Tinted Contact Lenses—A Handicap for Night Driving

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•THE DANGER of wearing tinted contact lenses when driving at night is the same as from other materials which prevent light reaching the sensitive retina of the eye. A typical set of commercial tinted, contact lenses gave the following transmissions (measured with a photocell corrected to the standard observer):

Property	Clear	Green	Blue	Brown	Gray	Amber	Pink
Transmittance (%)	91	78	84	71	76	90	-
Thickness (mm)	0.17	0.18	0.16	0.18	0.165	0.16	-
Another set[1] (computed to 0.20 mm) range, shades 1 to 3 (%)	-	84-93	64-93	71-89	58-92	-	91-93

[1] From (1).

The windshield can transmit 92 percent of the light reaching it when it is clean, although some of the safety glasses absorb light in addition to the 8 percent reflection losses. A transmission of 70 percent usually is the minimum legally acceptable. Spectacles, unless antireflection-coated, also decrease the light for seeing by some 8 percent lost from surface reflections. Therefore, nearly one-fifth of the light can be lost from the eye by a clean windshield and spectacle lenses, or untinted contact lenses.

Yellow (Noviol C) and similar lenses transmitting 85 percent of the light have been considered dangerous, as the seeing distance with them can be less than the stopping distance. On this basis, only the palest tints of contact lenses may be worn without corresponding loss of seeing, unless the lighting is increased correspondingly. The night luminances are rarely high enough to compensate for the absorption by tinted contact lenses.

Pinhole contact lenses (2) are occasionally prescribed for special purposes. Although they are not apt to be worn by anyone driving at night, practitioners should be aware of and warn the user of the reduction of night vision by such lenses.

Tinted contact lenses, absorbing more than 10 percent of light, can be a source of danger when worn at night, and it is recommended that no tinted or pinhole pupil contact lenses be worn when driving at night.

ACKNOWLEDGMENT

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luminance at rates of several per second could be expected to be more certain of visual response than a steady stimulus of equal contrast. This could be applied to a nighttime highway warning device, prepared from retroreflective materials. A group of such patches, set just off the shoulder of the roadway, could serve as a warning that directive instruction for the vehicle operator is to be expected.

It is quite easy to suggest experimental specifications for such a warning system, as shown in Figure 2. If it is assumed that the retroreflective material is to be presented as a set of panels 10 ft from the shoulder that there is a vehicle speed of 62 mph, or about 90 ft per sec, and that 10 percent temporal contrast at 5 cps is required, each cycle will therefore need 18 ft, and each panel must be 22 in. long. The panel can be square, about 2 ft per side. The panel should be set 3 ft above the road, at an angle to reflect the headlamp illumination, 2 ft above the road, back to the driver's position, about 4 ft above the road, when the driver is about 2 sec away from the device, or about 180 ft. The retroreflective material should be sharply, rather than diffusely, effective, or it could be specularly reflective mirrors. About 4 sec, or 360 ft, beyond the warning, the instruction sign should be placed. Naturally, such a proposed scheme as this will require road testing. Experimental verification of its application does not require great expense.

