

Psychology of Trip Geography

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THE authors deductively analyze highway accident focal points in terms of possible causative factors related to driver behavior. A concept is developed which the authors call "psychology of trip geography." This concept demonstrates that known psychological-behavior patterns can combine with the geography of the area over which a particular trip is planned to produce driver conditions conducive to accidents. Some of the recognized psychological behavior patterns considered are: the setting of aspiration levels, the rigid adherence to previously made plans, the general performance let-down incident to nearing completion of a task. Trip geography has reference not only to terrain and weather but also to the spatial layout of origins and destinations coupled with logical stopping places en route.

The authors state their belief that the psychology of trip geography leads to prolonged driving and other unsafe driving practices which, in turn, increase the likelihood of an accident. In this context, seemingly unrelated accident-causing factors, such as reduced tactile sensitivity, highway hypnosis, and hypoxia (mountain sickness), are demonstrated to fit meaningfully into the framework provided by the new concept. Prolonged driving reduces the tactile sensitivity of the driver; the importance of tactile cues for the driving task is discussed. Arguments are advanced for the increased likelihood of hypnotic and hypoxic effects also resulting from prolonged driving.

Pertinent literature in the fields of psychology, physiology, aviation medicine, and highway safety is cited in support of the various hypotheses advanced by the authors.

● ONE of the explanations for the continued occurrence of accidents on the open road is that higher speeds prevail there. It is true that the severity of an accident usually will increase with increasing speed; however, speed per se does not necessarily explain the occurrence of the accident. Moreover, many accidents involve late model cars in good mechanical condition. Furthermore, there are an increasing number of accidents on modern freeways and other types of well-designed, limited-access roads. The conclusion must follow that there is some causative factor for open-road accidents that is not found in speed itself or in the condition and design of the vehicle or the road. It is reasonable to conclude that this causative factor can well be sought in the physiological and psychological conditions underlying the behavior of the driver operating his vehicle, be it an old or late model, be it on a good or poor road.

There are a number of factors that can affect the condition of a driver and reduce his ability to drive safely. These factors can be considered as force complexes. Alcohol, for one, has been the subject of many studies, and its importance if fully recognized; fatigue, also, has received widespread attention, although its role is not as well understood as that of alcohol; road hypnosis and so-called hypnagogic effects have been discussed in recent years; hypoxia (mountain sickness) has been considered, particularly in the mountainous western states; and, no doubt, others could be added to this list. Yet, to the best knowledge of the authors, no single framework has ever been formulated into which any of these complexes, or any combination of them, would fit logically. Such a framework would have to show how individual complexes can combine to produce cumulative effects and, most important, why drivers permit themselves, either knowingly or

unknowingly, to fall victim to the effects of any of these complexes. Once such a framework were identified, knowledge of its existence would provide invaluable assistance to persons planning accident-prevention programs. An analytical study was accordingly initiated by staff members of the Institute of Transportation and Traffic Engineering of the University of California to look for some framework that would satisfy these conditions.

At the outset, it became apparent that meaningful results would most likely be achieved by studying some section or sections of our highways where there are high frequencies of accidents. The reasoning was that such sections mark locations where the force complexes are maximum and hence where a framework within which they operate would most easily be recognized. Such sections have been occasionally referred to in the past as "accident-prone mileage." However, for our present purpose the expression "accident focal point" appears preferable.

Attention of the authors was directed by traffic authorities of New Mexico to what seemed to be an accident focal point, namely the 160 miles of US 66 from the Arizona-New Mexico border to Albuquerque. In 1952 the fatal accident rate on this road was 18.5 fatal accidents per 100 million vehicle miles. The death rate (number of deaths per 100 million vehicle miles) can be expected to be greater than this fatal accident rate of 18.5. The National Safety Council reports in the 1953 edition of "Accident Facts" that the national rural death rate for 1952 was 9.8. It was accordingly decided to study this section of road in detail with a view to attacking the general problem of the framework of vehicle accident causation.

POSSIBLE FRAMEWORK OF ACCIDENT CAUSATION

By definition, a particular section of road becomes an accident focal point by reason of the high frequency of accidents occurring there. It follows that there is some unique characteristic of the section that distinguishes it from other sections of the same road, and from sections of other roads. But if the causative factor is to be sought in the physiological and psychological state of the driver, then a seeming impasse is reached, since

accident focal points are established in terms of unique characteristics of the road. The impasse would be heightened if it were established that the population of drivers using the accident stretch was the same as that using other sections of the same road and, similarly, that road design, condition of vehicles, and surrounding countryside were the same over all sections of the road.

The impasse, however, can be partially resolved by postulating that physiological and psychological changes take place in the driver as he proceeds along on a road and that such changes are related to space-time considerations unique to the road. To state this in another way: A driver would not be in the same psychological and physiological state from one space-time point to another and the extent of the difference is somehow related to the road in question. This space-time-psychological framework immediately makes evident an interaction between geography, trip plans, and driver conditions, respectively.

To illustrate this framework, let us postulate a trip from Los Angeles to the eastern seaboard via US 66. The driver leaves Los Angeles in the early morning, planning to stop overnight in Flagstaff, Arizona, 450 miles away. He is able to average between 50 and 60 mph. over this stretch because he maintains a high constant speed during the latter part of the trip between Kingman and Flagstaff. As a consequence, the driver is able to reach his originally planned goal for the day, Flagstaff, sooner than he had anticipated. His early arrival, combined with his awareness of the high average speed he was able to maintain, particularly over the last stretch, causes him to decide to go on to the next "logical" stopping place, which, in this case, would be Albuquerque, New Mexico. Some place between Flagstaff and Albuquerque he is involved in an accident.

A possible explanation for this accident would be that the driver was in an over-fatigued state and, hence, was unable to cope with or respond successfully to some minor condition on the road. This over-fatigue could have been the direct result of his having underestimated the time and driving effort necessary for him to reach his new goal, Albuquerque. Moreover, it could well be that he was unaware of this encroaching overfatigue. Both the under-

estimation and the unawareness of fatigue could have been increased by the driver's satisfaction with his previous accomplishment. This reasoning is supported by the work of Child and Whiting (1), who demonstrated that successful performance increases the aspiration level for succeeding performance. A generalization of this psychological phenomenon in the trip situation is that an overestimation of the travel time and effort necessary to cover one leg of a trip promotes a tendency to underestimate the time and effort needed to complete the next leg. Thus, the geography of the terrain over which the particular trip was planned can interact with known psychological behavior patterns to produce a driver condition conducive to accidents.

This is one example of a new concept that the authors propose to call "psychology of trip geography." It represents a framework into which the various interacting accident-force complexes can logically be fitted.

PSYCHOLOGY OF TRIP GEOGRAPHY

Geography, in the usual sense, refers to terrain features such as desert, mountains, typical weather, etc. Trip geography includes not only these, but also such elements as distribution of and distances between large cities, origin and destination points, sightseeing points, desirable eating and overnight accommodations, filling stations, road conditions, alternate routes, and other physical features influencing planning and execution of the trip.

The psychological factors involved are over and underestimating travel time and effort, inability or reluctance to change plans to cope with altered trip situations, injudiciously changing plans to meet an altered trip situation, consistently setting aspiration levels either too high or too low, and general performance letdown upon approaching the destination. This latter point can be related to a recognized phenomenon in work psychology in which the performance of the individual decreases as the end of his work period approaches (2, 3). Some other generally recognized factors that belong in this category are a tendency to assign and try to cover a particularly great distance on the first day of a long trip, a tendency to compare

accumulated travel time with that of previous trips (either the same trip or trips of similar distance and duration), and a tendency to change plans toward the end of the trip by taking on an unduly high load of travel time and effort to reach the destination, particularly home.

