Risk-Taking Behavior and Traffic Safety Symposium Proceedings

October 19 - 22, 1997
Chatham, Massachusetts

Prepared by
U.S. Department of Transportation
National Highway Traffic Safety Administration
Federal Highway Administration

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PREFACE

In 1996, then-Secretary of Transportation Federico Peña and General Motors Corporation Chairman John F. Smith, Jr., agreed on the need to address risk-taking behavior by drivers as potentially the most cost effective way of bringing about further improvements in traffic safety.

As a first step, the Department of Transportation and General Motors agreed to cosponsor a symposium, to provide a forum for gathering up-to-date knowledge on driver behavior issues.

The resulting symposium was held in Chatham, Massachusetts, on October 19-22, 1997. Over 80 traffic safety policymakers, researchers, and practitioners attended, presented their views, learned from others, and discussed the issues and potential solutions at great length. This book contains the papers and discussions presented at the symposium.

The symposium's goal was to present and discuss the best current knowledge and views on driver (and pedestrian) risk-taking behavior. The symposium was organized into four sessions.

- Describe the problem: what causes risk-taking and how does risk-taking affect traffic casualties?
- Analyze several specific risky behaviors: failure to use seat belts, speeding, and dangerous pedestrian actions
- Present examples of successful methods for reducing risk-taking behavior
- Offer suggestions for additional innovative methods

Each session was moderated by a distinguished traffic safety leader. In each session, four eminent researchers from around the world presented their research and views. For six of the papers, an invited discussant gave his or her prepared opinions. Then the moderator opened the floor to general discussion.

This book follows the same organization, with a chapter for the papers from each session. A final chapter presents post-symposium thoughts from the symposium co-chairs.

Any attempts to reduce driver risk-taking behavior are both difficult and controversial: difficult because driving behavior immediately touches the basic questions of why we act the way we do; controversial because any attempt to change our behavior immediately raises issues of individual

freedoms and the proper role of society in restricting or regulating individual behavior. It's not surprising that many persons who have thought about these issues have quite different views. To respect this diversity, this book presents the content, language, charts, and figures of each paper unchanged, just as prepared by the authors. Minor stylistic and typographical changes have been made to provide a common appearance across all papers. But each paper's author is responsible for the statements and opinions of his or her paper. In particular, General Motors Corporation and the Department of Transportation bear no responsibility for any statements, views, or opinions in this book.

In addition to the authors of each paper and the session moderators, many others contributed to the symposium's success. General Motors and the Department of Transportation funded the symposium, and staff from each organization cooperatively planned the program. Mary Magnini of Meetings Management Inc. handled all symposium logistics with consummate professionalism, grace, and good spirits. Richard Maurey and his staff from the National Highway Traffic Safety Administration designed and produced this book. The management and staff provided a delightful and comfortable venue for all symposium activities.

Symposium Co-Chairs

Jim Fell, National Highway Traffic Safety Administration

Thomas Terry, General Motors Corporation

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CHAPTER 1

THE NATURE OF THE PROBLEM: RISK-TAKING AND TRAFFIC CASUALTIES

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The papers in this first chapter provide four different views of what causes driver risk-taking and how risk-taking affects traffic crashes.

Douglas Beirness, in "Driving While Impaired: The Role of Risk-Taking, Alcohol, and Age," considers who engages in the common and clearly risky behavior of drinking and driving. He examines characteristics of two groups -- young beginning drivers who drink and older "hard-core" drinking drivers -- and notes connections with personality traits and with alcohol abuse.

Brian Jonah et al., in "Sensation Seeking and Risky Driving," review the substantial evidence relating risky driving to sensation-seeking. They note that sensation-seeking may have biological and possibly genetic bases. They report on two experiments investigating how both high and low sensation-seekers may react to vehicle improvements designed to improve safety. Wiel Janssen's comments elaborate on both portions of Jonah's paper.

