4 INCENTIVE PROGRAMS FOR PROMOTING SAFER DRIVING

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I will discuss incentive programs for promoting safer driving. I am an experimental psychologist who has spent most of his professional life studying learning and memory of college students as they work on artificial laboratory tasks; I have not done research on the psychology of driver safety, so you must be prepared to excuse a certain naivete in my remarks due to my unfamiliarity with the research on driver safety or current national programs to improve road safety. With those excuses given in advance, let me begin.

All of us are well aware that traffic accidents–and the injuries, fatalities, and damages they cause–are a major cost of our transportation system. Reducing those devastating costs requires a multidisciplinary effort: transportation engineers, automotive engineers, governmental agencies and police departments all contribute to making our highways safer. However, I will confine my remarks here to the behavioral science perspective.

I will focus on improving safe driving practices through programs aimed at individual drivers. One has only to examine the current laws and their failures to realize that the level of accident losses is about what our societies have resigned themselves to accept as the necessary cost of a fast, convenient transportation system that still allows its citizens to drive with relative freedom from aversive restraints. People love the freedom provided by their cars; they treat them as an extension of themselves. This attitude is reflected in a car advertisement currently playing on television in America. The ad opens with a long, slow shot of a Cadillac and a voice says, "Psychologists state that many men use performance cars as a symbol of their manhood. We'd like to point out (here the camera scans along the car) that Cadillac is significantly . . . longer . . . than the competition."

Because people's cars and driving often expresses their personal style, they resent any law that restrains their driving. This attitude must change, so that people view driving as a solemn obligation to protect the community rather than an opportunity to flaunt their individual machismo in reckless highway games.

Speeding: Variable Limit Systems

What driving practices contribute to vehicle accidents? The police consider speeding a major cause of auto accidents. Their popular slogan is "Speed kills." Despite their concern, there is no doubt that the present system for setting speed limits and enforcing their compliance is a colossal failure. I expect Europe is similar to America where practically everybody drives faster than the speed limit most of the time, and enforcement is infrequent and sporadic. When looking at this massive failure, the first thing a behavioral scientist would ask is, "Who's setting the speed limit? Why do 90% of the people think it's perfectly safe to go faster? Are we all so stupid that we are taking unnecessary risks?

I think a strong argument can be made that the speed limits on most highways are set too low and that we should consider more realistic, variable speed limits. In such a system, the speed limit on a given road would be set at a level that changed over time depending on the prevailing conditions of the highway, adverse weather and traffic congestion. I have heard that variable speed limits have been tried on some European highways with some success.

The notion of variable speed limits assumes that the middle 70% of drivers are rational in choosing a speed that balances their arrival time against the risk level they are willing to accept. Apparently drivers who go much faster, or much slower, than the average car are more likely to have an accident. Figure 1 shows this U-shaped relationship based on United States highway reports from 1982 (Warren, 1982). It shows the accident-involvement rates per 100 million vehicle-miles driven depending on the vehicle's deviation from the average speed in miles per hour, the three curves representing data from freeways, smaller highways during daytime and during night driving. The fact that slow-moving vehicles have as high an accident rate as fast vehicles indicates that both a lower and an upper speed limit should be set.[1] The graph suggests that accidents would be minimized if most people drove near the average speed at which traffic flows smoothly without bunching up. If everyone drove near that same speed, it would maximize distances between cars, reduce overtaking, lane changing, and rear-end collisions. A further recommendation is that the desired average speed would be that which most drivers would spontaneously adopt for given road conditions.

A variable system would post the recommended speed limit on electronic highway signs every few miles. These speed limits might be changed every half hour or so by a computer which took account of the traffic congestion and the weather. In addition, the signs could indicate lane closures due to work crews or accidents on the road ahead, suggested slowdowns due to traffic jams ahead, and alternate routings.

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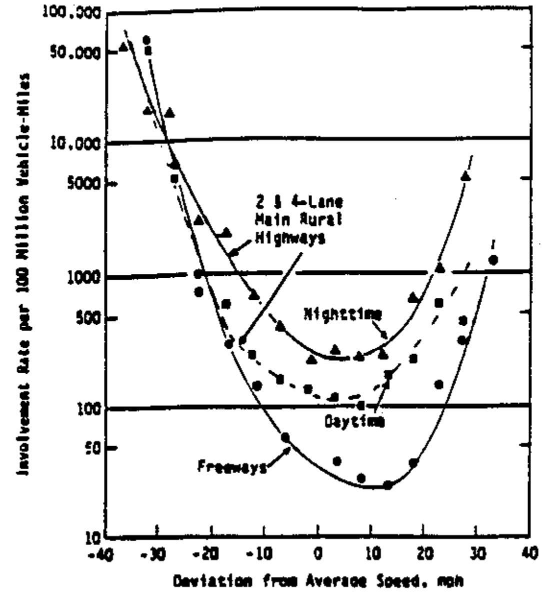
[1]) The U-shape of Figure 1 may be a consequence of the fact that accidents most likely involve a faster vehicle overtaking and hitting a slow vehicle. We could simulate travel of a collection of vehicles moving at different speeds, adding the assumption that whenever one vehicle overtook another their momentary accident-rates were slightly elevated. I imagine that that assumption would suffice to produce the U-shape of Figure 1.