Psychology of trip geography can also lead to a better understanding of accidents associated with shorter trips. Drivers commuting over short distances habitually allow fixed travel times between regularly travelled points. When an unexpected delay occurs, even normally cautious drivers force themselves to make up the lost time by increasing speed and taking unusual chances. The military pass situation is another striking example of the same phenomenon: military personnel tend to maximize their time away from base and then, faced with the stringent necessity of being back at a prescribed time, take undue risk on the road. Both are examples of unsatisfactory adjustment to unforeseen delays and of poor trip planning, even over short distances.

The psychological phenomena, in turn, can result in driving practices and conditions that can be expected to increase accident likelihood: practices and conditions like speeding up to arrive at the time estimated, trying to cover a previously planned distance at all cost, taking chances that are not normally taken, driving in an overfatigued state, interruption of the physiological day-night cycle (4, 5), general unawareness of reduced driving efficiency, and a general lowering of attention and caution.

For these reasons, the authors believe that this combination of psychology and trip geography represents a generally occurring phenomenon that hitherto has not been defined, and that could readily account for a number of accident focal points throughout the nation for which no other explanation has been advanced. It can even override effects of other accident producing conditions that have been examined very carefully in the past such as road conditions, weather conditions, visibility, glare, driver characteristics, and condition and type of equipment.

INTERACTING FORCES WITHIN THE FRAMEWORK

At this point, it is in order to consider

how individual accident force complexes interact within the framework provided by psychology of trip geography. To do this, let us turn again to US 66 in New Mexico, first assessing it critically for prevalence of individual force complexes, and then examining the ways in which these forces can interact.

The first force complex that suggests itself is hypoxia, in view of the fact that this stretch of road leads through territory with an average elevation of about 6,500 feet above sea level, with a peak of 7,300 feet at the Continental Divide. In individuals exposed to altitudes of up to 7,300 feet above sea level, the following psychophysiological effects of hypoxia have been demonstrated to appear: (1) increase in depth of breathing in some individuals; (2) increase of pulse rate in some individuals (pulse rate, however, returns to normal if the exposure is prolonged for more than one hour); (3) slight impairment of night vision and (in the low-pressure chamber) a decline of twilight visual acuity (the latter, however, is restored to normal within 24 hours of actual exposure to altitudes of about 6,500 to 10,000 feet); (4) tremor of the hands in some individuals; and (5) slight impairment of sensitivity to pressure on the skin.

In addition to these symptoms, a certain percentage of the driving population can be expected to react with slight sleepiness, headaches, and lassitude. However, demonstrable effects of generally impairing nature occur only at higher altitudes. This fact is the basis for the existing Air Force regulation that oxygen equipment is not mandatory when flying at altitudes below 10,000 feet. Of course, the experimental results in the field of hypoxia were obtained largely from a select group of individuals who, with few exceptions, were students, mountain climbers, sportsmen, and personnel of the Armed Forces. These represent a selection of young, fit people who can be expected to be in better than average physical condition. The driving population using US 66 in New Mexico probably has a different altitude-fitness composition. However, the extent to which these differences are a factor in accidents can only be conjectured at this time. Therefore, hypoxia by itself seems to be, at most, only a contributing factor in the high accident rate on this highway. A more-complete treatment of hypoxia

is presented in Appendix A.

A second force complex that was suggested by the nature of the terrain is related to so-called road hypnosis. This phenomenon seems plausible because of the monotonous countryside and the comparative lack of curves and obvious changes of grade. Various aspects of hypnotic effects have been reported, including velocitization, high-speed hypnosis, and hypnagogic hallucinations. However, it would be unreasonable to conclude that monotony of road and countryside is a necessary and sufficient condition for road hypnosis, of itself, to produce an accident focal point since otherwise accident focal points would prevail on all monotonous roads. A more-complete treatment of road hypnosis is presented in Appendix B.

Thus, both the hypoxia and the road-hypnosis force complexes when considered by themselves, appear to have limited significance and probably are not responsible for any large number of accidents. However, it can readily be demonstrated that when considered within the psychology of trip geography framework, they can be appraised from a new perspective and, thereby, possibly achieve significance.

There are many ways in which various individual force complexes can combine or interact within the framework of the psychology of trip geography. The authors believe the most important to be related to fatigue. There are several reasons for this: First, one of the most-frequently occurring unsafe conditions in the cross-country driver is fatigue.¹ Second, as was pointed out, psychology of trip geography can be a primary reason underlying fatigue, and thus explain it better than any other explanation hitherto advanced. This fatigue then acts as a catalyst in the accident causation system, serving to heighten the effect of otherwise unimportant force complexes. This leads to a consideration of plausible interactions between driver fatigue and single accident force complexes.

A study has been made by Luft (6) on the stress combination of hypoxia and light exercise. He observed a marked reduction in altitude tolerance and a de-

¹One of the authors had occasion to discuss the accident problem on US 66 with police officers patrolling this road. The officers volunteered the information that they frequently had stopped weaving cars only to find the drivers in an extremely over-fatigued state

layed recovery from the symptoms associated with exposure to altitude during light exercise. Since driving can be considered mild exercise, the mild hypoxia present at altitudes between 6,500 and 7,300 feet may impair driving efficiency. Moreover, hypoxia alone, particularly in the healthy individual, may be unimportant, but it may assume a certain importance in combination with the fatigue resulting from psychology of trip geography.

Another way in which psychology of trip geography, through its resultant fatigue effects, can interact with altitude is in impairing vision. Rose (7) has observed a reduction of twilight visual acuity and of night vision upon exposure to simulated altitudes between 6,500 and 10,000 feet (see Appendix A). A study by Petronio (8) reports a lowering of the light stimulus threshold and a contraction of the size of the field of vision in fatigued subjects, and an earlier study by Bujas (9) also reports a narrowing of the visual field in fatigued subjects.

Concerning the interaction between hypnosis and fatigue, a paper by Lahy (10), in which he cites work by Pieron, is relevant. In this study of fatigue effects on truck drivers in relation to their work planning (planning the hours of driving), Lahy points out that "it is in effect necessary as shown by Pieron that the physiological day-night rhythms, upon which the equilibrium of the body's recovery is based, are not disturbed. Here we have a most probable reason for the hypnagogic hallucinations which plague the driver and are, of course, likely to produce serious road accidents." Psychology of trip geography could result in disruption of this physiological day-night rhythm and, consequently, in increased likelihood of such illusions and their attendant dangers.

There is another aspect of fatigue that merits attention in this study: aeromedical research has revealed the importance of the body's system of mechanical senses in the proper control of aircraft. It has been shown that this system, and particularly the pressure sense of the skin, affords many important cues to the pilot, enabling him to fly properly.

The importance of the pressure sense was demonstrated by an experiment conducted by Strughold (11). He describes it as follows:

Without the cutaneous sensations, perception of the movements of our body in space becomes inaccurate. This was demonstrated by an experiment in 1928. I had my superficial gluteal nerves anesthetized and took a flight in a small airplane as passenger. I often had the feeling that the aircraft had slipped away under my body, and I was glad to stand again on my nonanesthetized feet after landing. . . . The pressure sense of the skin can be impaired by pressure itself. It has already been mentioned that because of its rapid adaptation, pressure sensation fades rapidly after a constant prolonged deformation, because the specific stimulus is the change in pressure, not the pressure as such. Prolonged firm pressure can also reduce the excitability of the tactile receptors. Everybody has experienced numbness of his buttocks after he has remained in the seated position for several hours. . . . The decreased excitability of the tactile receptors is apparently related to the interruption of blood circulation and thus of oxygen supply. I consider the effect of pressure on the pressure sense to be of definite importance to aviation; for, one can conceive that after long flights downdrafts will not be recognized and compensated for fully and rapidly enough by a pilot whose buttocks have been numbed by pressure. This may have a disastrous effect during landing.