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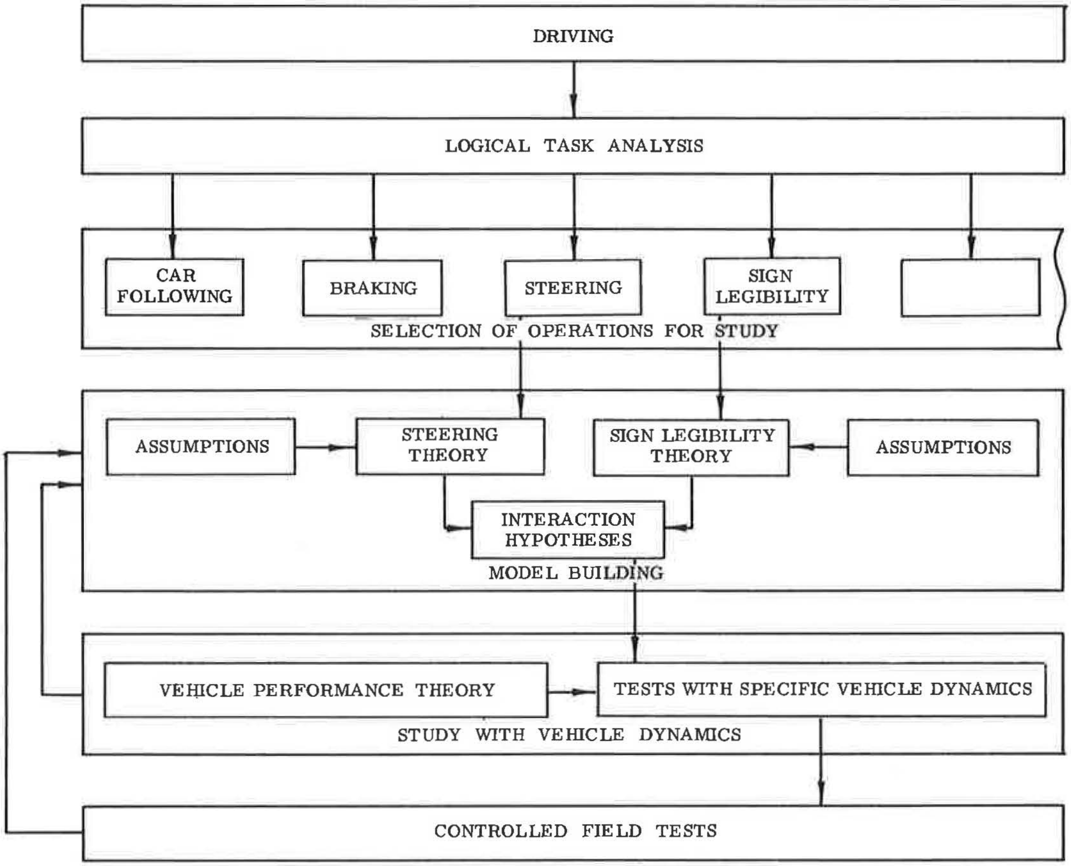

Figure 1. Programatic driving research.

The success of a program of research using the part-task approach demands that assumptions made in the modeling be explicit. If the guidance situation, for example, is to be simulated, some rather important assumptions must be made about how the driver is able to tell whether he is maintaining his position on a specific course. This is evidently some feedback mechanism or concept which should provide an explanation for the translation of these perceptual cues to psychomotor responses, such as turning the steering wheel. Some researchers have begged the question or deemed it unresolvable at this point in time. Others have made assumptions as to the nature of the feedback. Some researchers (1) have assumed that the driver pursues his course; he attempts to null the difference between his vehicle and the roadway course. Others (2) have postulated that the driver assumes a relatively stable hypothetical reference between lanes or a physical lane marking and attempts to compensate the difference between this stable reference and the vehicle.

The literature (3, 4, 5) of tracking in laboratory situations is voluminous. Neither of these assumed displays has been verified for the roadway situation, but it is with the aid of one or the other or some alternative that steering may be brought into the laboratory and data that are useful in the direct confirmation of hypothesized relationships derived.

BUREAU OF PUBLIC ROADS SIMULATION FACILITY

The Bureau of Public Roads is developing a program of research for which the part-task simulation concept is applicable. The process of what is called time sharing is already under study.