An immediate advantage of a higher average, variable speed limit is that in one stroke the state would reduce the currently outrageous percentage of people driving at unlawful speeds, and perhaps make speeding a more substantial social evil than it is at present. My variable system would convey the message that it is variability of speeds among different drivers that kills since that causes the bunching up of cars in dense traffic.
But even with variable speed limits, there will still be many speeders and reckless drivers. In America we have the saying: "The most dangerous part of a car is the nut that holds the steering wheel." What more can be done to reduce the reckless driving of the nuts?

Figure 1. Accident rates depending on deviation of vehicle from average speed on the highway, for freeways and for rural highways during daytime and nighttime driving. From Warren (1982).



Behavior Modification Techniques

Behavior modification techniques can be used to alter maladaptive habits like unsafe driving. These view the problem behavior in terms of its ABCs: the A stands for Antecedents or events that just precede the behavior, the B for the Behavior itself, and the C stands for the Consequences of the behavior--both the immediate consequences and the delayed ones. Consequences can be rewards or penalties and these can vary in their magnitude, timing, and type.

The set of techniques for modifying behaviors is large.
Scott Geller and Timothy Ludwig (paper in this volume) list 24 such techniques. I have compressed their list into three categories shown in Table 1: No explicit incentives, incentives for individuals, and incentives for groups of drivers. No incentives include the traditional methods favored by public agencies because they are inexpensive.

Table 1

Categories of Behavior Modification techniques

Adapted from Geller and Ludwig (this volume)

No Explicit Incentives

*State Norms; Model Behavior; Give Reasons
*Discuss; Persuade; Elicit Commitment
*Present Reminders; Activators

Individual Incentives

*Goal Set: by Agency; by Self; Competition
*Promised: Feedback; Reward; Penalty
*Received: Feedback; Reward; Penalty

Group Incentives

*Goal Set: by Agency; by Group; Competition
*Promised: Feedback; Reward; Penalty
*Rerceived; Feedback; Reward; Penalty

Here one tries to alter some behavior, such as getting drivers to buckle up their safety belts, by passing a law which sets forth the norms, by giving lectures informing people of the new rule , and by demonstrating or modeling the desired behavior in television ads or movies. Publicity and announcements can be effective, especially when the target behavior is easy to perform and its benefits are obvious. Publicity is far less effective when the behavior to be changed is inconvenient or a bother to carry out, or when it has its own sources of reinforcement such as speeding.

The second technique with no incentives engages the participants in discussion, trying to persuade them and get them to commit themselves to performing the desired behavior. We can also present cues which remind people of their commitment, and prompt them to carry out the behavior.
Unfortunately, people eventually habituate to reminders and tune them out. The hope is the reminders will train a strong habit that will persist because of its intrinsic reinforcement.
The second and third class of techniques in Table 1 use goals, incentives or disincentives; these have more certain, durable effects, and so are more often used. In these cases, the individual accepts a goal level of desirable behavior to work towards; his behavior is monitored and feedback is given about how closely his behavior approximates to the goal. The individual's goal may be set in three ways: by some agency, perhaps the company for which a truck driver works; by the individual deciding on his own goal, perhaps advancing it as he improves his behavior; or the goal may be set by competition within a group, such as to achieve more good-driving points than other drivers in the group.

Different kinds of consequences for the behavior may be promised in advance (as incentives or threats) or delivered after the action. Sometimes the feedback for performance may only provide information about it rather than explicit rewards. For example, in research conducted in Nova Scotia and in Israel, Ron Van Houten and his collaborators (1985) significantly reduced accidents and the percentage of vehicles exceeding the speed limit along given roadways by simply posting beside the highway a large sign saying "Drivers not speeding last week was X (e.g., 40%). Best record so far is Y (e.g., 60%). This sign gives feedback about recent group compliance, sets a standard, and prompts the lawful drivers to reward themselves by noting how they are contributing to the group welfare.

Parameters of Reinforcement

Information feedback can be augmented by explicit positive rewards for achieving the goal or by penalties for falling short of the goal, for undesirable behaviors. Rewards can be such things as praise, money, tokens, points, or coupons that provide a chance to win a lottery.
Penalties can be fines, reprimands, license suspensions, demands for restitution, for community service, or for repeated practice of the correct behavior undoing the error.
For example, a person caught running through stop signs might be required to repeatedly practice braking to a full stop at stop signs.

Adaptation Level theory as well as Weber's Law tells us that the impact of a given monetary incentive or penalty should depend on how large a change it brings about in his or her wealth. This change is best calibrated as a percentage of the person's wealth or income level.
Penalties need not be monetary: in America one of the most effective penalties for reckless or drunk driving is suspension of the driver's license for three months or longer, because this causes enormous inconvenience for the driver and his family. Such suspensions would still be very aversive even if shortened to two or three weeks, so they could be applied for less serious driving offenses but used more often. The principle is that a moderate punishment delivered with high probability is far more effective than a severe punishment delivered with very low probability.