Jean Shope's study "High-Risk Driving Among Adolescents: Psychosocial and Substance Use Correlates and Predictors" presents evidence relating teenagers' behavioral, personality, environmental, and family characteristics to their subsequent driving records. She concludes that the factors related to risky driving are developing years before driving actually begins.

Ron Van Houten and Louis Malenfant adopt a community rather than an individual point of view. In "Changing the Behavior of High Risk Takers by Modifying Community Norms: Taking Advantage of Powerful Social Contingencies" they present theoretical and experimental evidence to support their view that a community's social norms play a very large role in influencing an individual's risky driving behavior. They conclude that safety measures focused on the average driver can alter the behavior of risky drivers.

DRIVING WHILE IMPAIRED: THE ROLE OF RISK-TAKING, ALCOHOL, AND AGE

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INTRODUCTION

During the decade of the 1980s, an unprecedented wave of public attention and concern about the drinking and driving problem swept North America. Public outrage, sparked largely by groups of victims of drunken drivers, prompted new legislation, more severe penalties for offenders, as well as increased and more effective means of enforcement. The public grew more intolerant of impaired driving and it became increasingly socially unacceptable to drive after having consumed too much alcohol.

The diversity and intensity of the efforts during the 1980s did not go unrewarded. Virtually every indicator of drinking-driving and alcohol-related crashes revealed substantial decreases. Population surveys reported fewer drivers who admitted to driving after consuming alcohol (Jones and Boyle, 1996; Simpson et al., 1992); roadside surveys of nighttime drivers found a reduced prevalence of drivers with positive blood alcohol concentrations (BACs) (Mayhew et al., 1996; Voas et al., 1997); and, the incidence of alcohol use among drivers fatally injured in road crashes fell dramatically (Beirness et al., 1994; NHTSA, 1996). These data leave no doubt that the magnitude of the problem was considerably smaller at the end of the decade than it was at the beginning.

To illustrate, Figure 1 shows the percent of fatally injured drinking drivers in Canada[1] and the United States[2] for the years 1982 through 1995. The decrease in the percent of driver fatalities who had been drinking in both countries is readily evident. In the United States, between 1982 and 1990, there was a 28.6% decrease in drinking driver fatalities. An almost identical decrease (27.3%) occurred in Canada.

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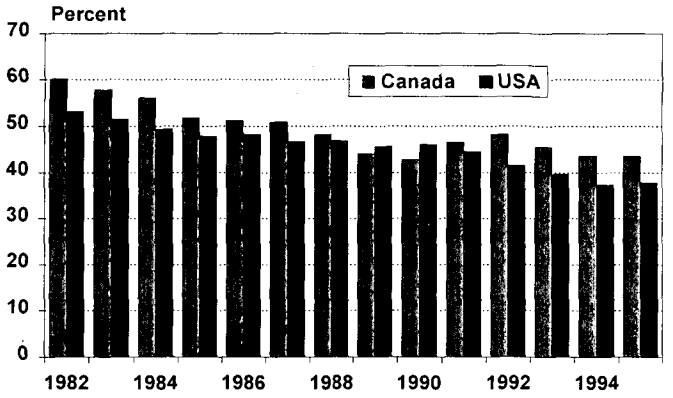
[1] Data from seven provinces from the Fatality Database, which is maintained by the Traffic Injury Research Foundation under sponsorship from Transport Canada and the Canadian Council of Motor Transport Administrators (CCMTA). The seven provinces are: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, and Prince Edward Island.

[2]Data are from the Fatal Accident Reporting System (FARS) for all states. Alcohol use in these data is determined by blood tests or imputed using an estimation procedure.

Figure 1: Percent of Fatally Injured Drivers With Positive BACs



While it is apparent that substantial progress has been made in dealing with the drinking-driving problem, the data also reveal that the problem has not gone away. In fact, in recent years, the rate of change has slowed considerably. In Canada, the rate actually increased before returning to a level more consistent with that evident at the end of the 1980s. In both the United States and Canada, drinking drivers continue to account for approximately 40% of all motor vehicle fatalities -- a combined total of about 18,000 lives in 1995.