These observations, to a certain degree, also seem to apply to the driving task, but to the knowledge of the authors, there are no reports concerning the importance of tactile cues in controlling an automobile.²

These tactile cues are possibly more significant than is generally assumed. The importance of visual cues as compared to tactile and postural cues for determining body position has been investigated by Witkin (12). His subjects were placed in a spatially ambiguous position and asked to adjust both a rod and their body position to what they perceived to be the vertical. It was demonstrated that the tactile and postural cues outweighed visual cues in the determination of the body's position in space. The author states:

The scores show that when a visual field was present, the rod was tilted considerably less from the upright of the field than was the body. This finding reflects the fact that the position of an external item such as the rod is determined. . . predominantly on a visual basis, i. e., by its relation to the surrounding field. Perception of body position, on the other hand, depends much more upon specific body experiences, which are affected by rotation, and is less influenced by the surrounding field.

²This was first pointed out by K Reismann in a personal communication.

The cues that inform us of linear and curvilinear accelerations and decelerations of the car are very strong as we can easily demonstrate to ourselves when riding in a car as a passenger. If one's eyes are closed while the car is being driven through a series of curves, stops, and starts, the strength of the resulting tactile and proprioceptive cues will become startlingly apparent. Changes in speed or direction are immediately perceived. These sensations are received through the tactile surface of the skin at all those places in contact with the auto seat, and there can be little doubt that we make use of these kinesthetic cues in the proper execution of the driving task. The impending slipping of a car in a curve may be first perceived by means of these tactile cues rather than through visual cues. Frequently, the car may still be in proper visual alignment in its lane at the time it begins to slip, and the visual cues alone do not give the driver sufficient time to detect impending slipping and to make proper corrections.

As has been shown in the previous section of this report, the psychology of trip geography may cause a driver to remain seated in his car for a rather extended period of time. As a result, the driver gradually becomes less sensitive to pressure and, hence, less sensitive to a source of cues that are likely to be important to his ability to drive safely. This effect could further interact with mild hypoxia, since Loewy and Wittkower (13) found that the sensitivity to pressure on the skin is slightly impaired at heights as low as 5,100 feet. This latter phenomenon is a second-order interaction to be expected on high-altitude roads.

There is another relation between tactile cues for the driving task and psychology of trip geography. This concerns the sudden transfer of the driver from an open road to a traffic situation that requires frequent stops, starts, and turns. With lessened tactile sensitivity, he may not perform the traffic maneuver as skillfully as usual.³ This may explain why cross-country drivers become involved in accidents in traffic situations they encounter en route.

³ Plans are being made to investigate experimentally the importance of tactile cues in driving

REMEDIAL MEASURES

The authors have presented a concept, psychology of trip geography, that was developed entirely by deductive reasoning with no experimental and little empirical verification. Certainly there are many aspects of the concept that could readily be subjected to rigorous experimental scrutiny, thereby providing information on the interaction of psychological behavior patterns with trip geography specifics. In addition to verifying the importance of the concept, such studies would provide direction for specific remedial actions. A program of this nature is now being planned by the Institute of Transportation and Traffic Engineering. Possibly other research organizations will choose to study the same problem. Several possible statistical plans for doing this are presented in Appendix C.

Long-range experimental studies are expensive and, what is more important when lives are at stake, extremely time-consuming. During the long periods of time the programs would have to be in progress before meaningful results could be obtained, the conditions under study would continue to cause accidents with the accompanying loss of lives. It would seem a strong deductive argument indicating that a particular condition is contributing to loss of lives should be sufficient justification for proceeding with remedial measures without waiting for experimental verification of the argument. For this reason, the authors want to encourage all those who are active in accident prevention to have the concept of psychology of trip geography in mind as they consider their accident problems. This, in essence, highlights the primary objective in presenting this report at this time, admittedly without supporting evidence. Recognition of this concept can provide meaningful direction to groups such as motor clubs, highway officials, traffic engineers, enforcement agencies, company safety directors, and other persons directing accident prevention programs.

To demonstrate this, let us return to the New Mexico example. In this instance the psychology of trip geography led us to the following considerations: Albuquerque will continue to be a frequently sought-after, one-day goal of travellers starting

from Los Angeles. People who are susceptible to mountain sickness will not be legislated off the highway and will continue to drive over this section of the road. Similarly, it is not likely that hypnosis-producing aspects of the highway and the vehicle will be altered in the foreseeable future. Consequently, the most effective recourse would be to create an awareness in the driver of the nature of the psychology of trip geography. This, in turn, would have a positive effect on his trip planning and his subsequent trip attitudes.

Little is known about driver attitudes and how to influence them (14) but, again, it is entirely in order to proceed with some program if there is a reasonable likelihood that it will influence trip attitudes. With reference to psychology of trip geography, such a program would consist of three stages: First, acquainting the driver with the ways in which psychology of trip geography can affect him (this is already being done to a certain extent by motor clubs, travel agents, gasoline companies, and other groups which provide trip planning services); second, warning the driver of the imminent hazards as he approaches the accident focal point; and third, continually reminding the driver of the presence of hazards as he passes over the accident stretch of the road.

Applying this procedure to US 66 would involve the following three-point program: (1) Groups providing trip planning services in the Los Angeles area would point out to drivers the nature of the possible effects associated with the psychology of trip geography as it applies to their proposed trip. These explanations would be similar to those presented in this paper. (2) At the Arizona-New Mexico state line, pamphlets repeating the information given in the trip planning stage would be distributed to drivers. (3) Road signs would be installed along the road in question, with messages related to the pamphlet and trip-planning information.

Some of the messages that might be placed on the road signs could refer to such items as: (1) the accident record of US 66, with particular reference to out-of-state drivers; (2) the possible ill effects of altitude, particularly as regards those road users with asthmatic, cardiac, and vascular histories, (3) the tendency for drivers to be unaware of the altitude reached on the road, due to the compara-

tive lack of sharp curves and steep grades; (4) the hazards of road hypnosis owing to the monotony of the road, particularly during the night; (5) the tendency to assume an unduly high load of travel time and distance, and the consequent dangers of driving in an over-fatigued state; (6) the loss of driving efficiency, particularly in the tactile facilities, if driving is extended beyond a reasonable time; and (7) the possible interaction among and accumulation of the ill effects likely to occur on this road.

Two types of road signs could be used. One type would simply reiterate some of the most-impressive and locally pertinent items of information already contained in the pamphlet; the second type would give the elevation. The signs could be arranged either at regular intervals along the road, or at equal elevation increments. Both types of signs would serve not only as sources of information but also as reminders of the hazards of this road. Even if altitude has no effect upon the accident picture the elevation markers would nevertheless serve a purpose in that they could be expected to focus the driver's attention upon his task in relation to this particular situation.

SUMMARY AND CONCLUSIONS

The authors deductively analyzed highway accident focal points in terms of possible causative factors related to driver behavior and formulated a new concept called psychology of trip geography. This concept makes it possible to understand how known psychological behavior patterns can combine with the geography of the area over which a particular trip is planned to produce driver conditions conducive to accidents. Some of the recognized psychological behavior patterns considered are: the setting of aspiration levels; the rigid adherence to previously made plans; and the general performance letdown incident to nearing completion of a task. Trip geography has reference not only to terrain and weather but also to the spatial layout of origins and destinations, coupled with logical stopping places en route.