The impact of a reward or penalty also decreases with its delay after the behavior. That is, future consequences are discounted when viewed from the present time. This is why self-injurious behaviors like smoking, overeating, or drug abuse may persist: the immediate gratification more than offsets the long delayed bad consequences of the behavior. Reckless driving practices are a bit like overeating or drug addictions: each act may confer some immediate gratification, such as getting ahead of other drivers, but habitual use is likely to be eventually destructive.
We can reduce the time discounting and bring forward the remote consequence by the use of language and imagery. Thus, we can rehearse the contingency between our action and its delayed outcome, as when we say "I'll be punished for this action next week," or later when we say "I'm being punished now for what I did last week."

One of the most important aspects of a reward or penalty is the probability that it occurs immediately after the critical behavior. The more reliable and consistent the outcome, the greater the impact of the incentive or disincentive contingency. This suggests that we should reward drivers for most instances of safe driving and penalize them for most instances of unsafe driving, and almost never permit the reverse to happen. Unfortunately, it is precisely in this area, of monitoring the behavior of the hordes of individual drivers and applying contingencies, that safety programs meet their greatest challenges. Later I will return to this topic of monitoring the driver's behavior.

To finish up the information in Table 1, the bottom part describes incentive programs for coherent social groups, such as truck drivers of a delivery service, taxi drivers, university students in different dormitories or fraternities, and so on. The impact of group goals depends on how much each member accepts and works to attain the goal, and *that* reflects the degree to which they identify with the group and can be influenced by its members.

While the slide lists the techniques separately, any given program to promote driver safety typically contains several such methods–lectures, reminders, incentives and penalties with both individual and group contingencies.
People wanting to change others typically bring to bear all the influences they can conveniently put together.

Different Approaches to Driver Behavior

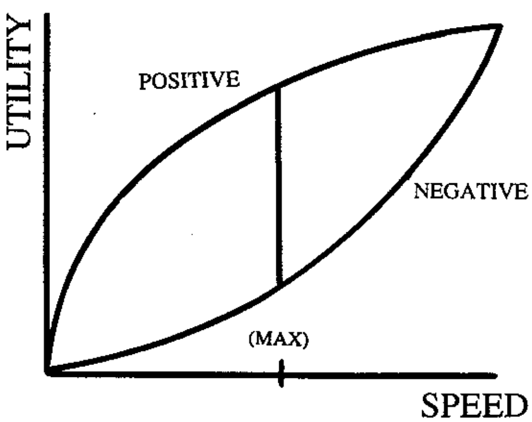
The behavior of the individual driver can be analyzed according to several different approaches and at several different levels. One approach is that of human factors which views the driver as an information processor. This approach analyzes the sensory information the driver uses in judging highway hazards, the motor skills needed to brake and maneuver in dense traffic, and his decisions in assessing upcoming road hazards and the ability to cope with them. This approach links up well with that of highway engineering and design, with its concern for building safer highways; it also links up with the approach of automotive engineers who try to design vehicles that are easier to drive safely.
A human factors approach might point out how drivers are misled by several illusions of motion perception which cause them to believe that they're going slower than they are, that they can see better than they in fact can, and that they can stop quicker than they can (see Appendix A).
Such findings illustrate the general principle that most drivers are overconfident about their ability to cope with unexpected events such as a sudden flat tire, a pedestrian darting into the road, or a vehicle ahead suddenly stopping.
Because drivers have driven so many hours without encountering these rare events, they have nearly extinguished watching out for them. Moreover, overconfidence in their ability to cope is rarely tested except when an unexpected event happens, and by then an accident is likely.
We can recommend that driver training classes should more often warn student drivers and gave them corrective feedback about these perceptual illusions and try to shake their overconfidence in their ability to cope with highway hazards.

Another approach, complementary to that of human factors, is to view the driver as a bundle of motivations.
This approach views a complex behavior like driving as a hierarchical plan with several levels of goals and actions.
At the top level in the hierarchy is the person's goal for taking a given trip, say, to drive into the city to attend a concert; at the next level the person chooses a route and an expected driving time, which determines when he leaves home and how fast he tends to drive; at the lower level of this plan hierarchy are moment-by-moment decisions about maneuvering in traffic, whether to overtake in given circumstances, and so on. Decisions made at the top level trickle down to affect the urgency of actions at lower levels. In particular, if the person hasn't allowed enough time, then he's more likely to speed and take greater risks.
Drivers are influenced by many possible motives–to reach one's destination quickly, to compete against other drivers, perhaps to show off one's driving skill, and so on.
But in the moment by moment decisions, the main

motive is to avoid accidents, injuries, and police citations. The driver's selection of a speed can be analyzed in terms of maximizing his utility, as shown in Figure 2. This plots two hypothetical curves, the top curve indicates the total positive utility of driving at different speeds, and the bottom cure indicates the total negative disutility or risk that the person associates with those speeds for given road conditions. The top curve reflects all positive factors leading to faster speeds, such as the value of getting to the destination, the thrill of beating other drivers, and most importantly the value of the time saved by getting to the destination sooner. The bottom curve reflects the combination of factors promoting caution, such as the person's momentary assessment of the accident probability based on conditions of the highway and his assessment of the probability of being caught by police were he to drive at a given speed.

