Research on Environmental Factors Affecting Human Behavior

Gerson J. Alexander, *Chief*
Human Factors Branch
Office Traffic Operations
Washington, D.C.

INTERACTION OF HIGHWAY INFORMATION AND THE DRIVING TASK

Highway engineers are under an increasing amount of pressure to make the highway system more responsive to the needs of the motorist. One of the many ways in which this can be accomplished is to transmit information to the motorist that will enable him to drive safely, efficiently, conveniently and comfortably.

To determine what information the motorist needs to perform the driving task, the nature of the task itself must be understood. What does the driver do, and how does information he receives help or hinder?

Recent research has given highway engineers an insight into the nature of the driving task, and the interaction among the subtasks, as well as the way drivers receive and use information. This paper discusses a concept of the task, some of the ways its subtasks are interconnected, and two areas of current research in the United States which upon their implementation should make the highway information system more understandable to the driver, and thus increase his efficiency and the safety of the entire network.

The two areas I wish to discuss are:

1. The interaction between the highway information system and the complex nature of the driving task and
2. The development of diagrammatic guide signs in the United States.

THREE ACTIVITIES OF THE BASIC DRIVING TASK

In a study performed for the National Cooperative Highway Research Program, one researcher suggests the basic driving task consists of three activities—control, guidance and navigation. These activities or subtasks can be described according to an ascendent hierarchical scale of task complexity.

Control

The control activity or subtask relates to the driver's interaction with his vehicle. The vehicle is controlled in two dimensions—speed and direction. The driver exercisies control through steering wheel, accelerator, and brake. Information that determines how well or how poorly he controls his vehicle comes primarily from the vehicle itself. He receives tactile feedback from each control mechanism and in the form of vehicle response to his controlling activity. This information is critical to successful performance of the control subtask.

Guidance

Guidance refers to the driver's ability to maintain a safe path on the highway. While the *control* subtask requires overt action by the driver, the *guidance* subtask requires judgment. The driver must evaluate the immediate environment and translate it into control actions needed to survive in the traffic stream. Information pertaining to this subtask comes from the highway—alinement, configuration, striping, regulatory and warning signs, hazards, shoulders, etc., and from other traffic—speed, relative position, gaps and headways, lane changes, etc.

Navigation

Navigation refers to the driver's ability to plan and execute a trip from point of origin to destination. Information pertaining to navigation must be used effectively if this part of the task is to be performed successfully. Maps, verbal directions, guide signs, and landmarks are typical sources for this kind of information.

The three subtasks—control, guidance, and navigation—form a hierarchy of task performance complexity. At the control level performance is relatively simple and so completely overlearned by most drivers that it is performed almost by rote. At the guidance and navigation levels performance is increasingly complex and drivers need more mental processing time in order to respond properly to information input.

Counteracting the ascendent scale of task complexity is a descendant scale of task importance. Performance at the control and guidance levels are critical to the safe performance of the total task. The direction finding task and the concomitant navigation information, while important, have a more pronounced effect on efficiency, comfort and convenience than they do upon safety.

To illustrate this point, consider the driver who does not respond to a turning roadway. He is likely to drive off the highway and injure himself. The driver who does not heed a sign indicating his next exit is likely to get lost or delayed. We can label the first incident as a catastrophic failure and the second incident as a failure, but non-catastrophic in nature.

ROLE OF EXPECTANCY IN RECEIVING AND PROCESSING INFORMATION

One of the key findings of this research, as far as the highway operations community is concerned, is the role that driver expectancy plays in his ability to receive and process information.

Expectancy is another factor that affects the driver—how he perceives information and how he uses it. Drivers, and people in general, expect certain things to operate in certain ways. When entering a dark room, a person will expect to find an *on-off* toggle switch for the lights. He also expects the switch will operate up for *on* and *down* for off. When it works the other way around, or when there is a rheostat knob, it takes a bit longer to respond properly to what is actually there. The same situation occurs with drivers. When a driver's expectancy is incorrect, either it takes him longer to respond properly or, even worse, he responds poorly or wrongly. If, for example, he is expecting a right-hand off ramp and alines his car on the right side of the highway to exit, and he is faced with a left-hand exit, it takes him longer to respond to that situation. He may, in fact, respond poorly by turning at the last moment to drive across three lanes to avoid missing his exit. Expectancies do occur in all three parts of the driving task.