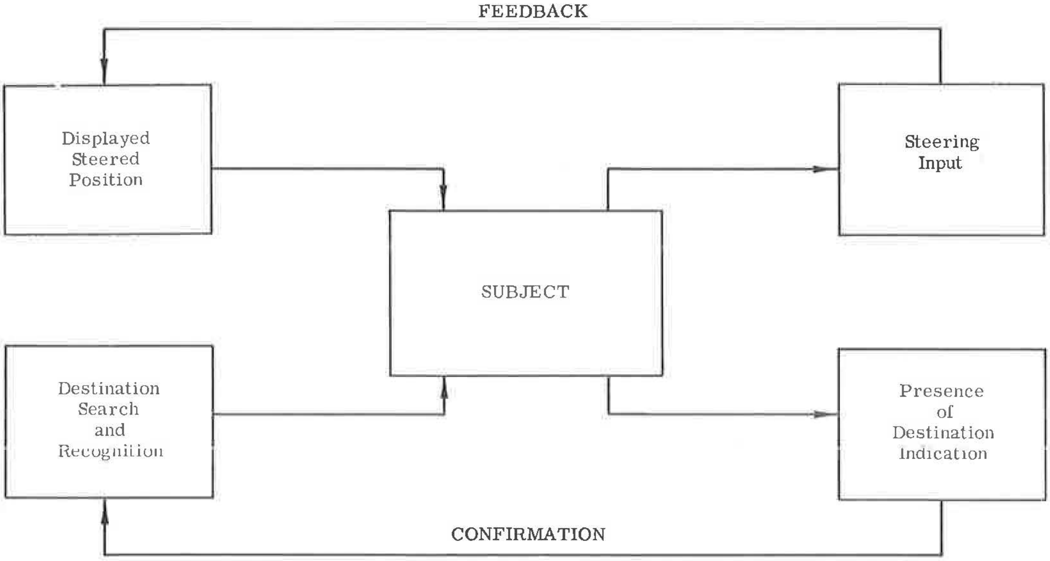

Figure 2. Perception and psychomotor requirements of time-sharing tasks.

Time sharing appears to be of fundamental significance in driving. Logical analysis suggests that the driver is required to carry out two fundamental classes of operation. One is a tracking task related to maintaining vehicle position relative to the roadway. The other involves the searching out and recognition of discrete or fixed elements in the driving environment. Several problems arise relating to the interaction of these two subtasks: What classes of interaction occur? How is performance of one affected by the other? How does increasing complexity influence performance of each operation? Such questions can be answered fairly directly and to a first approximation by simulating the two driving subtasks. Figure 2 shows the perceptual and psychomotor requirements involved in a conceptualization of the time-sharing task.

Formally, time sharing is defined as the process used by the human operator of attending to more than one task by paced or quasi-random sampling of displayed signals. Briggs and Howell (6) have qualified this type of alternation procedure to be applicable to either (a) central time sharing, when stimulation is transformed into a series of psychomotor outputs or stored for future use, or (b) peripheral time sharing, when several sources of available information must be acted on. Concern has been primarily with the latter but not with the exclusion of central processing.

The facility for conducting the time-sharing study defines the operating environment of the human operator. As in most psychological laboratory research, the apparatus may be considered in three logical blocks; the stimulus generation circuitry, the timing instrumentation, and measurement-recording subsystems. These components, in addition to the human operator, define the system in its entirety. Figure 3 shows a block diagram of the system in its entirety along with the timing paradigm.

For the time-sharing study, two stimulus-generating components for the perceptual inputs were employed. One was a low-frequency sine wave oscillator used to provide a tracking signal. The task was a single compensatory type. The error signal consequently was displayed on a CRT display and controlled by handcrank. For the recognition task, a rear projection motion picture tenchique was employed. The stimulus material was a series of signs with different messages from which the subject had to select a key one. Thus, the subject had a continuously varying tracking task and a discrete recognition task.

Timing was achieved by use of a photocell device controlled by the motion picture film, and was employed to control the measurement system. Essentially, there were

