason	<u>1</u>
Total	44

How does the tachometer assist you in driving? [question 16]
 (tach users only)

Response	# Times Mentioned
helps with shifting/gear selection	10
avoid over-rev/protect engine	4
how engine is performing	2
check speed	2
not very helpful/don't use	7
unclear from response	<u>2</u>
Total	27

In which of the following situations would you use the tachometer?
(All participants)

Question	Yes	No	Don't Know
...to check the engine speed [question 71]	31	0	1
...to check the vehicle speed [question 73]	11	20	1
...to check RPM for upshifting and/or downshifting [question 75]	22	7	3

Not only was there interest in determining why people use tachometers but also why they don't. Drivers report they don't use it because they don't need the information it provides and not because it is poorly designed. Most of those who don't use the tach drive cars with automatic transmissions. Others who drive cars with a manual transmission rely on the engine sound.

Why don't you use the tachometer? [question 31]
(only nonusers responded)

Response	# Offering
don't need it (automatic trans)	2
don't understand it	2
not important	1
response unclear	1
don't know	1
Total	7

...Which of the following are appropriate reasons in your case?
(only nonusers responded)

Response	Yes	No
you can't read the tachometer [question 32]	1	6
the tach is in a bad location [question 33]	1	6
the information on the display is not presented in an understandable way [question 34]	2	5
you don't need the information the tach provides [question 35]	7	0

Do you ever find yourself even glancing or looking at the tachometer?
 [question 36] (only nonusers responded)

Yes (6)	No (1)
When and what for? [question 37]	Why? [question 38]
shifting on highway 1	not necessary (manual transmission) 1
crosscheck speedo 1	
check idle 3	
curiosity 1	

(What do you think a tachometer is supposed to be telling you?
 [question 39] (only nonusers responded)

Response	# Choosing
RPM/revolutions/minute, engine speed (including one response "revolutions per minute your piston is going")	5
When to shift	2

The responses to the following question are interesting to compare with those concerning actual use (when and why). Previously the emphasis was on using the tachometer as an aid to shifting. Here, the emphasis is on checking the engine speed (independent of what one does with the information) and protecting the engine and drive train.

In theory, why are tachometers in cars? [question 51]
 (asked of all participants)

Response	# Times Mentioned
gives RPM	
to check/monitor engine speed	11
to determined how hard engine is working/engine stress/energy output	3
to allow driver to keep at optimum for conditions	5
shows maximum	3
help control engine speed	1
check engine performance	2
help teach when to shift if not accustomed to sound	3
optimize engine and transmission life	
protect engine	2
give information about engine for those who know about them	1
tells how fast pistons move	1
something to do with engine	1
don't know	3
Total	36

Other Cues - Sound

While participants were not asked if they use sound or the tachometer as the most frequent shift cue, these data suggest they are used equally often. Again, several participants noted their use of engine sounds depended upon traffic noise and how loud the radio was playing. In designing vehicles, engineers have tried to eliminate both traffic noise and engine sounds. Since drivers report they use engine

sounds to shift, there may be a point at which sound proofing the engine is not desired.

Do you rely on the engine sound to know when to shift?
[questions 40, 26]

Nonusers	
Yes 2	No 5
Why? [question 41] easy to deal with sound 1 don't know 1	Then what do you rely on? [question 42] speed range 1 not applicable 4 (automatic trans.)
Users	
Yes 23	No 2
Why? [question 27] good relationship/correlation with RPM 4 need to look elsewhere 6 not clear from response 8 catches attention/easy to do 2 automatic transmission 1	Then what do you rely on? [question 28] tachometer 1 not applicable 1 (auto trans.)

How Precisely is the Tach Read?

Also of interest was how closely drivers read their tachometers. Shown below are responses to such a question. Many drivers did not understand what was meant by "precisely" and it was explained to them. Others had difficulty recalling what the value is.

How precisely do you read it (the tachometer) and why?
[question 14]

Response	# Choosing
100 RPM	6
100-200 RPM	1
200 RPM	3
250 RPM	3
500 RPM	6
1000 RPM	1
unable to even guess subject's response is unclear (missing data)	1
Total	<u>4</u> 25

Tallies concerning why people selected those levels were difficult to generate. Most respondents simply did not answer that part of the question. Seven people said they read the display to the nearest graduation mark and two said they interpolated to the nearest half graduation.

