Auto Braking Reaction Times to Visual vs. Auditory Warning Signals[1]

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The Problem

Do automobile drivers react significantly faster to sight or to sound warning signals? Are they able to shift the foot from accelerator to brake and set the brake more quickly at the sight of a red light or at the sound of an automobile horn? How do women compare with men in speed of reaction? How do the various occupational groups, professional people, farmers, laborers, and others compare in speed of braking reaction time? What correlations exist between speed and age, speed and experience? These are questions which the present experiment seeks to answer.

Moss and Allen in 1925 reported on the personal equation in driving. Forbes, Moede, Sandor, Lauer, and DeSilva have studied various aspects of auto drivers' reactions, but the available literature does not seem to offer direct evidence on modes of stimulation, on sex, and on occupational differences.

These questions take on special importance at this time when highway safety is recognized as a problem of first interest to the nation. No one escapes the danger. The problem is of interest also in view of current campaigns against noise, which in some cities have resulted in ordinances designed to reduce the use of automobile horns and other sound signals. Finally, the present experiment is one of a series by Elliott which seeks to reveal the relative effectiveness of visual vs. auditory stimulation on such human reactions as attention to advertising, memory for advertising trade names, and comparative inquiry and enrollment responses to printed literature and the spoken word.

Procedure

The present investigation was carried on at the Indiana State Fair in September, 1936, with Dr. Louttit as the chief experimenter. He was assisted by Lt. Don L. Kooken, of the Indiana State Police; Officer Freed, of the State Police; and Dr. Elliott. Zenon Szatrowski handled the statistical compilations.

A Ford coupe was parked at a conspicuous location in the Indiana University Exhibit Building, where several thousand visitors passed daily. Mimeographed blanks describing the experiment and asking for the age, sex, driving experience, occupation, and home community of each subject were made available to persons who asked to take the test. After filling out these blanks and hearing the explanation of procedure, each subject took the driver's seat in the car, held the accelerator half way to the floor with his right foot, and at the appro-

[1] This experiment was reported by Frank R. Elliott Nov. 5, 1937, before the Indiana Academy of Science and by C. M. Louttit June 19, 1937, before the Western Psychological Association.

priate signal shifted his foot to the brake pedal and pushed it down.

Reaction times were measured on a calibrated Bergstrom chronoscope placed at the experimenter's eye level. The experimenter controlled both sound and sight signals from his control board. The magnetic clutch of the chronoscope was activated through the stoplight switch of the automobile. The time measured was that from presentation of the stimulus to that when the brake pedal had been depressed and the stoplight switch had been closed. Each subject was given three trials with the sight and three trials with the sound signals in a standard chance order. No suggestion was made as to which signal would be given; the subject was warned to respond to either. The visual stimulus was a 100-watt bulb mounted on the wall directly in front of the driver's seat. The auditory stimulus was an auto horn suspended under the hood of the car, in such a way as to prevent vibration being felt by the subject.

Results

About 700 people took the test over the period of one week at the Fair. Some record blanks were found incomplete, with the result that the number of subjects varies slightly in the different situations. Average time for 697 subjects in the visual situation was .524 seconds, with a range from .350 to .850 seconds. Average time for 687 subjects in the auditory situation was .514 seconds, with a range from .350 to 1.150 seconds.

Table I shows the averages on the three trials for each mode by each subject, with the standard error of the distribution, the absolute difference between visual and auditory scores, and the critical ratio indicating the reliability of the difference.

Table II shows similar material for the two sexes.

Table III shows the distribution of reaction times averaged for three trials, with the modal group requiring .400 to .499 seconds for both visual and auditory modes.

Table IV shows average reaction times by occupational groups.

Table V compares average reaction times of the various groups and shows the reliability of the differences.

Table VI shows correlation between reaction time, age, and driving experience of the subjects.

TABLE I.—Reaction Times to Visual vs. Auditory Signals—All Subjects

Modes of Present.	Number of Subjects	Av. Times (Seconds)	Sigma Dist.	Diff. in Times	Critical Ratio
Visual (Red Light)	697	.524	.083		
Auditory (Auto Horn)	687	.514	.091		
Vis. vs. Aud.				.01 Sec.	5.26

TABLE II.—Reaction Times of Males and Females

Sexes	Modes	Number Subjs.	Av. Times (Seconds)	Sigma Dist.	Diff. in Times	Critical Ratios
Females	Visual	98	.563	.101		
Males	Visual	545	.520	.079		
Females vs. Males	Visual				.043	4.00
Females	Aud.	98	.548	.107		
Males	Aud.	545	.508	.088		
Females vs. Males	Aud.				.040	3.48

TABLE III.—Reaction Times of Occupational Groups—Both Sexes

Occupational Groups	Number Subjs.	Visual Mode		Auditory Mode	
		Av. Times (Seconds)	Sigma Dist.	Av. Times (Seconds)	Sigma Dist.
Professional	40	.502	.048	.491	.069
Semi-Prof.	28	.517	.022	.500	.080
Students	201	.517	.085	.492	.088
Salesmen	40	.533	.075	.526	.096
Clerks	27	.549	.089	.528	.075
Truck or Taxi Drivers	34	.517	.065	.497	.057
Skilled Labor	95	.514	.090	.497	.091
Farmers	91	.540	.030	.533	.090
Common Labor	103	.546	.085	.537	.127

TABLE IV.—Group Differences in Reaction Times—Both Sexes

(Of 36 Possible Comparisons of Occupational Groups, Only the Following Had Statistical Significance)

VISUAL MODE

Group Comparisons	Time Differences (Seconds)	Critical Ratios
*Professional vs. Farmer	.038	5.3
Professional vs. Common Laborer	.044	4.1
Semi-Professional vs. Farmer	.023	4.6
Semi-Professional vs. Common Laborer	.029	3.2
Student vs. Farmer	.023	3.3
Student vs. Common Laborer	.029	2 9
Skilled Laborer vs. Common Laborer	.026	2.9

AUDITORY MODE

*Professional vs. Common Laborer	.046	3.0
Student vs. Farmer	.041	2.9

*The first-named group in each pair shows the lower reaction time.