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likelihood of an accident. In this context, seemingly unrelated accident - causing factors, such as reduced tactile sensitivity, highway hypnosis, and hypoxia (mountain sickness), were demonstrated to fit meaningfully into the framework provided by the new concept. Arguments were then advanced for the increased likelihood of hypnotic, hypoxic, and reduced-tactile-sensitivity effects resulting from prolonged driving.

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APPENDIX A

Hypoxia

The problem of mountain sickness or hypoxia has been the subject of intense studies during the past 25 years since the exposure to altitude became routine in the operation of aircraft, and the majority of the problems of aviation medicine center around this phenomenon. Most investigations in the field of hypoxia, however, deal with conditions existing at altitudes over 10,000 feet above sea level; relatively few studies have been made of effects of human exposure to altitudes below 10,000 feet. Enough material is available, however, to pass judgment on the validity of the hypoxia hypothesis.

The objective and subjective effects of hypoxia are related to a drop in the oxygen saturation of arterial blood that occurs with exposure to altitude. The oxygen saturation of the arterial blood is dependent upon the oxygen partial pressure existing in the air breathed by the individual. All the quantities involved (oxygen saturation, alveolar oxygen tension, and partial pressure of oxygen in breathing air) decrease with increasing altitude. Both the oxygen

partial pressure of atmospheric air and that of alveolar air decrease very nearly according to a logarithmic law, while the oxygen saturation of arterial blood behaves differently (see Fig. A). The oxygen saturation of arterial blood at sea level is about 96 to 97 percent, and it drops only slightly up to 10,000 feet: at this level, the oxygen saturation of arterial blood is still approximately 87 to 89 percent. This is the main reason why a healthy organism is only slightly affected by altitudes up to about 10,000 feet.

Exposure to altitudes ranging between 10,000 and 30,000 feet, on the other hand, results in a steep drop of the oxygen saturation of arterial blood. It is in this range that the typical symptoms of altitude sickness occur. Armstrong (15) lists a number of subjective symptoms in the order of their frequency as they are experienced at various altitudes between 12,000 and 16,000 feet (see Table A).

In general, with increasing altitude the number and intensity of the symptoms listed in Table A increase, and the time required

for symptoms to develop is shortened.

There are essentially two classes of psychological reactions to exposure to altitude: some individuals react with outbursts of hilarity, uncontrollable laughter or at least with pronounced euphoria; others feel fatigued, depressed, and sleepy. In

the depth of breathing is increased considerably. At 12,000 feet, lung ventilation is apt to increase as much as 20 to 100 percent over the sea-level values. Increase of depth of breathing becomes noticeable in some individuals at heights of 4,000 feet. The rate of breathing, how-

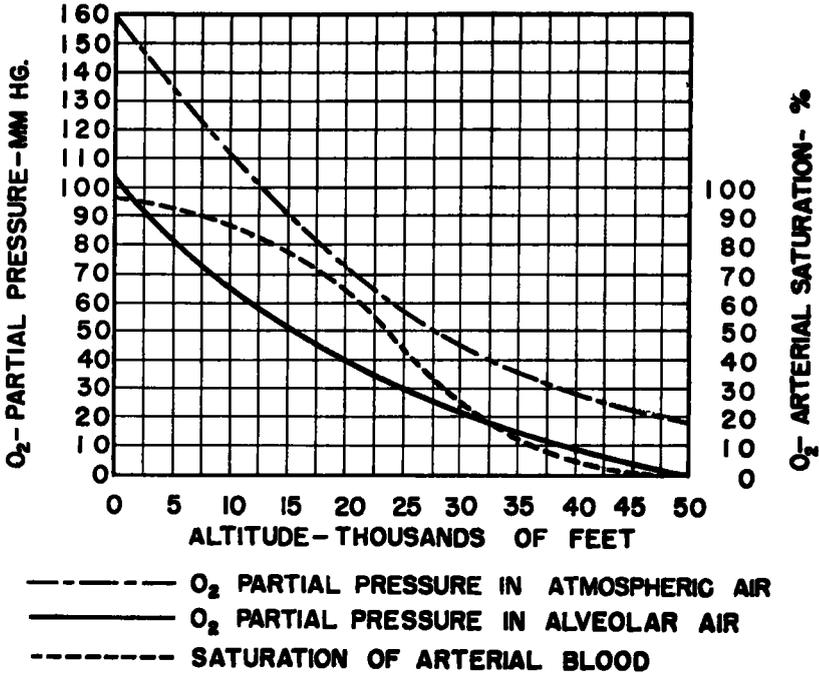


Figure A.

some individuals, exposure to altitude produces severe headaches, dizziness, a definite feeling of sickness accompanied by vomiting, muscular weakness, and mental confusion or even prostration.

TABLE A
SUBJECTIVE SYMPTOMS OF ALTITUDE SICKNESS

12,000	Altitude (feet) 14,000	16,000
Sleepiness	Headache	Headache
Headache	Altered respiration	Altered respiration
Altered respiration	Sleepiness	Psychological impairment
Lassitude	Psychological impairment	Euphoria
Fatigue	Lassitude	Sleepiness
Psychological impairment	Fatigue	Lassitude
Euphoria	Euphoria	Fatigue

But disregarding physiological details, the following objective symptoms become manifest in a human being exposed to altitude:

Respiration. Upon exposure to altitude,

ever, does not exhibit any significant increase.

Pulse. The pulse rate begins to increase at a height of about 4,000 feet and becomes rapid at altitudes of 14,000 feet. A mean increase of 27 beats per minute is observed at these heights. At altitudes below 12,000 feet, the pulse rate generally returns to normal if the exposure is prolonged for more than an hour.

The Senses. Night vision is the function of the eye first affected by altitude. This effect is demonstrable at altitudes as low as 4,000 feet. Rose (7) studied twilight visual acuity at simulated altitudes (in a low pressure chamber) and observed a marked decline under these conditions, but the twilight visual acuity was restored to normal within 24 hours at actual altitudes of about 6,500 to 10,000 feet. At higher altitudes (above 15,000 feet) accommodation, depth perception, and light perception are decreased. McFarland (16)

has studied the increased latency and the unusual quality and intensity of visual after-images observed at higher altitude. The deviations from the normal after-image phenomena are demonstrable at altitudes of about 9,000 to 10,000 feet and become pronounced at altitudes of 18,000 to 20,000 feet. Hearing is not normally affected below 16,000 to 18,000 feet. The senses of touch and pain are markedly dulled at high elevations. Loewy and Wittkower (13) found a slight impairment of sensitivity to pressure on the skin at heights as low as 5,100 feet.

Neuromuscular Effects. The first neuro-muscular effect to appear upon exposure to increasing levels of altitude is tremor of the hands. Goralewski (17) reports that 30.7 percent of a total of 58 subjects exhibited tremor when exposed to a height between 4,000 and 10,000 feet. At higher altitudes (12,000 to 30,000 feet) the following symptoms appear in this order: clumsiness and incoordination of finer muscular movements, slow-down of movements, cramps, and finally paralysis. These phenomena have also been studied extensively by other authors using hand-writing tests.

Psychophysical Effects. This realm of phenomena was explored in a series of ambitious studies by McFarland (16, 18, 19) using airplanes and during an expedition to the Andes. The effects do not become demonstrable below a height of about 12,000 feet. Simple reaction in response to an optical stimulus was impaired slightly only at the highest elevations (20,000 feet). The variability of response, however, was increased at lower levels (14,000 feet). At lower and medium altitudes (6,000 to 10,000 feet), a number of authors have observed an increased response of the reflex mechanisms that has been explained as a first compensatory reaction of the organism in response to a condition of mild hypoxia. McFarland further observed a slight decrease in momentary memory and, at higher elevations (14,000 to 20,000 feet) a signif-

icant reduction in mental capacity and volition, accompanied by mental fatigue and inability to concentrate.