The basic assumption of this model is that people will choose to drive at the speed that maximizes their net utility, the difference in positive minus negative utilities. The speed that maximizes the utility is indicated in Figure 2 as MAX and is an equilibrium

Figure 2. Hypothetical utility (positive) and disutility (negative) curves representing the value of driving at different speeds. The analysis requires a concave-downward positive curve and concave-upward negative curve, as provided by power functions with exponents less or greater than unity.



point because any further increase in speed beyond that produces a gain that is more than offset by an increase in risk. The model is similar to that of Gerald Wilde (1982) who assumes that people drive so as to produce a preferred level of risk.
The model implies that the equilibrium speed changes appropriately as we alter the positive incentives or the risks for fast driving. Figure 3 illustrates the case of increasing the value of getting to the destination quickly- -for example, a man is rushing his pregnant wife to the hospital. This situation increases his value of getting there quickly, raises the upper curve, and shifts the maximum net utility to the right, to a higher speed. Figure 4 illustrates the case of increasing the risk of fast driving-perhaps the road is slippery, visibility is poor, or police surveillance has increased. This raises the risk curve, so the equilibrium point shifts to the left, to slower speeds when there is more risk.

The equilibrium model can easily be applied to analyze what happens in new conditions such as imposing a speed limit that is strictly enforced. That generates a graph like that in Figure 5 which has a jump in the risk curve at the speed limit. If the rule is strictly enforced, then the optimal solution is to travel

Figure 3. By providing greater reward for reachting the destination quickly, the positive utility curve is raised, moving the maximum point of net utility to a higher speed.

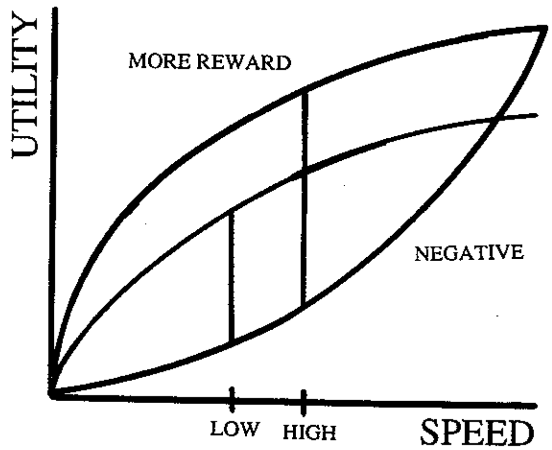


Figure 4. By increasing the perceived risk, the point of maximum net utility is moved to slower speeds.

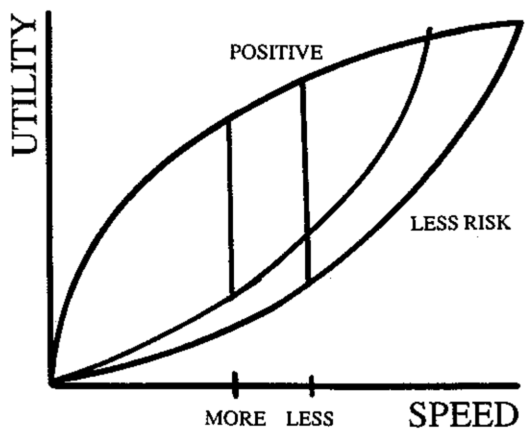
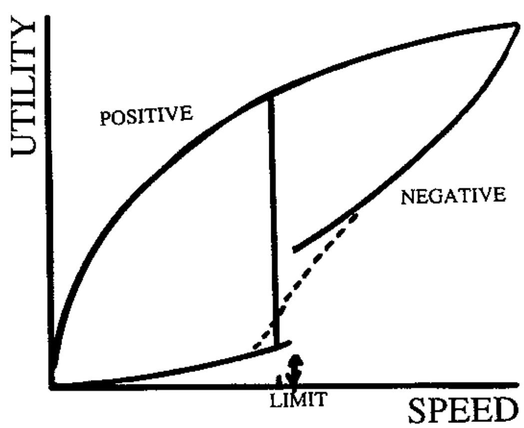


Figure 5. A speeding limit causes a jump in the risk curve. If the limit is more likely to be enforced at higher speeds, the dashed average risk curve is obtained.



