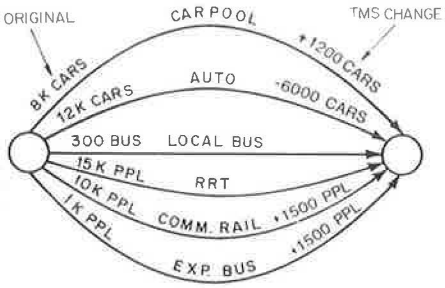
Figure 4. Hypothesized distribution of trips.



CASE 4: EFFECTS OF A TRANSPORTATION SYSTEM MANAGEMENT ACTION

Because there is such a diversity of possible actions that can be taken in a transportation system management (TSM) effort, only a simple illustration is addressed here.

Consider the situation illustrated in Figure 4 and based on a hypothesized distribution of trips by several modes in the corridor of interest. The FI values for the subject modes can be used to compute a person-weighted total risk, defined as the summation over the modes of "people times the individual modal FI values", computed for the initial system.

Based on the forces that motivated the TSM action (e.g., increased utilization of capacity or energy conservation), it is hypothesized that the amounts shown on the right-hand side are put into effect. The total person-kilometers is not changed, but the total system risk has had a net decrease of 8.6 percent. This simply highlights the fact that a shift among modes, whether due to TSM actions or other causes, can itself induce changes in the total societal baseline. At the same time, the individual modal FI values for the individual traveler may not change.

CONCLUSIONS

In any systematic study, it is necessary to evaluate the effectiveness of any countermeasures taken. This is often done by a simple before-and-after study of relevant statistics. Unfortunately, many safety-related studies involve long time periods in the collection phases. This can be much more than an inconvenience. As illustrated in this paper, it is quite reasonable that major forces and trends in our society (or in any society) will cause the safety baseline to change during the analysis period. Without careful planning, historical data can be rendered meaningless and erroneous conclusions can easily be drawn. This paper illustrates some key forces that will cause future changes in the accident experience large enough to rival or exceed the effects of most rather successful accident countermeasures and make some rather meaningless ones look rather good.

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**J. Byun was with the Transportation Training and Research Center, Polytechnic Institute of New York at the time this research was performed.*

Applicability of Behavior Theory to Transportation

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The applicability of two theories of behavior—the humanistic theory and the behavioristic theory—to two areas of transportation—safety and modal choice—was tested. The first experiment supported the use of the behavioristic theory to explain driver compliance to speed limits and found that public information campaigns were ineffective. The second experiment also supported the use of the behavioristic theory and showed that reinforced choices will be made more often in an environment where positive controls govern the consumers' modal choice.

At least since 1970, the federal and state governments have attempted to coordinate their concerns with transportation environmental safety, pollution, and energy conservation. Throughout the same period, and especially since the 1973-1974 energy crisis, the federal government has attempted to reduce the use of petroleum-based fuels. As a result, by one means or another, the public is being asked to make greater efforts toward energy conservation and the control of environmental pollutants. A major contributor to both the high level of air pollutants and the rate of energy consumption is the motor vehicle and the driving behavior of its operators.

The motor vehicle and its operators are part of an interface within the transportation system. As with all systems subject to behavior analysis, it is necessary to assume that a transportation system has its own well-defined environment. The transportation environment supports a specific transportation culture that, in turn, controls a set of appropriate vehicle-operator behaviors. These behaviors are controlled, to some degree, in the following manner.

When a driving behavior is appropriate, positive and negative cultural controls reinforce that behavior, thus increasing the probability that it will be repeated. When a behavior is inappropriate, it is either ignored or punished, thus decreasing the probability that it will be repeated.

The transportation environment in the United States has been so designed that the only controls over driving behavior are aversive in nature. Such controls include (but are not limited to) the issuance of traffic summonses to noncomplying drivers, the loss of driving privileges, increases in insurance premiums, the loss of life and property (or the threat of loss of these), and increases in maintenance costs.