Adaptation to Altitude. After a period of time, an organism exposed to altitude acquires a certain degree of altitude fitness. A person transposed from sea level to altitudes of 10,000 to 15,000 feet is apt to lose the major symptoms of altitude sickness within a period of a few days. Full adaptation, manifested by an increase in red cells and hemoglobin concentration in the blood, is acquired after a continuous stay at altitude for periods ranging from 2 weeks to 2 months. Upon return to sea level, the altitude adaptation is gradually lost within about the same length of time.

Pathological Aspects. Schneider (20) and Graybiel, et al, (21) have demonstrated that defects of the vascular system (arteriosclerosis) and the heart have a pronounced effect upon altitude fitness due to the inability of impaired vascular and cardiac systems to cope with hypoxia. Armstrong (15) assumes that anemias and respiratory diseases such as asthma and pneumonia are also apt to impair altitude fitness.

Concerning the altitudes encountered on highways in western sections of the United States the following can be concluded: As can be expected from the oxygen-saturation curve of arterial blood as a function of altitude, no major disturbances and symptoms of hypoxia should be present below 8,000 to 10,000 feet. There are, however, several passes in the West that lead well above the 10,000 feet altitude mark, such as Independence Pass (12,095 feet), Iceberg Pass (11,800 feet), and Milner Pass (10,759 feet), Red Mountain Pass (10,900 feet). In California there are a number of passes that reach close to 10,000 feet, such as Tioga Pass and Sonora Pass. At these altitudes the psychophysiological consequences of hypoxia could indeed, for a sizeable percentage of the population, result in a serious impairment of driver efficiency.

APPENDIX B

Hypnosis

So-called hypnotic effects may be a causative factor in accidents, particularly single car accidents, occurring on roads such as US 66. However, there is little experimental evidence in the available literature on this subject. Each writer seems convinced of the occurrence of the driver-hypnosis phenomenon, but usually does not go beyond anecdotal reports and conjectural statements (22, 23, 24).

To date, there are three types of postulated hypnotic effects. G.W. Williams (25) has pointed out two types. The first, which he calls "velocitization," refers to the driver's inability to appreciate his actual speed in terms of stopping distance when travelling at high speeds, and the second, which he terms "high-speed hypnosis," is a state of trance brought about by traversing mile after mile of monotonous highway. The third effect, "hypnagogic hallucinations," has been discussed by A. L. Mosely (26). He reports instances of long-distance drivers who imagined they saw something on the road and had to make emergency stops. This phenomenon typically occurred: (1) at night, (2) on long distance runs, (3) while the vehicle was moving, (4) while the driver activity was at a low level, (5) while the driver was feeling fatigued and sleepy. The hallucinated object required an emergency stop to avoid collision, which procedure the driver carried out without knowing the situation was not real.

Most drivers have experienced velocitization when entering a low speed zone after having driven many miles at high speed. Under these conditions, travelling at a low speed is usually perceived as though one were travelling at a still slower pace. It is reasonable to assume that the tendency to underestimate relatively low speeds under these conditions is merely an extension of a similar tendency for underestimation that was present while travelling at the higher speed. This assumption is supported by the known tendency of drivers to underestimate braking distance as speed increases. Perhaps velocitization is better explained as an habituation effect in which the driver accommodates to the high speed, and then

experiences a lag or delay in accommodating to the reduced speed.

All that seems required for velocitization to occur is a relatively brief period (about 15 minutes or longer) of driving on a good highway at a fairly constant and high (50 mph. or greater) speed. If velocitization does occur, it could be a contributing factor to highway accidents that involve errors in braking time.

Of these three effects, high speed hypnosis bears the greatest resemblance to the hypnotic trance as publicly demonstrated by professional entertainers. Indeed, one of the strongest arguments for the validity of high-speed hypnosis is found in the similarity that exists between certain prolonged driving conditions and known trance-inducing procedures. For example, the driving situation often presents such conditions as the monotonous hum of the engine, extended stretches of flat, tangent highway over uniform terrain, highly repetitious vibration patterns, and long periods of concentration on a single task. These conditions have their counterpart in the procedure often used by hypnotists, namely prolonged concentration on a single aspect of the environment such as a bright spot of light and uniform and repetitious external stimuli (e. g., remaining seated in a quiet room). One factor not encountered in the driving situation that occurs in many hypnotic procedures is the verbal suggestion of sleep given by the hypnotist. However, there is reason to believe that this factor of verbal suggestion only accelerates the hypnotic process and that prolonged exposure to the conditions previously mentioned will, by itself, be sufficient to produce a trance like state.

Many studies (27, 28, 29) have shown that a hypnotic trance closely resembles the waking state and is entirely different from that of sleep. It has also been shown that a person can perform driving functions while he is in such a state, but that his ability to react to sudden, unexpected road conditions such as a dip or curve in the road, would be expected to be impaired (30). Thus, the increased susceptibility

of drivers to accidents while they are in a hypnotic state is apparent.

The third aspect of driver hypnosis, specifically, hypnagogic hallucinations of objects or persons on the highway, probably occurs more often than has been reported. This is indicated by many instances where driver illusions are mentioned in casual conversation with drivers, especially with drivers on cross-country trips. There are many possible reasons why accident reports would not be expected to contain mention of hallucinations: (1) the hallucinating driver may be killed, (2) the emotional shock involved may cause unconscious forgetting or repression of the hallucinations, (3) the possibility of guilt may also cause such repression, (4) the possible consequences of admitting hallucination may bring about willful

withholding of information, and (5) the driver may never become aware of having hallucinated. Consequently, even in cases where they do occur and cause accidents, it is quite likely that hallucinations will be overlooked as causal factors, making it extremely difficult to isolate this particular aspect of driver hypnosis and establish its importance as an accident causing factor.

It is entirely possible that any or all of the above-mentioned aspects of hypnotic effect on drivers can be operating on highways and thereby contributing to the accidents that occur. However, since so little is known about the necessary conditions for the occurrence of these phenomena, specific conclusions as to their prevalence cannot be made at present.

APPENDIX C

Some Statistical Plans

Analyses of accidents can be directed toward a number of problems relating to psychology of trip geography or toward force complexes, such as hypoxia and hypnosis, that fit into a framework provided by the concept. But whether or not a particular analysis can be performed is determined entirely by whether or not the appropriate road usage information has also been collected. For example, hypotheses relating to the difference between male and female driving accidents can be tested only when the amounts of male and female driving are known. It is almost axiomatic that little if anything can be learned from accident data without the attendant usage information, which is the mandatory experimental control on the accident information. Several statistical plans will be developed here that will demonstrate the importance of usage information. The hypotheses considered are related to psychology of the US 66 trip geography in New Mexico.

California authorities would be concerned with the involvement of California drivers in accidents on this road. Hence, a problem of immediate interest would be whether or not the ratio of California driver accidents to other driver accidents is greater than the ratio of the number of

California vehicles using the road to the number of other vehicles using the road. The same problem restated from the standpoint of New Mexico authorities, would be whether or not nonresident drivers suffer a percentage of the accidents higher than the percentage of nonresident vehicles using the road. To solve either of these problems, it is first necessary to weight the accident experience of the two classes of drivers (California versus others or New Mexico versus others) according to the numbers of vehicles of each particular class using the road during the time in question. Normally, there will be some difference between the two weighted accident experiences. The problem to be solved statistically is whether such an observed difference is indicative of a real difference between the two classes of drivers, or whether the observed difference is merely the result of chance variation. One statistical plan for solving this problem is described below; it utilizes the well known chi-square test of independence, which is usually described in detail in any statistics textbook (31).