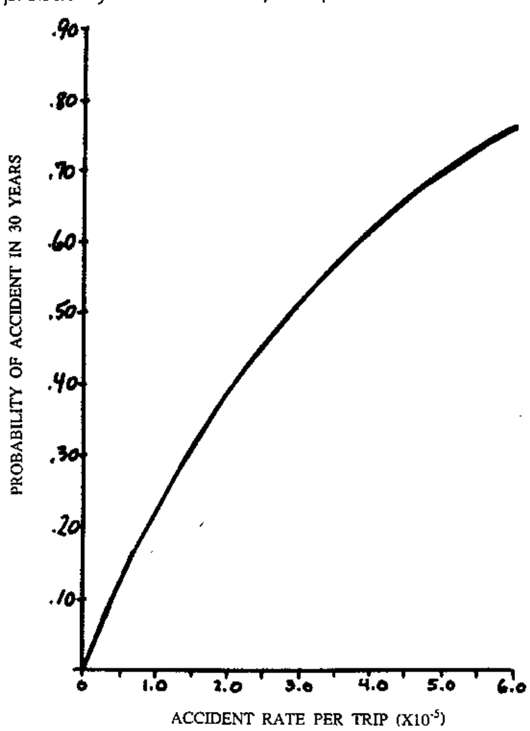
at a speed just below the limit. If the limit is not strict but more likely to be enforced the more one exceeds it, then we get the expected risk function represented by the dashed line, and that has a somewhat higher equilibrium speed.

Modifying the Risk Curve

The risk curve reflects many factors, such as the person's fear of having an accident at different speeds. We can elevate the risk curve by campaigns to frighten drivers, by publicizing and re-enacting on television many vivid examples where an unsafe action in a risky situation leads to a gruesome accident with much bloody maiming of the driver and his passengers. Other factors will lower the risk curve. For example, alcohol lowers people's fear of bad consequences. If the risk curve is lowered, then the maximal net utility will be moved to the right, towards higher speeds. So the drunk driver not only has poorer coordination and slower reactions, but he will also maximize his subjective utility by driving at a faster speed. And that is a lethal combination.

One way to increase the perceived risk is to get the driver to appreciate in more vivid terms the high probability that reckless speeding can lead to tragedy. The objective probability of being involved in a traffic accident is incredibly low, as is the probability that one will be caught and cited for speeding. An estimate I've seen (in Slovic, Fischoff & Lichtenstein, 1978) is that the chance that an individual will be killed on any given auto trip is about 3 chances in a million, and that he will suffer a disabling injury is about 1 chance in a hundred thousand. Suppose that a person who drives safely lowers his chances of injury per trip by half to 1 in 200,000, whereas the reckless driver doubles his rate per trip, to 1 in 50,000. But these changes in probabilities are just too tiny for people to appreciate. However, these figures can be made far more impressive to drivers if they are scaled upwards to refer not to chances per trip but rather to chances of an injury or fatal accident over a 30-year lifetime of average driving, say, of 15 trips a week. This probability is shown in Figure 6 for different accident rates. In these terms, the chances of a disabling or fatal accident in a driver's lifetime is now almost one in two for the reckless driver, whereas safe-driving practices reduce that to around a one in 10 chance. Stated in this way, the reduction in risk is considerably more concrete and impressive (Slovic et al., 1978). A similar framing of benefits could be made to promote buckling up safety belts, which supposedly reduce the extent of injuries in accidents by over 50%.

Figure 6. Probability of an injury accident in 30 years of driving at 15 trips per week related to the probability of an accident per trip.



Behavioral approaches also suggest that we examine common motives for speeding and see if we can reduce those factors. For example, we know that interrupting an ongoing plan to get somewhere is almost always frustrating. People react to backed-up traffic jams with upset, irritation, and determination to speed up once they pass the traffic jam.
Is there any way to reduce that emotional reaction? One way is to teach drivers to reduce the time-pressure by leaving early and expecting some delays. An expected delay is not nearly so upsetting as an unexpected one, which is why rush-hour commuters learn to expect delays and are considerably less frustrated by them.
A second method to reduce the aversiveness of an interruption is to plan for pleasant activities or jobs to do while waiting in a vehicle. While sitting in traffic jams, one can dictate letters, make telephone calls, listen to music or books on tape, plan daily errands or a vacation, and so on. Importantly, people can learn to use the interruption as an opportunity to carry out alternative plans. By reducing the frustration of the delay, the recklessness of the driver should be decreased after he's passed the traffic jam.

Monitoring Behavioral Compliance

Let me return now to the important topic of monitoring the driver's behavior. Effective behavior-change programs arrange some way to monitor the relevant behaviors and to give timely feedback. This monitoring component is precisely what we do not have for individual drivers. There is no Big Brother sitting beside each driver, giving him valuable points when he drives safely, and penalizing him whenever he commits some unsafe act. In place of such a monitor, researchers and agencies interested in studying driver behavior use derivative measures, such as accident rates and police citations for speeding or reckless driving.
For some purposes, such as setting auto insurance premiums or deciding whether to suspend someone's driving license, those kinds of derivative measures can be useful.