When checking, how precisely do you read it (the tachometer)?
 [questions 72, 74, 76]

Reported Precision (RPM)	Check Idle Speed [question 72]	Check Vehicle Speed [question 74]	Shift [question 74]
100	13 ¹	6	7
200	1 ²	3	5
250	4 ²	0	3
500	7 ³	1	7
1000	3	0	0
2000	1	0	0
don't know	2	1	0
Total # drivers	31	11	22

1. This includes one subject who said to the nearest 20 RPM. This was assumed to be a memory error.
2. This includes one subject who said to nearest 1/4 division.
3. This includes four subjects who said to nearest 50 RPM. This was assumed to be a memory error. Many tachs drop a digit or two, thus confusing some drivers as to what the magnitude of the actual value is.

Tachometer Markings

Drivers generally understood that the red zone identified an excessive engine speed that could harm their engines. However, drivers were imperfect in making decisions using that knowledge. For example, one-third of the test sample thought it was not OK for the pointer to go into the red zone for a moment.

Most tachometers have a red zone near the top of the scale.
What does it show? [question 67]

Response	# Choosing
risk/damage to engine	
limit of engine capacity	3
excess pressure/stress/strain on engine	3
could blow up engine	2
damage, wear or failure	7
stay out of zone/don't exceed limit/shouldn't be in	6
engine going too fast/ dangerous RPM level	5
shift gears	1
means trouble	1
engine could overheat	2
not decipherable	<u>2</u>
Total	32

With regards to the tachometer red zone, which of the following are true and which are false?

Question	False	True
<p>It is OK to drive a car for a while with the pointer at the lower edge of the red zone? [question 68]</p>	13	19
<p>It is OK to drive a car for a while with the pointer at the middle of the red zone [question 69]</p>	29	3
<p>Sometimes, say when you miss a shift, the tachometer will go into the red zone for a moment. That's OK. [question 70]</p>	10	22

How Often is the Tach Read?

Drivers reported they used the tachometer "often," relatively more often than the speedometer in city driving (as opposed to other types), and made greater use of it when driving fast. (In pilot studies participants were not able to make direct numeric estimates of frequency of use and hence it was not asked.) When asked how often they would use an "upshift light," almost half of the drivers responded "don't know." Those drivers were generally unfamiliar with the concept.

In normal day-to-day driving, would you use your tachometer more than your speedometer?

Question/Response	Yes	No	Not Applicable
...in interstate highway driving? [question 6]	4	28	0
...in city driving? [question 6]	15	17	0
...in suburban driving? [question 63]	11	21	0
...in rural driving? [question 64]	10	22	0
...in other driving (racing) [question 65]	3	0	29

When driving a car with a manual transmission fast or very fast, do you use the tachometer more often, equally as often, less often, or don't know how often than when driving at a moderate speed?
[question 66]

Response	# Choosing
more often	17
equally as often	8
less often	3
don't know how often	<u>4</u>
Total	32

When upshifting during normal day-to-day driving,
would you use the following items...

Question	Often	Sometimes	rarely	Don't Know
an upshift light? [question 77]	6	3	8	15
the speedometer? [question 78]	14	7	11	0
the "RPM" indicator? [question 79]	13	12	5	2

Tachometer Terminology

Almost all of the drivers knew what RPM stood for and understood what torque was, a concept key to understanding the behavior of a manual transmission.

What does RPM stand for? [question 52]

Response	# Offering
Revolutions	
per mile	1
per minute	
of the engine	12
of the engine crankshaft	7
of the engine camshaft	1
of the engine flywheel	1
of the engine driveshaft	1
of the engine piston range/ how fast pistons move	2
of the engine don't know what	2
of the engine turning over	1
rotations per minute	1
rotations of the engine	1
can't remember, I don't know	<u>2</u>
Total	32

What does the term "torque" mean to you? [question 53]

Response	# Times Mentioned
Simple descriptions	
twist	6
pressure applied	
other	4
power	
amount of pressure to turn the engine/tightness of something	
Engineering definitions	8
amount of force in a circular rotation/movement above an axle/tangentially applied force/force about a point/force on lever about a center/rotating force ($l \times \alpha$)/force applied through a distance/force times length	
Unit-based (foot and pounds, work done in inch/pounds)	2
Consequential descriptions	4
pulling ability of engine/	
power output of car/	
force of motor/	
takeoff power/	
gear ratio	5
nothing/I don't know	5
Total	34

Marketing Questions

About half of the respondents in this sample who drive vehicles with tachometers wanted a tachometer in a car with an automatic transmission.