Let V_n represent the volume of non-resident vehicles using the road during some period of time, and let A_n represent the number of accidents involving these

nonresident vehicles. Similarly, let V_r and A_r represent respectively the volume and number of accidents involving resident vehicles. V_n, A_n, V_r, A_r all pertain to the same period of time (Table B).

TABLE B

Resident		Nonresident		Total	
Volume	Accidents	Volume	Accidents	Volume	Accidents
V_r	A_r	V_n	A_n	V	A

$$\frac{\left[A_r - (A) \frac{V_r}{V} \right]^2}{(A) \frac{V_r}{V}} + \frac{\left[A_n - (A) \frac{V_n}{V} \right]^2}{(A) \frac{V_n}{V}} = X^2 \text{ 1-df} \tag{1}$$

If the chi square value calculated as shown in Equation 1 is greater than the pertinent tabulated value, it can be concluded that the difference between resident and nonresident accident experience is greater than that which would be expected by chance; if the calculated value is less than the tabulated value, then it can be concluded that the difference was no greater than what would be expected by chance. It should be noted that the only usage information required for this analysis is the volume of resident and nonresident drivers using the road during the period of time under consideration, but without it the analysis could not properly be performed.

Another problem of particular interest involves the determination of whether or not the residence of the driver involved in an accident (resident or nonresident) is related to his direction of travel (eastbound or westbound). Statistically, this hypothesis pertains to the independence of the residence of the accident driver from his direction of travel. The previously described chi-square procedure can be used to test this more detailed hypothesis, the only difference being that more detailed usage data is required.

Let the subscripts e and w represent eastbound and westbound directions of travel respectively (Table C). V_{er} represents the volume of eastbound, resident drivers during some period of time. A_{wn} represents the number of accidents involving westbound, nonresident drivers, etc. The hypothesis of independence could be tested by computing the chi-square statistics according to Equation 2. The hypothesis would be rejected or ac-

cepted if the computed statistic was greater or less respectively than the pertinent tabulated value.

TABLE C

	Resident		Nonresident		Totals	
	Volume	Accidents	Volume	Accidents	Volume	Accidents
East-bound	V_{er}	A_{er}	V_{en}	A_{en}	V_e	A_e
West-bound	V_{wr}	A_{wr}	V_{wn}	A_{wn}	V_w	A_w
Total	V_r	A_r	V_n	A_n	V	A

$$\frac{\left[A_{er} - (A) \frac{V_{er}}{V} \right]^2}{(A) \frac{V_{er}}{V}} + \frac{\left[A_{wr} - (A) \frac{V_{wr}}{V} \right]^2}{(A) \frac{V_{wr}}{V}} + \frac{\left[A_{en} - (A) \frac{V_{en}}{V} \right]^2}{(A) \frac{V_{en}}{V}} + \frac{\left[A_{wn} - (A) \frac{V_{wn}}{V} \right]^2}{(A) \frac{V_{wn}}{V}} = X^2 \text{ 1-df} \tag{2}$$

An interesting group of possible analyses deals with the large number of possible interactions between the various postulated

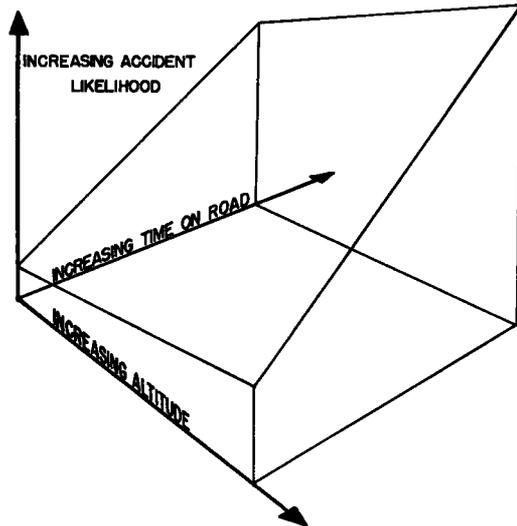


Figure B. Hypothetical effects on accident likelihood of (1) increasing time on road, i.e., fatigue, (2) attitude, and (3) fatigue x attitude interaction.

accident-causing factors. Each interaction would have to be studied separately because some might require different statistical plans than others. The interaction

of most apparent interest in this study deals with the relation between psychology of trip geography and altitude since this particular combination seems to be unique on Highway 66.

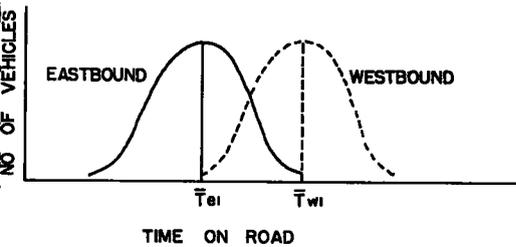


Figure C. Distribution of time on road at Point 1.

Possibly, this interaction can be described by a relation like that shown in Figure B where, for a given road time, there is a gradual increase in accident rate with increasing altitude, and, for a given altitude, there is a very sharp increase in accident rate with increasing road time. This implies that an increase in fatigue greatly increases accident likelihood irrespective of altitude, but altitude is important only when there is an attendant high fatigue level. The supporting arguments are: (1) as a person becomes more fatigued physiologically as well as psychologically he is more likely to have an accident, (2) time on road is a conservative measure of fatigue, (3) hypoxia effects will not occur except at higher altitudes, and (4) the possible interaction between fatigue and hypoxia effects previously described actually exists.

It is possible to examine this relation more rigorously. The mean altitude of each section of some arbitrarily decided length of the road is known. The accident rate there could be determined directly from the usual accident and volume data. Characteristic road times (time spent driving) for the drivers at the time they reach the section could be defined as the arithmetical average of the distribution of road times of all drivers when they reach the section. This distribution of road times would also allow for necessary variability determinations:

Since the eastbound trip geography is different from the westbound, any single point along the road would probably provide two different road-time distributions

occurring at the same altitude, one distribution for the eastbound and another for the westbound traffic. This is shown in Figure C where \bar{T}_{e1} represents average road time eastbound at the i th section of the road, and \bar{T}_{w1} represents average road time westbound at this same section. These two averages can be paired because of their common altitude, there being as many such pairs as there are sections of road. This essentially would separate out altitude effects and allow for testing the road time (fatigue) hypothesis.

The hypothesis that there is no difference between the eastbound and westbound road times could be tested by using the "Student t " test as follows:

Let Z_i represent the difference between the east and westbound traffic at the i th section and let \bar{Z} represent the average of all these differences.

$$Z_i = \bar{T}_{e1} - \bar{T}_{w1} \quad (3)$$

$$\bar{Z} = \sum_{i=1}^m Z_i \quad (4)$$

where m is the number of sections

The statistic t would be:

$$t = \frac{\bar{Z}}{s_z / \sqrt{m}} \quad (5)$$

where

$$s_z = \frac{\sum Z^2 - \frac{(\sum Z)^2}{m}}{m - 1} \quad (6)$$

The hypothesis that there is no difference between eastbound and westbound road times would be rejected or accepted according to whether the computed t was greater or less than the appropriate tabulated t with $m-1$ degrees of freedom. The hypothesis that there is no difference between eastbound and westbound accident rates could be tested by using the chi-square statistic. The following conclusions could be reached by combining the results of the road time and accident analyses:

1. When eastbound and westbound accident rates are equal, then: (a) the discovery of different average road times would suggest that road time (fatigue) is not contributing to accident causation at that section of the road and (b) the discovery of similar average road time would not permit any conclusions as to the effects of road time on the accident rate.