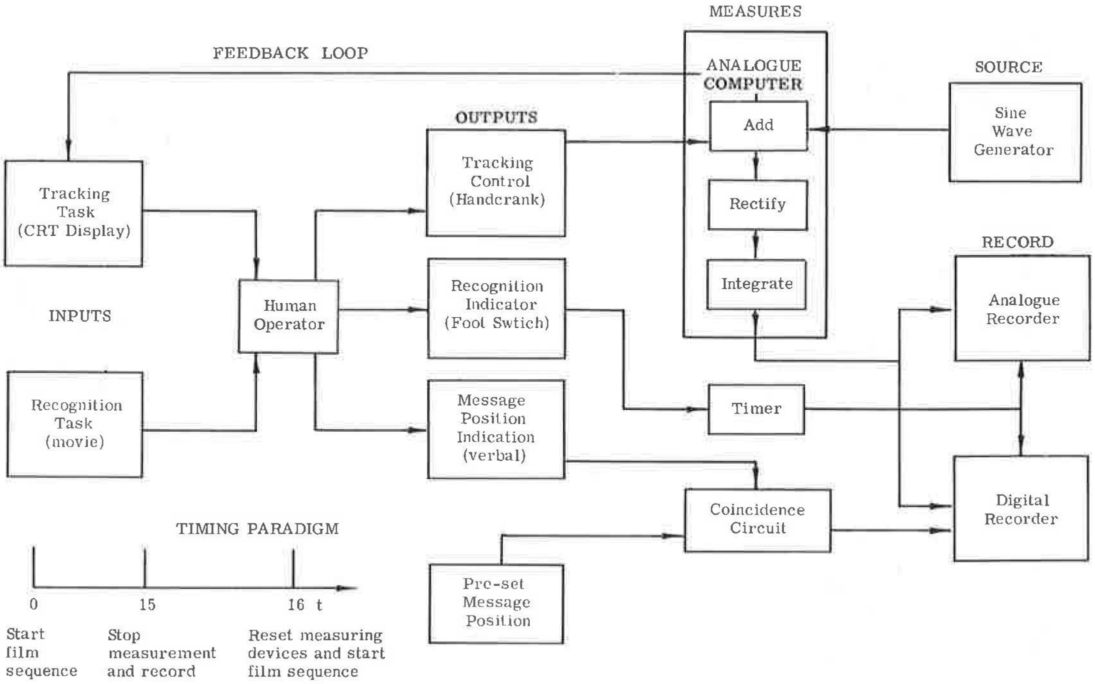

Figure 3. Time-sharing simulation system.

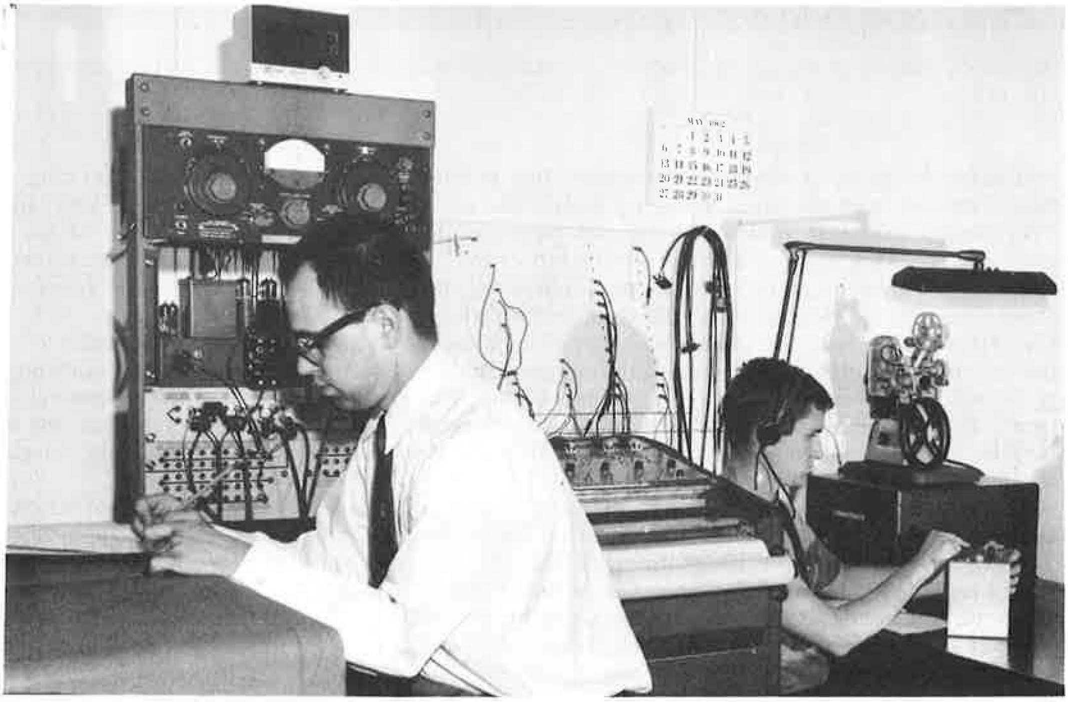

Figure 4. Laboratory apparatus employed in time-sharing study.