Would you want a tachometer in a car with an automatic transmission? [question 54]

Yes 17		No 15	
Why? [question 55] <u>Response</u>	# Offering	Why? [question 55] <u>Response</u>	# Offering
to know what trans is doing	1	not necessary	8
check of engine drivetrain/ engine performance	3	unclear response	1
get feel for engine	1		
curious about what engine is doing	1	missing data	6
to check for trouble/ protect engine	2		
check idle speed	4		
know when to shift	1		
don't know	1		
no reason	3		
no answer given/not decipherable/ unclear	3		

Speedometers

Following are the responses to questions about speedometers. For most of them two question numbers appear, because different numbers were assigned to tach users and nonusers.

Drivers report they make frequent use of the speedometer (always, most of the time). They claim that looking at it is strongly driven by external events (when they see a speed limit sign, when they see a police car, when someone passes them, etc.). They claim to read it to the nearest 1 or 2 mph, much more accurately than is needed to see if

one is speeding. About two-thirds of those tested said they used the speedometer in conjunction with the tachometer.

When do you use the speedometer? [questions 17, 43]

What for and why? questions 18, 44]

Do you use it in any other situations? [questions 21,47]

Please explain [question 22]

Please describe them [question 48]

Responses	# Times Mentioned
most of the time/ always/when driving (no specific reason given)	13
when I see speed limit sign	11
when I see a police car	6
when I see a curve sign	1
when driving in town	5
when driving on highway	8
when setting cruise control	1
in school zone	1
when shifting	1
when someone passes me	1
in parking lot	<u>1</u>
Total	49

How precisely do you read it? [question 20, 46]

Response	# Choosing
nearest mph	10
2 mph	12
5 mph	6
10 mph	1
other	
1-doesn't work	
2-nearest 2.5 mph	<u>3</u>
Total	32

When driving, do you use the speedometer in conjunction with your tachometer? [question 23]

Yes 18		No 7	
Why? Under What Situations? [question 24]	# Offering	Why? [question 25]	# Offering
when shifting	8	don' know/can't think of why I should	5
curiosity when checking speed		don't use speedo	1
normal scan/habit/curiosity (when check speed)	3	broken speedo	1
when cross-checking instrument accuracy/when I is broken or erratic	4		
when hauling trailer to avoid over-rev	1		

SUMMARY

1. Drivers who regularly drive cars fitted with tachometers reported they use them more often in urban driving than other situations. They said they use tachometers to know when to shift (the predominant reason), to monitor for excessive engine speed, and to check the engine idle speed. A few drivers reported they could use the tach to cross-check vehicle speed (when the speedometer was broken). Drivers noted that whether they used the tachometer or engine sound as the primary cue would be affected by circumstances (traffic noise, engine soundproofing, towing a trailer, etc.). Drivers also remarked that the owner's manual did not provide enough information about when to shift or what the engine idle speed should be. Placing such information on the cluster could be helpful.

2. Drivers reported they read the tachometer to the nearest minor tick mark or interpolated to the nearest half graduation. In responding to questions of reading error, drivers had difficulty in both understanding the question ("What do you mean by how precisely do I read it?") and in recalling a value.

3. Drivers seemed to know what red line/red zone markings were for, but were less than perfect in understanding the tradeoff between how far into the red zone one can go and for how long one can safely do it.

4. Drivers who use tachometers were familiar with the basic associated terminology (RPM, torque).

5. People who drive cars with tachometers (not all drivers) had mixed views about having a tachometer in a car with an automatic transmission.

6. Drivers said they regularly looked at the speedometer with its use being strongly influenced by external events (speed limit signs, police cars, people passing, etc.). It was reported speedometers are typically read to the nearest 1 or 2 mph.

7. Finally, this effort convinced the experimenters that surveys should always be conducted using computers to collect the data. Computer support reduced the time to construct the survey, permitted last minute changes in question content, reduced the time to test each participant, eliminated the problem of lost data due to illegible responses and reduced the number of incomplete ones, facilitated ongoing review of the data as it was collected, and lastly, reduced the time to analyze the data, because they were already keyed into the computer. Further work, however, needs to be done to develop analytic software. While it took time and money to develop this software, the short-term payoff has been large.