TABLE V.—Correlation Between Reaction Time, Age, and Driving Experience

Correlations	Visual Mode		Auditory Mode	
	r	PE	r	PE
Time (1) and Age (2)	+.37	±.022	+.37	±.022
Time (1) and Experience (3)	+.09	±.026	+.24	±.025
Time (1) and Age (2) With Experience Partialled Out ($r_{12.3}$)	+.38	±.022	+.29	±.024
Time (1) and Experience (3) With Age Partialled Out ($r_{13.2}$)	—.14	±.026	+.04	±.026
Age (2) and Experience (3)	r = +.556			

TABLE VI.—Distribution of Reaction Times Averaged from Three Trials

Reaction Time In Milliseconds	Visual Mode	Auditory Mode
300–399	7	23
400–499	299	329
500–599	286	246
600–699	84	64
700–799	15	18
800–899	6	4
900–999	0	1
1000–1099	0	1
1100–1199	0	1

Summary

This investigation of automobile braking reaction time for nearly 700 subjects indicates that it takes about 1/100 of a second less time to set the brake following an auditory stimulus (sound of a horn) than to set the brake following a visual stimulus (sight of a red light). The average auditory time is .514 seconds; visual time .524 seconds. The difference is reliable, with a critical ratio of 5.26. Differences between visual and auditory reaction times are all of the same order of magnitude in the various sub-groups. The subject who reacts rapidly by one mode also tends to react rapidly by the other, as indicated by a positive correlation of .84 between visual and auditory reaction times.

Women require about 4/100 of a second more time to set the brake than men, either following visual or auditory stimulation. The differ-

ence is reliable in each case, with a critical ratio of 4.00 in the case of visual presentation and 3.48 in the case of auditory presentation.

The lower the occupational group on the Barr scale, the longer its reaction time tends to be. Thus, the time for common laborers is .546 seconds by visual mode, while the time for professional people is .502 seconds by the same mode. Common laborers require .537 seconds by auditory mode, while the professional group reacts in .491 seconds by auditory mode.

Truck drivers and taxi drivers as a group had a faster reaction time than their rating on the Barr scale would indicate. Their time, however, is not much faster than the average time of all subjects.

No significant difference was found between the average reaction times of 262 subjects living in rural areas or in villages of less than 2500 population and 433 subjects living in urban areas. Rural subjects were faster than urban subjects by .006 seconds in the visual tests, while urban subjects were faster by .007 seconds in the auditory trials.

Braking reaction time tends to increase slightly with age, as indicated in Table V by a positive correlation of +.37 between reaction time and age. The correlation between time and experience drops to +.09 for visual mode and +.24 for auditory mode. With the experience factor held constant, the correlation between time and age is +.38 for visual and +.29 for auditory presentation. With the age factor partialled out, the correlation between time and experience drops to —.14 for visual mode and +.04 for auditory mode. From these correlations it appears that age has somewhat more significance in braking speed than does experience. This finding is corroborated in the average times of taxi and truck drivers. They rank high in experience but do not react much more quickly than the average subject.

Discussion

While the difference of 1/100 of a second may seem an insignificant advantage in favor of the auditory mode, it is to be remembered that an automobile traveling at 60 miles per hour will continue 44 feet before the average driver of our experiment can even set the brake. After that, experiments have shown, the automobile normally will continue another 198 feet before the mechanical action of its brakes can bring it to a full stop. Thus, any fraction of a second saved in driver's reaction time may easily mean the difference between life and death.

This would be particularly true of automobiles coming head on at high speed, where a listless or drowsy driver might be brought to his senses and to a foot-braking or hand-steering reaction just in time to avoid collision. Even slightly speedier braking reaction might avert crashes from cars backing into each other. Split-second reaction either on the part of driver or pedestrian often saves human life.

It might seem at first glance that the reaction time advantage of sound over sight would be offset by the slower speed of sound. In the 1/100 of a second quicker reaction time which our subjects showed for sound signals, sound would travel only about 11 feet; whereas, light's speed would be practically instantaneous. On the other hand, the

chemical processes of the visual receptors require more time for the sensation of seeing than the physical processes of the auditory receptors require for hearing.

A main factor in favor of sound is that it is non-directional, while sight requires more direct fixation. Further, warning light signals are often confused with advertising signs, Christmas decorations, and other ornamental lighting, while the sound of an auto horn is rather distinct as a warning signal.

In spite of city ordinances against noise, there still seems to be a definite need for the automobile horn and the policeman's whistle. Sound signals bring faster reaction than sight signals in our field tests, just as sound stimuli have brought faster time than sight stimuli in the simple reaction time tests of the psychological laboratories.