Control and Expectancies

The driver expects his vehicle to respond in a certain way. When he depresses the brake with a certain force, he expects the car to slow at a certain rate; but if for some reason the brakes fail, or if his car is on a patch of ice, the car does not respond in the way he expects. In that situation, the driver is less likely to handle his vehicle properly. The same is true of steering, if he turns the wheel with a certain force and to a certain position, he expects the car to turn at a given rate in the desired direction. If it doesn't for one reason or another—sand on the road, for example—then it is unlikely that he will respond quickly or properly.

Guidance and Expectancies

In the guidance subtask, expectancies relate to highway design and traffic interaction. Highway designs that drivers do not expect include left-hand off ramps, tangential off ramps, left-hand on ramps, two-lane on ramps, two-lane off ramps, lane drops at exit, and lane drops between exits, to name a few.

Navigation and Expectancies

In the navigation task, expectancies relate primarily to guide signing. From what is known about the way expectancy works, highway engineers should recognize and are beginning to recognize that it is their responsibility to tell the driver what to expect if it is not within the realm of what he should normally expect.

In pre-trip preparation, many drivers will assume that their destination, no matter how obscure, will be signed for on the freeway. While this appears to us engineers as unreasonable, it may be quite logical from the driver's viewpoint. Since the driver has no way of knowing what is signed and what is not, and he knows that many places are signed for, it is fair for him to assume that his destination is signed for.

Evidently then, what is needed is a means by which drivers can predict the content of guide signs at key decision points along their route.

The engineering community is also beginning to recognize that uniformity while a desirable goal is not going to solve the problem completely. One of the things we must look for is ways to provide the driver with better guidance in his pre-trip preparation. The entire field of mapping and pre-trip planning has been largely over-looked by both the research and operations communities. It is indeed unfortunate that up until now no one has felt this problem important enough to devote specific attention to it.

DEVELOPMENT OF DIAGRAMMATIC GUIDE SIGNS

To paraphrase a Washingtonian of some note, "Let me make myself perfectly clear." The driver who is somewhat unprepared for what he is going to see on the highway can be expected to have some uncertainty and/or confusion at one or more places along his route. Such uncertainty is directly relatable to unusual and erratic maneuvers and subsequent crashes on our highway systems.

The driver's prior knowledge of the nature of a complex interchange between freeways will, we believe, enable him to negotiate that complex interchange with less likelihood of error.

The development of diagrammatic guide signs, while it predates the motion of driver expectancy is directly related to it.

In the past several years, much has been said and written about the use of graphics in highway signing. Symbology for warning and regulatory signs has been used in Europe and Canada for many years, and is now a part of our Manual on Uniform Traffic Control Devices. Recently, there has been some investigation into the value of graphics in guide signing. Graphic guide signing, or diagrammatics, has also been used in Europe and Canada to depict unusual highway geometrics.

Evaluation Studies of Diagrammatic Signs

In 1968, several states, in cooperation with the Federal Highway Administration began to install diagrammatic signs on the interstate on an experimental basis.

Using HP&R funds and in some cases only state funds, signs were erected and evaluated in Virginia, New Jersey, Wyoming, Illinois, and Wisconsin, among others. Also, FHWA in 1969, contracted for some laboratory investigation of diagrammatic sign design. From these beginnings, it became apparent that diagrammatic sign treatment was not going to be a panacea to complex freeway interchange design.

The Federal Highway Administration has recently completed a large study to determine specific values to be achieved through this signing technique. Of significant value to operating highway departments, information has been generated on general graphic design, spatial relationship between graphic and verbal content, deployment interchange selection and site location.

This research has shown that the only place where diagrammatic signs are unequivocally superior to conventional signs is at interchanges containing an off-route movement to the left of the through-route movement. At other interchange types there is either no significant benefit or some decrement in traffic performance due to the diagrammatic treatment.

So, once again, we find that signing cannot be used to ameliorate the effects of substandard or even standard but complex interchange design.

Other Benefits of Sign Studies

There are other benefits to these studies. In addition to defining guidelines for the use of diagrammatic signs we are beginning to get an understanding of how traffic control devices and other highway environments affect driver perception. Our signing studies are indirectly measuring such factors as driver stress, the effects of uncertainty, and mental processing limits. We consider it critical to have a better functional grasp of the motorist's perception of his environment. While we are learning how drivers perceive and react to signs, it is a high priority item to discover how he perceives and reacts to the rest of the highway environment. Included in this research priority would be a quantification not only of the relationship between accidents and geometric design, but also, of driver expectancies regarding information at all three levels of the driving task.

CONCLUSION

Highway safety cannot be fully achieved until attention is given to *all* factors that affect system operation. When the system is understood as a system in research, design, and operations, greater strides in making highways safer for motorists can be made.