Statistical analysis of accident rates has shown a yearly increase in such rates and that there is no positive correlation between increased levels of aversive control by enforcement agencies and decreased levels of accidents or violations (1).

One of the most important pieces of information relevant to the control of driving behavior may have been gained during the 1974 fuel crisis. Drivers drove more safely when controls so demanded and, in addition, it was found that the use of single-occupancy vehicles decreased and that of public transportation modes increased.

During the fuel crisis, most drivers became aware of the direct relationship between speed and the fuel consumption of their motor vehicles. Although it was also true that, during this period, speed limits were lowered via legislation, it seems rather unlikely that such legislation alone caused the observed significant reduction in the speeding behavior of drivers. Similarly, the correlated decrease in the use of single-occupancy vehicles and increase in the use of public transportation modes cannot be explained as simply a consequence of the legislated lower speed limits. The fact that obtaining fuel was such an annoying task, requiring driving around to find a service station that was open and waiting in lines for hours, thus, having to give up other more rewarding activities, coupled with the sudden and marked increase in the cost of fuel, provided the needed negative control over speeding behavior. The reinforcement contingency was quite clear: Driving at 88.5-km/h (55 mph) resulted in the removal (from the drivers's immediate environment) of a series of unpleasant and aversive stimuli to which he or she might have been exposed.

Driving at lower speeds resulted in the removal of unpleasant stimuli and in an increase in the frequency with which appropriate behavior was being reinforced. Driving at higher speeds resulted in the continued exposure to aversive transportation-related stimuli and in the occasional punishment of such inappropriate behavior by enforcement authorities.

Once the fuel crisis was over, however, and gasoline was plentiful again, speeding behavior showed spontaneous recovery; no reasonable amount or severity of law enforcement can control such behavior and depress its level of frequency to that observed during the fuel crisis.

Everett, Hayward, and Meyers (2) have described a design that tested bus ridership as a function of the reinforcement of such behavior. When positively reinforced, ridership on a campus bus increased markedly. When reinforcement was withdrawn, ridership on the bus decreased to the premanipulation levels.

Paine and others (3), in studies of consumer attitudes toward automobile versus public transportation modes conducted in Baltimore and Philadelphia, found these attitudes to be controlled by powerful social norms. These norms reinforce the choice of private automobile over public transportation. The choice of private automobile is reinforced despite the harmful consequences of increased air pollution and the continuing depletion of natural resources.

The major purpose of the studies presented in this paper was to test the divergent predictions of two theories of human behavior as they relate to the behavior of drivers in the transportation environment. The two theories are

1. The humanistic theory of behavior and
2. The behavioristic theory of behavior.

EXPERIMENT 1: 88.5-km/h SPEED LIMIT

The underlying hypothesis in this experiment was that there is a direct relationship between noncompliance with limits of vehicle operating speeds and the strategy of speed control used. Two strategies of speed control were considered.

The first strategy was based on the explanation of speeding behavior through the use of the humanistic theory of behavior. This theory hypothesizes that the variables that control vehicle operating speeds are

1. The depth of penetration of information relevant to the consequences of speed control,
2. The operators' motivation to become self-actualized by seeking a measure of self-control over the speed at which the vehicle is operated, and
3. The success of the reeducative strategy of driver education.

The second strategy of speed control considered was based on the explanation of speeding behavior through the use of the behavioristic theory. This theory hypothesizes that the variables that control vehicle operating speeds are the past histories of reinforcement and punishment relative to the speeding behavior of the operator.

There were 80 participants in this experiment (37 male and 43 female), all students at the State University of New York College at Fredonia. Participation was voluntary, and participants gave their informed consent before participating in the survey. All participants were licensed drivers.

A questionnaire devised to measure attitudes and behavioral practices regarding the 88.5-km/h speed limit was administered. On the average, participants had been licensed drivers for at least 3 years, and 45 percent owned their own automobiles. There were about 2.3 automobiles/driver's family. The fastest average speed ever driven on a major divided roadway was 133 km/h (83 mph). The slowest average speed reported was 54 km/h (34 mph), and the overall average operating speed reported was 94 km/h (59 mph). Forty-seven percent of the sample drivers had had at least one accident, and there was an overall average of 1.8 accidents/participant.