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APPENDIX A - Vehicles Driven by Subjects

Domestic

Chrysler

- '68 Dodge Challenger
- '80 Dodge D50 pick-up
- '83 Plymouth Horizon

Ford

- '74 Ford Mustang (2)
- '75 Ford Mustang (3)
- '79 Mercury Capri
- '80 Ford Mustang
- '80 Ford Fiesta
- '82 Mercury Lynx Wagon
- '82 Ford EXP

GM

- '74 Chevrolet Camaro
- '75 Buick Skyhawk
- '78 Chevrolet Corvette

Foreign

Austin-Healey

- '65 Sprite Mark 3

Datsun

- '76 B210

Fiat

- '69 850
- '80 X1/9
- '81 Strada

Honda

- '81 Civic
- '81 Accord
- '83 Accord 4 door

Mazda

- '74 RX4 (rotary)
- '78 GLC Sport
- '79 RX7

Toyota

- '80 Corolla

Volvo

- '82 DL 4 door

VW

- '78 Scirocco
- '79 Scirocco

APPENDIX B - Survey Questions and Their Sequence

UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE

TACHOMETER & SPEEDOMETER QUESTIONNAIRE

Written by Paul Green and David Miller, UMTRI-Human Factors
Version of 8/11/83

I am going to be asking you some questions about tachometers and speedometers and their usefulness to you. Your candor in responding will be appreciated.

[Note: The computer automatically asks for experimenter and subject name, and subject number here.]

1. Enter sex of subject. (Don't ask.) Enter m or f.
2. Introductory questions -
OF THE CARS YOU DRIVE, WHICH ONE HAS A TACHOMETER? (If they identify, multiple cars, then say - LETS JUST TALK ABOUT THE ONE YOU DRIVE MOST OFTEN. Enter make, model, year.
3. DOES YOUR CAR HAVE A MANUAL OR AUTOMATIC TRANSMISSION? Enter m (manual), a (automatic), or d (don't know).
5. WHEN YOU BOUGHT THE CAR...
a) DID IT COME WITH A TACHOMETER? OR
b) DID YOU ORDER IT AS AN OPTION? OR
c) DID YOU ADD IT LATER?
Enter a, b, or c.
6. WHO INSTALLED IT?
7. DO YOU EVER USE IT? Enter yes or no.
11. WHEN DO YOU USE YOUR TACHOMETER?
12. WHAT FOR AND WHY?
14. HOW PRECISELY DO YOU READ IT AND WHY? Try to get them to give you a number.
16. HOW DOES THE TACHOMETER ASSIST YOU IN DRIVING?
17. WHEN DO YOU USE YOUR SPEEDOMETER?
18. WHAT FOR AND WHY?
20. HOW PRECISELY DO YOU READ IT -
a) NEAREST MPH, b) 2 MPH, c) 5 MPH, d) 10 MPH, e) OTHER

Enter a, b, c, d, or e.

21. DO YOU USE IT IN ANY OTHER SITUATIONS? Enter y or n.
22. PLEASE EXPLAIN.
23. WHEN DRIVING, DO YOU USE YOUR SPEEDOMETER IN CONJUNCTION WITH YOUR TACHOMETER? Enter y or n.
24. Why? UNDER WHAT SITUATIONS?
25. WHY?
26. DO YOU RELY ON THE ENGINE SOUND TO KNOW WHEN TO SHIFT? Enter y or n.
27. WHY?
28. THEN WHAT DO YOU RELY ON?
31. OK, THAT'S FINE. MORE SPECIFICALLY, WHICH OF THE FOLLOWING ARE APPROPRIATE REASONS IN YOUR CASE?
 - a) YOU CAN'T READ THE TACHOMETER? Enter y or n.
 33. b) THE TACH IS IN A BAD LOCATION. Enter y or n.
 34. c) THE INFORMATION ON THE DISPLAY IS NOT PRESENTED IN AN UNDERSTANDABLE WAY. Enter y or n.
 35. d) YOU DON'T NEED THE INFORMATION THE TACH PROVIDES. Enter y or n.
36. DO YOU EVER FIND YOURSELF EVEN GLANCING OR LOOKING AT THE TACHOMETER? Enter y or n.
37. WHEN AND WHAT FOR?
38. WHY?
39. WHAT DO YOU THINK A TACHOMETER IS SUPPOSED TO BE TELLING YOU?
40. DO YOU RELY ON THE ENGINE SOUND TO KNOW WHEN TO SHIFT?
41. WHY?
42. THEN WHAT DO YOU RELY ON?
43. WHEN DO YOU USE THE SPEEDOMETER?
44. WHAT FOR AND WHY?
46. HOW PRECISELY DO YOU READ IT?
 - a) NEAREST MPH, b) 2 MPH, c) 5 MPH, d) 10 MPH, e) OTHEREnter a, b, c, d, or e.