Closer examination of the data reveals that the decreases in the drinking-driving problem have not been equivalent across all groups within the population. In this context, two groups of drinking drivers have been the subject of considerable interest: youth and the hard core. These two groups appear to have responded very differently to the countermeasure efforts of the 1980s. Whereas alcohol-related crashes among youth have decreased dramatically, the problem has changed very little among older drivers with high BACs.

A comparison of data on alcohol-involved fatalities among these two groups i.e., young drinking drivers and older drivers with high BACs demonstrates the differences. Figure 2 shows the percent of all driver fatalities age 16 to 20 in the United States[3] who had been drinking and the percent of all driver fatalities age 25 to 44 with BACs in excess of 150 mg% for the years 1982 through 1995. Comparable data for Canada are shown in Figure 3. Over this period of time in the U.S., the percent of young drinking driver fatalities decreased by 47%; in Canada, between 1982 and 1993, the decrease of 42%. Meanwhile, the percent of fatally injured 25 to 44 year-old drivers with BACs in excess of .15 decreased by 16% in the U.S. and only 7.8% in Canada.

An examination of data from roadside surveys also provide evidence of differential changes in the prevalence of drinking and driving among different groups in the population. In general, data

[3]Data are from 17 states with alcohol testing rates among fatally injured drivers of at least 80% in at least 12 of the last 15 years. The states are: California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Maine, Minnesota, Montana, Nevada, New Mexico, North Carolina, Oregon, Rhode Island, Washington, West Virginia, and Wyoming.

from the U.S. National Roadside Surveys in 1986 and 1996 indicated that the proportion of drivers with low BACs (i.e., <.05) has decreased by almost 50% (from 17.6% in 1986 to 9.2% in 1996) whereas the proportion of drivers with BACs between .05 and .099 decreased by only 3.8% (from 5.2% to 5.0%) and those with BACs of .10 and over decreased by 12.5% (from 3.2% to 2.8%) (Voas et al., 1997).

Figure 2: Percent of 16-20 Year Old Driver Fatalities With Positive BACs and 25-44 Year Olds With BACs >.15

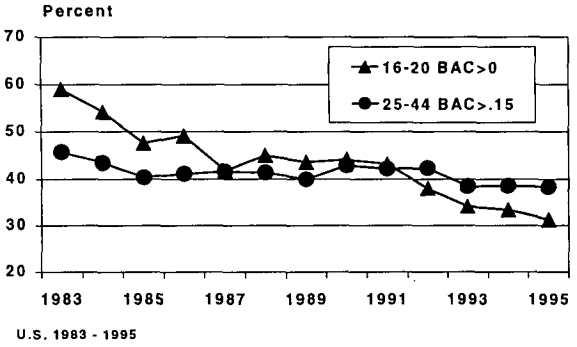
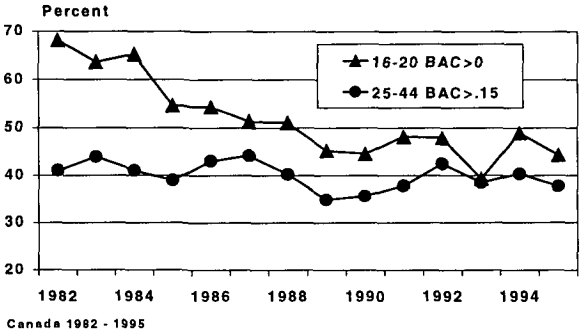
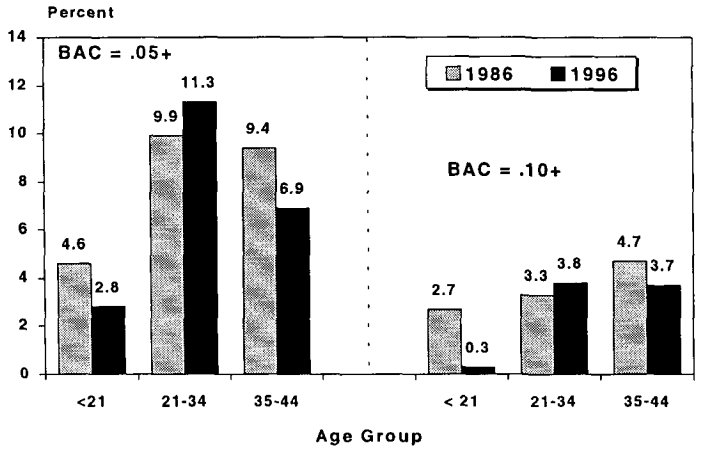