Ninety-one percent of all participants indicated that they believe that a national speed limit is necessary because people in general are not responsible enough to control their own speeding behavior. Eighty-four percent of all participants believed that compliance with the 88.5-km/h speed limit saves lives, and 79 percent asserted that it saves gasoline as well. Eighty-nine percent of all participants believed that automobiles are major contributors to air pollution and that driving at 88.5-km/h reduces overall pollutant emission.

Drivers' compliance with the speed limit was not positively correlated with the index of information penetration. A negative trend of correlation was observed but it did not reach significant levels ($r = 0.135$; $df = 78$).

With regard to choices of transportation mode, 55 percent indicated that they would use their own automobiles to commute from home to work. Thirty-four percent would carpool as an alternative, but only 6 percent indicated that they would consider a form of public transportation. Eighty-four percent of all participants indicated that they believed that public transportation (subway, bus, or train) is the transportation trend of the future, and 76 percent indicated that they believed public transportation to be more fuel efficient and less polluting than private automobile transportation.

The humanistic theory of driving behavior was not supported. The information tested had deep penetration as shown by the facts that 84 percent of the participants felt the 88.5-km/h speed limit did save lives, that a slightly smaller percentage believed that it saved gasoline, and that 89 percent believed that compliance with it will reduce air pollution. However, participants reported a low level of compliance with the speed limit, excessive speeding behaviors, and a high frequency of accidents. Ninety-one percent of the participants indicated that they favored law enforcement of speed limits and felt that people, on the whole, are not motivated by self-actualizing needs to control their own speeds.

Contrary to commonly held beliefs, the reeducative strategy of driver education has been largely ineffective in the actual control of speeding behavior. Government-sponsored programs aimed at increased dissemination of information relevant to the positive consequences of compliance with national speed limits were successful when information penetration was measured. These reeducative programs were responsible for the formulation of responsible attitudes with respect to transportation. However, these programs were not successful in controlling driver behavior.

Thus, the results of the experiment supported an explanation of driver speeding behavior through behavior analysis and a behavioristic theory of driving behavior. Furthermore, the results suggest that the control of driving behavior through the use of punishment and other aversive controls is ineffectual. The control of driving behavior through positive and negative reinforcement is the most effective means of behavioral control. In operation, such reinforcements could mean express lanes for buses and carpools and reduced tolls, insurance rates, and fuel costs for compliant drivers and for drivers opting to use public transportation rather than driving alone. The second experiment was designed to test these largely hypothetical assumptions.

EXPERIMENT 2: MODAL CHOICE

The major purpose of this experiment was to test the premise that the reinforced choices would be made more often in an environment where positive controls reinforce consumer choice of the public transit and carpool options and do not reinforce the private automobile choice.

Four experimental conditions were designed. It was hypothesized that pretest choices of private automobile would remain unchanged in the control and incentive conditions but would change significantly in the reinforcement and mixed conditions.

The participants in the experiment were 40 male and 40 female undergraduate students enrolled at the State University of New York College at Fredonia. All participants had a valid driver's license, gave informed consent before participating in the experiment, and did not take part in experiment 1. Participation in this experiment was voluntary.

The instrumentation used in the experimental design corresponded to two experimental phases:

1. Measurement of attitudes toward existing transportation modes and
2. Simulation of a commuting transportation environment.

The measurement of attitudes was accomplished by using a two-part (pretest and posttest) questionnaire to record participants' responses. A game that simulated the actions taken by a person living 80 km (50 miles) from his or her job was developed to reproduce a real commuting environment. Participants traveling to work were asked to develop transportation-related behaviors appropriate to one of four types of environment:

1. An environment that reinforces appropriate modal choice,
2. An environment that provides year-end incentives for appropriate modal choices,
3. An environment that provides both immediate reinforcement and year-end incentives for appropriate modal choices, and
4. An environment that does not control the modal choice.