Bonus-malus systems Insurance companies are interested in promoting safe driving because, up to a point, it increases their profits. They do this with bonus-malus incentive systems which reduce a driver's annual insurance premium for each year of accident-free driving, or which raise his premium when he has an accident or is cited for a moving violation. Bonus-malus systems are useful tools, but the ones familiar to me could be fine tuned for greater effect. One suggestion is to make the payoff for good driving far more salient and conspicuous, and give it more promptly. Most customers are hardly aware of the incentive, since the premium reduction is often buried in the midst of the new billing of the annual premium; so the subjective experience is the unpleasant one of receiving just another bill to pay. One has no sense of being rewarded for good driving. A preferable option would be for the insurance company to collect in advance a large annual premium, and then to mail back cash refunds every four months of accident-free driving, making a big fanfare linking the cash refund with the customer's safe driving. Of course, that adds short-run administrative costs for the company, but it might be cost-effective in the long run.

While the bonus-malus system is a good incentive system, it falls short in several respects: first, one would like other segments of society besides the insurance industry to become involved in solving this society-wide problem of devastation on our highways; second, many drivers in America, estimated at 25%, do not carry any insurance whatsoever even though it is required by law in most states–that fact alone suggests how lax is the enforcement of our traffic laws; a third problem is that the unsafe driving behavior targeted for change only very rarely leads to police citations or injury accidents. Thus, the data used by insurance companies in the bonus-malus system have only a weak relation to the unsafe driving maneuvers that need to be changed.

I want to emphasize that it is the absence of an appropriate monitoring system for individual drivers that presents the major obstacle to implementing more powerful behavior change programs. Even the most sophisticated incentive programs will be minimally effective unless we can first solve the monitoring problem. We will have to be able to observe when people are driving safely or unsafely and then quickly apply rewards or penalties contingent upon how they are behaving. Without reasonably direct observation, precise response-outcome contingencies cannot be arranged, and so incentive programs will invariable yield ineffectual results.

Engineering Monitoring Systems

Because monitoring the behavior of individual drivers is so important, I scanned the transportation literature for engineering solutions to the problem. I found a few hopeful techniques, and there are probably several more that I missed. One device for monitoring a car's speed is a tachograph recorder, which is a small clock-driven device which can record a vehicle's speed, distance traveled, idling time, quick jerky stops, and so on. Each function is recorded by an ink stylus moving over a paper chart. In an experiment by Larson and her associates (1980), tachographs were installed in 224 police cars during 1976-77 in the Nashville, Tennessee police department, so that the driving of each officer using the vehicle was fully recorded. At the end of each 8-hour shift, the officer turned in his driving chart to his sergeant supervisor who reviewed the chart daily, questioned the officer about any speeds above the speed limit, questioned unexplained periods of idling, small collisions, and so forth. The supervisor provided officers with praise for acceptable charts, criticism for taking unacceptable risks; if the infractions were serious and frequent enough, the supervisor could issue a departmental reprimand to the officer and could even suspend him from duty with loss of pay for several days. This type of intervention, with monitoring plus incentive feedback, greatly increased safe driving, lowered speeds, and reduced the accident rates for these drivers; personal injuries from auto accidents were cut by one half to two-thirds in different divisions of the police department. The savings in lost work-days and in repair costs for vehicles more than paid for the costs of installing the tachographs. Moreover, after a brief period of initial resistance, the field officers accepted the tachograph monitoring as a helpful part of their job. Based on such results, one can recommend greater use of tachographs throughout the world in companies and agencies committed to lowering driving accidents of their employees on the job. For example, tachograph monitoring is an obvious method for long-distance trucking companies to check whether their drivers are taking the required number of rest stops to avoid the dangers of driving while tired or sleepy. Of course, the trucking company itself may not care to enforce safety rules on its drivers, since driving slower and taking rest stops lowers the hauling productivity and profit of the fleet of trucks.

And so one would have to address that problem, too.

A second method for monitoring driver behavior is the electronically-activated camera used at intersections in Singapore and some cities of New Zealand. The camera photographs cars running through red lights at intersections, thus catching them redhanded (Chin, 1989).

The license number of the red-light violator is identified and the car's owner receives a citation in the mail along with a photograph, the time, and place of the offense. The system need not be turned on except for a few hours a day, so long as the public believe that it may be recording them at any time at any intersection. The impact of such recorders can be considerably enhanced by publicity about the numbers of cited offenders.

Automated Surveillance Systems

I would propose greater use of such surveillance or monitoring systems. The camera system is fine and could be set up over freeways on gantries to monitor speeding: But the camera requires personnel to read the license plates of the vehicles; better to automate the vehicle identification, too. Using my imagination, I can envision future cars and highways in which each vehicle would have on board a small microprocessor or computer for recording speeds, weather conditions, the incidence of sudden stops, bumps and collisions, and perhaps the use of safety belts. Each vehicle would also have a small radio transmitter continuously sending out the vehicle's registration number and its current speed. Every few miles some unobtrusive receiver boxes on gantries over each lane on the highway would record these identifying numbers and classify the speed as excessive or not for the given road conditions.

If the person were driving under the speed limit, he could be rewarded with a feedback signal like a door-bell chime that sounded in his car, informing him that his name was being placed in a state-wide, weekly lottery with a chance to win a substantial sum of money. On the other hand, if the vehicle's speed were excessive, then any of several penalties might be imposed. One alternative would have the receiver send to a central computer the registration number, the time, place, and speed of the offending vehicle. That computer would then mail out a citation and notice of fine to the owner of the vehicle, giving all the relevant information. If the owner of the vehicle was not driving it at the time, it would nonetheless be his responsibility to identify the culprit and see that the fine was paid.