47. DO YOU USE IT IN ANY OTHER SITUATIONS? Enter y or n.
48. PLEASE DESCRIBE THEM.
51. --common short answer and true/false questions--
IN THEORY, WHY ARE TACHOMETERS USED IN CARS?
52. WHAT DOES THE TERM "RPM" STAND FOR? Probe to see if they know it's revolutions of the engine, not the wheels... e.g., REVOLUTIONS OF WHAT?
53. WHAT DOES THE TERM "TORQUE" MEAN TO YOU?
54. WOULD YOU WANT A TACHOMETER IN A CAR WITH AN AUTOMATIC TRANSMISSION? Enter y or n.
55. WHY?
61. IN NORMAL DAY TO DAY DRIVING, WOULD YOU USE YOUR TACHOMETER MORE THAN YOUR SPEEDOMETER...
...IN INTERSTATE HIGHWAY DRIVING? Enter y or n.
62. ...IN CITY DRIVING? Enter y or n.
63. ...IN SUBURBAN DRIVING? Enter y or n.
64. ...IN RURAL DRIVING? Enter y or no.
65. ...IN OTHER DRIVING (FOR EXAMPLE RACING)? Enter y or n.
(If they identify other situations, enter them.)
66. WHEN DRIVING A CAR WITH A MANUAL TRANSMISSION FAST OR VERY FAST, DO YOU USE THE TACHOMETER a) MORE OFTEN, b) EQUALLY AS OFTEN, c) LESS OFTEN OR d) DON'T KNOW HOW OFTEN THAN WHEN DRIVING AT A MODERATE SPEED? Enter m, e, l, or d.
67. MOST TACHOMETERS HAVE A RED ZONE NEAR THE TOP OF THE SCALE. WHAT DOES IT SHOW? (Show cluster with tach.)
68. WITH REGARDS TO THE TACHOMETER RED ZONE, WHICH OF THE FOLLOWING ARE TRUE AND WHICH ARE FALSE?
A) IT IS OK TO DRIVE A CAR FOR A WHILE WITH THE POINTER AT THE LOWER EDGE OF THE RED ZONE. TRUE OR FALSE? Enter t or f.
69. B) IT IS OK TO DRIVE A CAR FOR A WHILE WITH THE POINTER IN THE MIDDLE OF THE RED ZONE. TRUE OR FALSE? Enter t or f.
70. C) SOMETIMES, SAY WHEN YOU MISS A SHIFT, THE TACHOMETER WILL GO INTO THE RED ZONE FOR A MOMENT. THAT'S OK. TRUE OR FALSE? Enter t or f.
71. IN WHICH OF THE FOLLOWING SITUATIONS WOULD YOU USE THE TACHOMETER. ANSWER YES, NO, OR DON'T KNOW.
..TO CHECK THE IDLING SPEED. Enter y, n, or d

72. WHEN CHECKING, HOW PRECISELY DO YOU READ IT?
73. ...TO CHECK THE VEHICLE SPEED? Enter y, n, or d.
74. ...WHEN CHECKING, HOW PRECISELY DO YOU READ IT?
75. ...TO CHECK "RPM" FOR UPSHIFTING AND/OR DOWNSHIFTING?
76. WHEN CHECKING, HOW PRECISELY DO YOU READ IT?
77. WHEN UPSHIFTING DURING NORMAL DAY TO DAY DRIVING, WOULD YOU USE THE FOLLOWING ITEM: OFTEN, SOMETIMES, RARELY, OR DON'T KNOW.
..AN UPSHIFT LIGHT? Enter o, s, r, or d.
78. ...THE SPEEDOMETER? Enter o, s, r, or d.
79. ...THE "RPM" INDICATOR? Enter o, s, r, or d.
81. --general comments--
DO YOU HAVE ANY GENERAL COMMENTS ABOUT TACHOMETERS?
82. DO YOU HAVE ANY GENERAL COMMENTS ABOUT SPEEDOMETERS?
83. --biographical information--
WHAT DO YOU DO FOR A LIVING? (If student, ask for major. If unemployed, ask for occupation.)
84. HOW MUCH FORMAL EDUCATION HAVE YOU HAD?
85. HOW OLD ARE YOU? (If subject is reluctant to give exact age, then ask - ARE YOU LESS THAN 20, 20-29, 30-39, 40-49, ETC.?)

[At this point the computer asks the experimenter to comment on the subject's behavior.]