In the last scenario, participants were, in effect, asked to use their past history of reinforcement to make a decision. Random assignments were made to the various conditions. In all conditions, participants traveled (twice each) to work by bus, as members of a carpool, or alone in their own automobiles. It was required that a formal economy that used simulated money and account sheets be maintained by all participants except those in the control and incentive conditions. All participants were required to follow instructions presented to them on cards placed at strategic locations.

These cards contained information relevant to keeping the formal economy. Thus, participants were informed about the gasoline efficiency of their automobiles, travel time, out-of-pocket costs, and travel routing. Under all conditions except the control condition, the participants were given information on tax incentives related to various transportation modes.

All participants completed the posttest questionnaire and were debriefed by the experimenter.

The general opinion of the participants was that the simulation resembled a real-world situation. Thus, 98 percent of all participants felt that the simulation game was very much like the real-world situation. One participant felt that the simulation was only somewhat like real-world transit conditions, and one participant did not answer the question during debriefing.

Of the participants in the immediate-reinforcement condition, 70 percent changed their choice of transportation mode in the desired direction. Of the participants in the combined condition (immediate reinforcement and year-end incentives), 60 percent changed their choice of transportation mode in the desired direction. Only 30 percent of the participants in the control and incentive conditions changed their choice of transportation mode in the desired direction.

To test for differences in frequency of change among the four different conditions, a χ^2 test was used. The control condition was used to supply the expected value, which was compared with each treatment condition.

The difference in frequency of change between the immediate-reinforcement condition and the control condition was significant at the $p < 0.01$ level. The difference in frequency of change between the combined condition and the control condition was significant at the $p < 0.02$ level.

There were no significant differences in frequency of change between the control and incentive conditions or between the combined and reinforcement conditions.

Thus, the results of this experiment conclusively support the experimental hypothesis. Participants overwhelmingly indicated their preference for the private automobile when asked to choose the mode by which they would commute from home to work. Those randomly assigned to the reinforcement and combined (reinforcement and incentive) conditions changed their opinion and chose, on a posttest, to commute by public transportation or by carpool. Incentives promising positive year-end consequences to appropriate behaviors were found to be ineffective in controlling driver behavior. The incentive and control conditions showed no differences between pretest and posttest choices.

It is becoming increasingly clear from experiments such as these that strategies of transportation behavior that use the explanatory powers of behavioristic theories promise to have real and lasting effects on the control of driving behavior and modal choice. On the other hand, predictions of greater control of driver behavior through the application of humanistic principles remain unsupported.

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Improving Traffic Safety in Rural Kansas

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The traffic engineer's goals are to provide safe, efficient, and convenient movement of persons and goods on streets and highways and to provide adequate modal transition. In larger urban areas and along primary roads, this purpose has been met to varying degrees. However, in rural areas where most cities have populations of less than 5000, there is a lack of proper traffic-control devices and of traffic engineering studies and help. In southwestern Kansas, the population density is less than 4 persons/km^2 (10 persons/mile^2), and there were no local traffic engineering personnel in the 41 150-km^2 (16 000-mile^2) area. The Greater Southwest Regional Planning Commission created a position of regional traffic engineer in late 1976, which was funded through the Kansas Department of Transportation and the Federal Highway Administration. During the first two years, the engineer has (a) involved 29 of the 45 cities in federally funded traffic-sign-improvement projects, (b) completed or initiated analysis at several high-hazard locations, (c) assisted local units of government to become aware of and obtain state and federal funds, and (d) worked with local government personnel in 18 of the 19 counties in the region to establish some local expertise in traffic safety. The primary benefit of the regional traffic engineer has been that traffic engineering has been brought to southwestern Kansas with a personal touch. The local units of government could not individually afford and, in fact, would not need a full-time traffic engineer. Under the commission assistance plan, the engineer is on call to all the local units, is governed by them, and is used by them. A regional traffic engineer is a means of providing expertise to rural areas.