A problem with the mailed citation is that the punishment is delayed until the driver receives it in the mail. We could make the penalty more immediately contingent on the speeding by having the roadside receiver turn on a buzzer inside the vehicle informing the driver that he has been caught speeding and will soon receive a citation in the mail. As a more Draconian punishment, one could imagine that the buzzer also informs the speeder that within 60 seconds his motor will shut off and stay off for, say 15 minutes, so he should quickly pull over to the side of the road to wait out this delay. For a person in a hurry to get someplace, being interrupted and having to endure a time-out or delay of 15 minutes would be a very frustrating, aversive, and effective punishment. It is also a punishment that is inexpensive, has no human-agent to get angry at, does not clog the court system, and is a punishment that fits the crime because it undoes or reverses one inherent incentive for speeding, namely, to get somewhere sooner.

Let me carry my fantasy a step further. Suppose that we use the computer on-board each vehicle like a tachograph which would record and accumulate over several months its total number of speeding episodes, collisions, red-light runnings, and so forth. This recorder would be safely locked away in a tamper-proof strongbox in the trunk only to be opened and inspected every six months when the owner took the vehicle into his insurance agent. At that time, the owner and agent would examine the accumulated record for that period. Depending on the driver's safe driving record, the agent would on the spot refund part of the last period's premium and calculate the new premium to be paid for the upcoming period. This fantasy is technologically feasible now, and might add, say, 2% to the price of a new car.

Turning to other means for enhancing safe driving, automotive engineers have suggested many useful innovations.
One device would be a built-in light-meter that automatically turns on the headlights of the vehicle when you turn on its motor if the natural lighting is too low for adequate visibility. Another useful device would inform the driver by a buzzer just how safe is the distance in following the vehicle ahead of him. The buzzer becomes louder the less safe the distance to the car ahead relative to the driver's current speed.

Speed-Controllers

Other useful devices are those that artificially control the maximum speed of a vehicle, such as motor governors which are required on buses and large trucks in America. Another speed-controller is the deaccelerator (Schulman, 1985). This device attaches to the accelerator pedal and provides very high resistance when a driver tries to depress the pedal beyond a pre-set speed limit. The resistance increases as the pedal is depressed to levels above the speed limit. However, in case of an emergency need to go faster, the driver can overcome the pedal resistance by pressing with great force, and thus speed up.
The system has been successfully field-tested in a fleet of university-owned vehicles driven by employees, and it works well. Apparently, the pedal resistance is sufficient to remind drivers of the speed limit, and the extra required to go faster is sufficient to deter them from speeding. The deaccelerator's disadvantages are that it is not yet tamper proof and it can be pre-set for only one speed on a given trip, so it does not adjust to the different speeds appropriate to different roads.
A more flexible device could be invented with available technology that could electronically control the vehicle at any of several preselected speeds. Perhaps it would be feasible to make an electronically-controlled governor or deaccelerator that would be linked to and controlled by a computer on-board the vehicle. A transmitter on gantries over the highway would send to each vehicle's receiver a radio signal specifying a speed limit appropriate to present highway and driving conditions for the next few miles; and this speed limit would be electronically set onto the deaccelerator pedal. With this system, then, a driver would be deterred from going any faster than a variable speed limit, although with special effort he could over-ride the pedal resistance to accelerate to avoid accidents.
You might be surprised to see that although I am a behavioral scientist, these last proposals to improve driver safety call mainly for technological fixes from highway engineers and automotive engineers. I do so because, within our presently inadequate system for monitoring driver behavior, it is far easier to change highways and cars so as to monitor and constrain drivers than it is to change their behavior directly. Psychologists know a lot about how very sophisticated and complex schedules of reinforcement control the behavior of subjects in laboratory experiments.
However, modifying driver behavior does not require sophisticated reinforcement contingencies. In my opinion, it simply requires better implementation of very simple, familiar contingencies. But that requires far better systems for conveniently monitoring drivers' behaviors so that we can apply those simple contingencies. And that's why I have emphasized various engineering solutions as a first step in monitoring to improve drivers' behaviors.