2. When eastbound and westbound rates are different, then: (a) the discovery of different average road times would suggest that road time (fatigue) is important, assuming these differences are in the same direction as those of the accident rates and (b) the discovery of similar road times would suggest that road time is not contributing to the accident situation at this section of the highway.

This is necessarily a fairly complex statistical treatment, but the key to it, just as with the simpler chi-square tests, is the availability of appropriate usage information, which, in this case, is the distribution of road times.

There are many more simple, enumerative types of statistical analyses that could readily be performed. Such analyses can give positive evidence of the

presence or absence of specific accident causes, and an increased general understanding of the accident problem on this section of the road. The only data requirements are accident information along with the appropriate road usage information. Of course, the road usage information must pertain to the same period of time as the accident information. Highway 66 seems to be particularly suited for such statistical study. Road usage information could be collected reasonably inexpensively yet accurately since there are a minimum number of cross roads. Because the accident experience there is high, the effectiveness of accident prevention measures should be detectable through statistical analysis, and a long range statistical program on the accident experience on this road should produce meaningful and useful results.

Discussion

CHARLES M. NOBLE, Chief Engineer, New Jersey Turnpike Authority — The writer has long been interested in psychological studies pertaining to highway accidents.¹ It is encouraging to note the increased attention being given this subject and although progress has been slow, greater interest and application of talent to the problem should result in increasing knowledge in this relatively unknown field. It is believed that the Institute of Transportation and Traffic Engineering of the University of California could well join forces and work closely with the Committee on Highway Safety Research of which Dr. T. W. Forbes is technical director so that the overall effort can be effectively coordinated.

The writer agrees that if accident statistics show that certain highway areas have a high accident rate and if the causes of such accidents are known, a program of corrective measures should be promptly tried out and evaluated. Only in this way can the psychological approach be proved effective. Public information is a useful and powerful tool in this effort so the public can be informed where dangerous stretches of highway are located, the

causes of accidents in these areas and the prevalent human errors that lead up to such accidents.

The policy of applying corrective measures as soon as they have been devised has been followed by the New Jersey Turnpike. Every accident is studied and causes determined when possible. Then every practical means for accident reduction is applied. As rapidly as promising measures are developed, they are put into effect and the results observed. To date, the analyses indicate that human error and mechanical failure are responsible rather than the design of the highway. Augmentation of police personnel proved an effective measure in accident reduction.

It is interesting to compare the New Jersey Turnpike 1952 and 1953 accident and fatality rates. It is evident that the application of safety measures has resulted in lowering these rates:

	1952	1953
(a) Accident rate	92.7	87.1
(b) Fatality rate	6.11	4.14
	(per 100 million vehicle-miles)	

To date it has not been feasible to determine the individual effect of each of the various measures utilized.

It is noted that a standard operating procedure has been promulgated to cover those cases involving restricted visi-

¹ "Thoughts on Highway Design Research as Related to Safety of Vehicle Operations." Page 242, Proceedings of the Highway Research Board, 1937, Vol. 17

bility and other effects of adverse weather. It is noted that the 1953 New Jersey Turnpike accident rate is only 9 percent of the national rate and the fatality rate is approximately 60 percent of the national rate.

One of the critical accident problems on the New Jersey Turnpike is occasioned by rear-end collisions where one vehicle smashes into the back of another, often without any indication that the driver saw the vehicle ahead. This indicates that the driver lost depth perception and the ability to determine how far a vehicle is ahead. Obviously, this situation is more serious at night.

Because of this accident experience which seems to be widespread nationally, the New Jersey, Pennsylvania, and Ohio turnpike commissions recently met in Harrisburg, at the request of the Pennsylvania commission to consider the drafting of uniform regulations concerning rear lighting and rear bumpers for trucks. A committee has been appointed from the staffs of the three commissions and this committee is now at work drafting recommendations.

It is noted that newspaper publicity although sometimes painful can be beneficial inasmuch as it serves to warn the public that the driver after all must still drive the car. The public generally has become so used to the many scientific miracles unfolded during the last 40 years that many motorists gain the impression that somehow engineers have been able to design highways which make it unnecessary for the driver to actually drive the car. Publicizing the continued need for driver responsibility is a worth while effort and the public press can also contribute toward public safety by emphasizing habits which are inherently dangerous and inevitably lead to accidents, such as bumper riding, passing on the right, etc.

It seems to me that a most-important contribution by the authors of this paper is in pointing out that certain areas of highway may be dangerous, not because of their physical characteristics but because of their location relative to trip origins. This thought deserves much consideration and should be the basis of effective safety publicity.

In conclusion, I am glad to see this activity in the field of driver psychology

and hope that it will be pressed forward in a coordinated and purposeful manner.

JAMES S. BURCH, Engineer of Statistics and Planning, North Carolina State Highway and Public Works Commission — "The authors have presented a concept — that was developed entirely by deductive reasoning with no experimental and little empirical verification."

That sentence is perhaps the most significant in the 10,000-word text. The paper employs dozens of phrases such as: a possible explanation; the authors believe; can only be conjectured; probably, may, may be, could be; appear to have; seem to apply, may explain.

The three-author paper appears to be a psychological dissertation or postulation on an hypothesis and, therefore, an academic discussion, rather than a research paper. Since it isolates no variables and develops no new knowledge, it has value only in the field of discussions of possibility.

Three readings leave this capsule impression. Overfatigue is probably the special contributing factor to this high accident record. That fatigue contributes to accidents is a conclusion which has been accepted as true in the safety field for the past 50 years or more. Drivers who do not know this are doomed to accident involvement.

To one who has spent 30 years in the highway field, the remedial measures suggested are either inadequate or impractical. If the highway officials believe this concept to have merit, they could have uniformed troopers stop all out-of-state cars moving east in the late afternoon, at this section, and strongly advise a 10-minute break, to overcome hypnosis, hypoxia, fatigue, depressed cutaneous sensations, and other such phenomena.

The major merit in the paper is stated as follows: "The authors want to encourage all those who are active in accident prevention to have the concept of psychology of trip geography in mind as they consider their accident problems. This, in essence, highlights the primary objective in presenting this report at this time, admittedly without supporting evidence."

It is encouraging to note that the Institute of Transportation and Traffic Engineering is now planning a program to verify the importance of the concept and

provide direction for specific remedial actions.

It has long been known that the weakest aspect of the vehicle-road-driver combination involves basic shortcomings of the driver. It is to be hoped that the study program suggested can contribute new and definite knowledge about such shortcomings in a way that can be reliably accepted as true by the public and leaders in the field of highway safety. The paper falls far short of this goal, as stated by the authors.

T. W. FORBES, NRC Committee on Highway Safety Research¹ - The formulation of an hypothesis for a particular problem based on information from other areas of scientific research is one of the fundamental first steps which has often led to research in a new direction and resulted in new information. The authors have formulated such an hypothesis regarding possible causes of accidents on a certain stretch of highway in New Mexico on the basis of fatigue and altitude effects. They have cited a wide range of studies on such effects from aviation physiology and psychology and have pointed out that these factors may be both interacting and additive. They have also called attention to certain known perfectly normal but illusory sensations which may play a part in highway accident causation.

This hypothesis furnishes a possible alternative explanation for what has been widely called "highway hypnosis," without accurate formulation or verification, and perhaps even with an aura of mystery. As a more straightforward explanation the authors' hypothesis seems more acceptable scientifically. To the best of the writer's knowledge, little valid evidence for true hypnotic characteristics has been shown for the wide range of driver reports to which the term "hypnosis" has been so generally and loosely applied.

The title "Psychology of Trip Geography" is perhaps unfortunate since the impression from the title may obscure what seem to be important phases of the paper. On analysis it can be seen that the title refers only to certain details of the hypothesis, i. e., possible reasons why drivers become overfatigued.