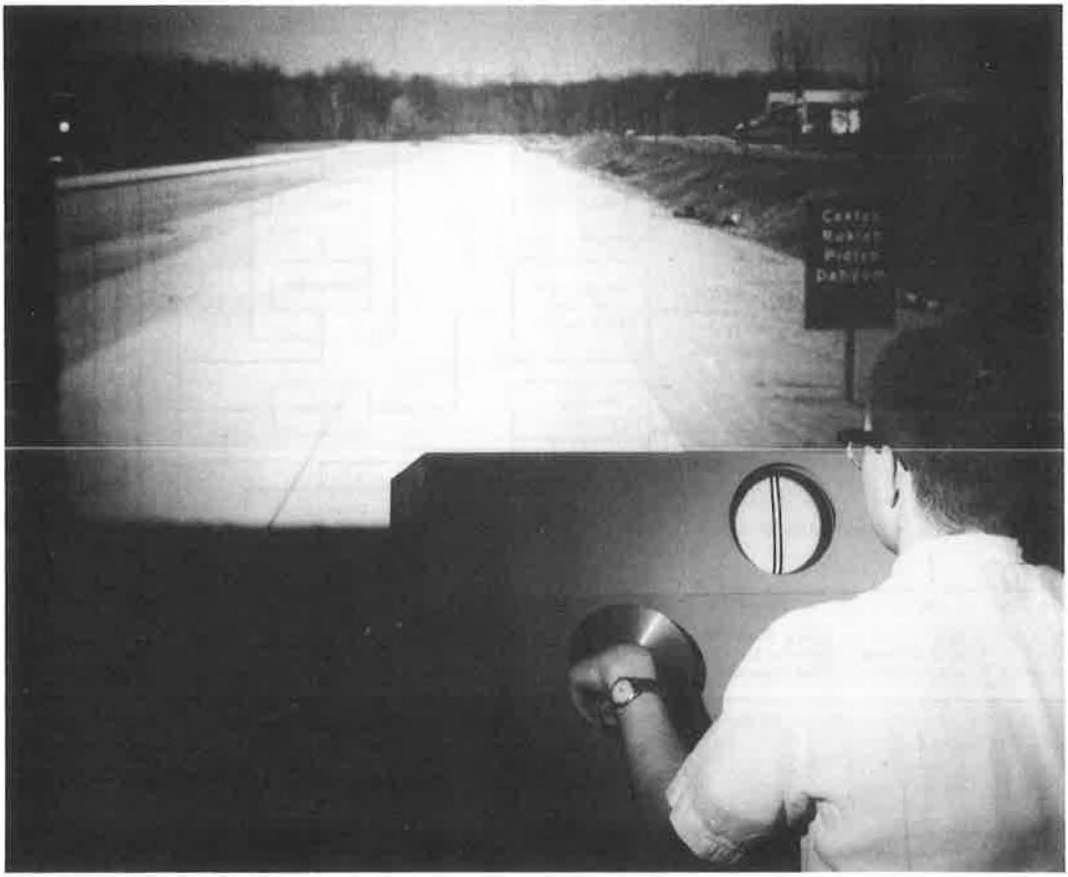

Figure 5. Subject seated at driving console performing tracking and search-and-recognition tasks.

two parts to the response measurement: one related to the measurement of tracking performance, and the other concerned with the recognition task. To measure tracking proficiency, a small analogue computer was used to measure instantaneous tracking, absolute tracking error, and the integrated error. Because the last of these was used as an overall measure of tracking performance, the operation was carried out for a fixed time period during which the subject had to perform the recognition task. For the latter operation, the measures of performance were the response time at which the subject recognized a key message on the sign and the accuracy of that recognition. A digital counter measured time, started by the film sequence and stopped by the subject. A simple coincidence circuit was used to code the correctness of subjects' identification of the message. Figure 4 shows an overview of the stimulus generating, timing, and recording subsystems.

Both digital and analogue recording were employed. Integrated error, recognition time, and accuracy of recognition were coded in digital form and printed out on a digital recorder. The analogue recorder continuously recorded the sine wave input, the subject's tracking, the tracking error, and the cumulative error. Also recorded was an indication of recognition. Hence, with digital records, data for statistical analyses were immediately available; with the analogue record, data for microanalysis of the time-sharing process were available.