Final Comments

Many other safety recommendations come to mind regarding new devices, new regulations, and constraints on car advertising (see Appendix B). But enough of my fantasies and proposals to reduce traffic accidents. I imagine each of us has his own set of proposals to improve future transportation systems. There is little doubt that if adopted the various proposals would drastically reduce the accident and injury rate on our highways. But I think we can be reasonably certain that few of our proposals will be adopted by the public and the politicians. In fact, any American politician who proposed stringent controls and monitors of the sort suggested here could be committing political suicide. Why would our safety proposals be so unpopular? Partly because of the costs, but largely because the public does not want us to control their behavior, even when those behaviors en mass are killing us off at an alarming rate. The public consists of a large number of car-junkies or speed-freaks; they are like drug addicts who oppose attempts to control access to the drugs that are destroying them. Some of our proposals for traffic controls conflict with the libertarian ideologies of Western societies-conflict with the value placed on liberty, freedom from restraint, individualism, and personal expression. Our societies want us to solve the problem of high accident rates, but to do so within the constraints of a democratic, laissez-faire society which jealously guards all manner of individual freedoms. We are in a position similar to that of doctors who have been asked to stop some disease epidemic that is ravaging the population, but we are not allowed to inconvenience anyone by installing effective public health measures.
What one does in these circumstances is to try to develop inexpensive band-aids and convenient but mildly effective measures that will be acceptable to the public. I think those are honorable goals but difficult to achieve. I convey my best wishes for success to the participants as you begin this conference on promoting driver safety. You are embarked upon a worthy mission. I will end by wishing you a safe journey.

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Appendix A

Several perceptual illusions can contribute to unsafe driving. Leibowitz and Owens (1986) have noted one perceptual miscalibration that can lull drivers into a false sense of security by believing that they can see and react far better than they actually can. The human visual system consists of several components, two of which are important in driving: one important subsystem is that used in guiding ourselves as we move around–for example, aiming and steering a car between the white lines of a highway lane; the other is that involved in object recognition–for example, reading signs or identifying pedestrians along a highway. Guidance can be carried on reasonably well in semidarkness, whereas object recognition is seriously degraded by poor lighting. Safe driving requires both systems, but in particular it requires the ability to detect hazardous objects and road conditions. Because the driver can steer his car alright in conditions of poor visibility, in twilight, rain, or fog, he can be fooled into believing that he can also identify road hazards equally well, and therefore be lulled into driving faster than warranted by the visibility. This may be why the accident rate per mile driven during night time is 3 to 4 times higher than in daylight. In darkness, a dark-clothed pedestrian or a stopped vehicle on the road ahead can be identified in low- beam headlights at a distance of about 100 to 120 feet.
Since it takes a driver about 2.5 to 3 seconds to identify an unexpected road hazard and begin to brake his car, a driver going 40 miles per hour will go about 150 to 175 feet before he can come to a complete stop–by which time he's likely to have hit the pedestrian or rear-ended the stopped car. And 40 miles per hour is a relatively slow speed; at higher speeds, drivers increasingly over-drive their headlights, relying almost completely on everything getting out of their way.

Other distortions of the risk curve can be produced by various illusions of motion perception (Shinar, 1978). The perception of velocity depends on the rate of streaming of the optimal flow field in peripheral vision. The error of velocity estimation increases if there are very few features or landmarks along the road. Thus we are likely to misjudge our speed when we move along flat, gray, featureless roadways or drive in conditions of poor visibility, such as fog or night time on unlit roadways. Because people underestimate their speed, they tend to follow other cars much too closely, so they can't avoid a collision if the car ahead suddenly stops.

Another illusion of motion perception is that of velocity adaptation, whereby the subjective feeling of a given change in speed is greatly enhanced by its contrast to the speed to which the person has just adapted. Thus, a person who leaves a freeway by reducing his speed from 120 to 80 kilometers per hour will perceive that 80 kph as very slow. This illusion of slow motion can cause him to exit the freeway at a speed considerably above the safety margin.
These are perceptual illusions that can be overcome-the first, by highway designs to include road features and embedded reflectors; the second, by extending exit ramps and using signs that gradually reduce the driver's speed as he exits.

Appendix B

Proposals to improve driver safety come easily to mind.
One recommendation would require periodic inspection of vehicles to see that they have working brakes, headlights, and safe tires. In America, this inspection could be done at the same time as the required smog check on the engine.
Another recommendation would require periodic testing of drivers, especially the very old and very young. Other recommendations would apply to drunk drivers; there should be more random sobriety testing on highways along with stronger measures to minimize repeatedly drunk drivers. The most effective penalty is immediate suspension of the driver's license. Another technique is to install a breathalyzer on the drunk driver's car so that the driver must pass a breathalyzer test for low blood alcohol in order to start the car. Another measure would be to prosecute the bars and saloons where the drunken drivers were drinking just before they went out on the road.
Another recommendation would be for the state to

control advertising that sells cars by promoting non-safe attitudes towards cars and their uses, that glorify cars and their powerful engines as a means for self-enhancement, for expressing one's freedom from social restraints, for macho challenging of competitors to drag races. We could prohibit the showing of popular TV series and films that portray fast, reckless driving as a thrilling behavior to be admired and imitated.

In America this summer (1990) one of the more popular films is Days of Thunder about the thrill and glory of stockcar racers. The handsome hero, played by Tom Cruise, drives recklessly on and off the track, is involved in multiple scrapes and crashes, yet manages to escape without serious injury, eventually winning big prizes, the pretty girl, and the public adoration of all the other macho males in the film. I would bet that, through modeling reckless driving as joyful and admirable, that film alone will indirectly cause more auto accidents this summer than have been prevented by a whole year's traffic-safety publicity campaigns conducted by the highway patrol.

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