¹ The opinions expressed are those of the author personally and not necessarily of any organization with which he is connected.

Inclusion of specifications for remedial measures also seems unfortunate since this might give the impression (undoubtedly unintended by the authors, we are sure) that they consider their statement of the hypothesis sufficient without further test. Moreover, the expedients suggested, such as signs along the highway and pamphlets have not always proved very effective in other applications where they have been used.

Incidental mention in the text and Appendix B on hypnosis somewhat uncritically introduce "highway hypnosis," "velocity-tization" and "hypnagogic hallucinations," apparently implying that these are true hypnotic effects. It is not very clear whether this is part of the hypothesis or merely extraneous information.

As with all hypotheses, this one must be put to experimental test, and Appendix C gives some plans for a statistical analysis of accident records. However, it seems improbable that this approach alone will be sufficient to prove or disprove the hypothesis since numerous factors of the hypothesis may be averaged out in this type of analysis. Such an analysis may furnish some clues but for evaluation of some of the factors hypothesized, other experimental methods would seem to be indicated.

Bearing all this in mind, however, the formulation on a basis of measurable variables of an alternate hypothesis to the somewhat loose and unformulated hypothesis of highway accidents caused by "highway hypnosis" seems to the writer an important contribution toward fresh thinking and the stimulation of research. If psychological explanations and true hypnotic effects are to be included in the hypothesis, however, the formulation should be sufficiently definite and clear to allow experimental evaluation.

SIDNEY J. WILLIAMS, Assistant to the President, National Safety Council - We may agree that the fatal accident rate on this section of highway probably is unusually high. We may further agree that contributing personal factors include hypoxia or mountain sickness, even in mild form at these altitudes; road hypnosis including hallucinations; and, importantly, the cumulative effect of these and other influences.

The novel concept presented is, of

course, the "psychology of trip geography." (Is this cumbersome term necessary? Why not "trip psychology?") Here is postulated a driver leaving Los Angeles for the East, intending to stop overnight at Flagstaff, then deciding to push on to Albuquerque; result, haste plus fatigue, etc., equals an accident. A plausible idea, but why didn't the authors rough-check it against the record? Did many of these accidents involve east-bound out-of-state drivers in the late afternoon or evening?

Apparently the psychology of trip geography boils down to this: many drivers try to go too far, in one day, or in one hour. Will they be dissuaded by pamphlets handed out at the state line, or by road signs to be read at 70 plus? Hardly. By advice from their trip-planning services? Perhaps. The State of Washington has recently found that vigorous enforcement against violators (speed and other) is a potent dissuader.

Assuredly, we all need to know more about personal factors contributing to accidents. And knowledge generally starts with hypotheses. Thus we are grateful to these authors, if only for giving us something to shoot at.

HEINZ HABER, ROBERT BRENNER, SLADE HULBERT, Closure — The authors are gratified by the stimulating discussion of their paper and wish to extend their thanks to the discussors.

Williams and Forbes question the wording of the title of the concept, "psychology of trip geography." This concept pertains to the manner in which psychological aspects of driver behavior interact with trip planning and certain geographical specifications of trips. It was decided that all three terms, "psychology," "trip," and "geography" necessarily appear in the title. The authors recognize that the concept title is somewhat cumbersome, and therefore suggest that the concept be referred to in the future as "PTG." For example, one could refer to a driver's adherence at all costs to a previously fixed trip schedule as "poor PTG adjustment."

Noble's comments support the contention that it is in order to proceed with remedial techniques that hold promise of reducing accidents. The authors are quick to agree that highway officials who are in-

timately familiar with the problems of a particular accident focal point are best qualified to devise immediate remedial methods. It is desirable that careful measurements be ultimately made to verify the effectiveness of the remedial measure.

The authors believe the remarks of Forbes concerning highway hypnosis correctly emphasize their contention that ". . . there is little experimental evidence in the available literature on the subject . . ." and ". . . since so little is known about the necessary conditions for the occurrence of these phenomena specific conclusions as to their prevalence cannot be made at present."

The postulated trip to Albuquerque is only ". . . one example of the concept . . ." If this is not recognized, the generality of the concept might not be fully understood. Overfatigue is only one accident producing condition that may engulf the driver who makes poor PTG adjustments. Many other accident producing conditions such as increased aggressiveness, impatience, speeding, etc., can be expected to result from poor PTG adjustments.

The authors are fully aware that the ideas presented in this paper have not been developed beyond the stage of hypothetical thinking. Eventually, these hypotheses must be subjected to the scrutiny of experimental research and verification. Meanwhile, however, these ideas may serve the purpose of realigning our thinking and opening a new approach to the highway accident problem. In the past, an accident on the road has been looked upon as a singular event which occurs at a certain place and at a certain time. Practically the entire work and effort that went into investigating the causes of an accident were directed toward elucidating the circumstances surrounding the vehicle, location and time of the accident, and the condition of the driver at the place and time of the accident. In practically all instances of accident investigation, the individual accident is traced back not more than a few hundred feet in space, and 30 seconds or so in time. The authors believe that accident causation should better be traced back 400 to 600 miles in space, and up to and possibly more than 12 hours in time. From this point of view an automobile accident is not considered a singular event, but the sudden

culmination of a series of events of which the actual accident is only the conspicuous end product. The extension of the accident causality in space and time, of course, makes it relate to a much greater section of the highway plant, to the geography of the highway plant, to its operational characteristics, and to the manner of its use by the driving population.

In order to put the ideas surrounding psychology of trip geography to use, information is needed on the average driving and trip planning habits of the population. It is perhaps a significant point that practically no information is available in this field. This lack of information can be explained by the fact that, in the past, investigations of accidents were confined to the immediate place and time where they occurred. The only reliable information on trip planning and execution is available through the records of truck fleets and bus companies. We do not know, however, how the average private citizen executes a trip and in what manner he uses the highway plant: in other words we do not know PTG behavior.

A second thought that comes to mind in relation to psychology of trip geography is the fact that the modern automobile in conjunction with the modern road outperforms man by a wide margin. Only 20 years ago the automobile and the road constituted a system of only moderate reliability. Trips exceeding 400 miles and 12 hours could not be made with the same ease and regularity as is possible today at any time. Before the advent of the modern luxury car equipped with balloon tires, coil springs, automatic transmissions, power steering, and power brakes, the driver could hardly overextend his natural facilities of attention, alertness, and delicate judgment. In

other words, before he could be more or less subconsciously overcome by mental and psychological fatigue, his natural physical fatigue, or mechanical failure of his car, or road difficulties prevented him from continuing his driving. Today, both the reliability and ease of operating a modern car on a modern highway cause the driver to reach the limit of psychophysical performance long before there is any chance that his equipment will fail. There can be little doubt but that the great increase in performance of our modern transportation plant has influenced the driving and trip-planning habits of the average driver. It can be concluded that this development makes it necessary to put greatly increased emphasis on problems of mental and psychophysical fatigue, the role of tactile sensitivity in the driving task, and the natural limits of man's performance of a physically easy, but psychophysically strenuous task.

An avenue of approach to a better understanding of the problems at hand suggests itself. (1) collection of PTG behavior information such as trip planning and execution by the average driver in different sections of the country; (2) studies on the importance of tactile cues in the driving task; and (3) studies of psychophysical performance and limits, in relation to the driving task.

It is to be hoped that work in these research areas will lead to a better understanding of the accident problem. Research in this field requires that the problem be considered in terms of the geography of the entire country, the physical and engineering characteristics of the highway plant and the vehicle, and the peculiarities of the driving task in relation to known psychological behavior patterns.