The facility described obviously looks little like an automobile. The operator is seated at a console (Fig. 5). He is confronted with a simple compensatory task and the task of searching out key messages on signs along the simulated roadway. It is in the operations that most of the similarity to driving lies, certainly not in the appearance.

The system output provides the raw data by which the model of time sharing may be implemented. Not only may a set of restricted hypotheses be tested within a specific and limited model but also, where additional data are collected (particularly continuous data), a number of ad hoc hypotheses may be tested. Confirmation or rejection of specific hypotheses permits model building. Ad hoc information permits expansion of the inquiry and eventually a more general prediction of behavior.

For purposes of this discussion, the experimental design and results are not reported here. The signficant factors to be examined in this section are the system's output and the specific aims of the research, as a means to illustrate the type of research developed by the part-task simulation method.

For development of the time-sharing study, a system has been synthesized that has as its input a tracking function and a search and recognition task. Expectations as to the response to each are rather clear-cut. The interactions of the two supply unique information about the time sharing of the two tasks. Specifically, the output of the system yields measures of tracking performance and dynamic legibility under conditions systematically varied to permit an analysis of performance across each task.

The model of time sharing devised has dealt with the relative decrement of one task while another maintains dominance. There are, of course, other measures which permit inference of these relations.

ADVANTAGES OF PART-TASK SIMULATION

A part-task facility of the type described here has certain inherent characteristics relative to research in driving. Essentially, it provides a laboratory facility organized around a set of fundamental building blocks. These elements allow a great flexibility in the kinds and classes of research that can be carried out. It is adaptable and modifiable to changing requirements and insights that come through the research process.

Also, because of the simplicity and elementary nature of the laboratory, rather rigorous planning of research is mandatory. The user must define in detail and in advance exactly what he is going to do and how he is going to do it. Because this is not really a "driving simulator," the researcher is never allowed the luxury of studying "just driving." Further, the researcher is never under the illusion that research performed using the facility is a complete analogue of the real driving world. It is obvious that the research can, at most, say something about a very few specific human processes that are perceived to be important in driving. It is always evident with this kind of research that validation in the real system will be required for any of the results obtained in the laboratory facility.

Another feature of laboratory research of this type is that it represents a direct way to develop and test models of driving behavior separate from the host of other variables that confound research done on the highway. By abstracting certain aspects of driving performance in this fashion, it is possible, to a first approximation at least, to uncover and examine in detail the specific behavioral processes determining observed performance. To develop a general model of driving, a synthesis will be required of several such behavioral processes. It is in "teasing out" of these underlying processes that the present facility holds its greatest promise. It has been developed for radical modification, allowing a breadth of research, and hence can serve as several different part-task simulators to meet research requirements.

A very practical advantage of this type of facility is that the researcher can get on with the business of doing research very rapidly. The speed with which studies can be programed and carried out is quite high, allowing pursuit of what appear to be promising lines of research or the dropping of others as the situation demands. It is easier, therefore, to coordinate the laboratory studies with the test track and field studies that are also going on. If something is uncovered in a field study, it can be very quickly brought in and set up in the laboratory to be examined in depth as required.

CONCLUSIONS

The part-task facility discussed in this report is actually less a simulator than a laboratory for the analysis of the driving task. It is designed as a means for directly testing conceptual and experimental models of driving processes. Its ultimate objective is to determine the nature and functional characteristics of certain of these driving processes and to delimit classes of interaction phenomena that arise in driving.

From one viewpoint of driving simulators, this facility should not be considered a simulator. It is, in reality, a laboratory for the conduct of behavioral research using dynamic stimulus material. It is only in the use of this kind of stimulus material that the facility may be considered in any way as a simulation of driving. Consequently, if the research carried out in this laboratory is to be related directly to driving, it must ultimately be validated by actual, controlled field studies. Thus, the research program of which this facility is a part is conceived as one part of a closed loop in which research progresses from the laboratory to the test track to the field situation and back again. With this research approach, a highly flexible laboratory facility is necessary. It needs to be one that allows freedom for a large range of behavioral studies capable of examining a host of performance dimensions. The present part-task facility is aimed precisely to fill those areas of research needs.

ACKNOWLEDGMENT

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