Figure 3: Percent of 16-20 Year Old Driver Fatalities With Positive BACs and 25-44 Year Olds with BACs >.15



A closer examination of the roadside survey data reveals, however, that these general changes were not equivalent across age groups. Figure 4 shows the percent of drivers in three age groups (under 21, 21 to 34, and 35 to 44) in the 1986 and 1996 roadside surveys. The left side of the figure shows the percent of each age group in the two surveys with BACs of .05 and over; the right side shows the percent with BACs of .10 and over. The proportion of drivers under 21 years of age with BACs of .05 and greater decreased by 39%; the proportion with BACs of .10 and greater decreased by 89%. These changes compare with decreases of 26% and 21% among drivers age 35 to 44 with BACs of .05 and greater and .10 and greater, respectively. Among drivers age 21 to 34, the proportion of drivers actually increased by about 15% in both BAC categories. These data indicate that the prevalence of drinking and driving has decreased to a greater extent among younger drivers than among older drivers with elevated BACs.

Figure 4: Percent of Drivers in U.S. National Roadside Surveys According to BAC and Age



Further progress in reducing the number of deaths and injuries attributable to impaired driving may well depend on our ability to refine our understanding of the nature of the problem so that appropriate and effective countermeasures can be focused on the relevant target groups. An examination of the characteristics of these two groups and the nature of their behaviour may provide insights into the causes of these divergent trends and suggest directions for future countermeasure options.

The purpose of this paper is to examine the characteristics and the nature of the behaviour within two groups of drinking drivers youth and the hard core -- in an attempt to determine the role of three factors risk-taking, alcohol and age -- that may contribute to and perpetuate the behaviour. Enhancing our understanding of these factors will facilitate the development of specific and targeted countermeasure programs to deal with the problem that remains.

DRINKING-DRIVING AMONG YOUTH

Young drivers were identified as one of the first key target groups for drinking-driving countermeasure programs. Student activist groups were formed, prevention messages were developed specifically for youth, the minimum alcohol purchase age in the United States was raised to 21, and zero tolerance laws were introduced to reduce the incidence of drinking and driving and alcohol-related crashes among youth. And, such measures appear to have been successful.

For example, in the United States, the number of drinking drivers between 16 and 20 years of age involved in fatal crashes decreased by 63% between 1982 and 1995. This compares with a decrease of about 27% among all other age groups. In Canada, the number of drinking driver fatalities in the same age group decreased by 59%. In comparison, the decrease in all other age groups was about 16%. Clearly, alcohol involved fatal crashes involving young people have decreased considerably more quickly than among other age groups.

The prevalence of driving after drinking as determined by roadside surveys reveals similar trends. It was previously shown (Figure 4) that among drivers under 21 years of age, driving with a BAC of .05% or greater has decreased by 39%, from 4.6% in 1986 to 2.8% in 1996. The proportion of young drivers with a BAC of .10 or greater has decreased by 89%. Among 21 to 34 year old drivers, there was actually an increase in the prevalence of drinking-driving between 1986 and 1996. Once again, these data illustrate that young drivers have decreased their involvement in drinking and driving at a much faster rate than older drivers.

Despite the substantial declines in drinking and driving and alcohol-related crashes among youth, many young people continue to drive after consuming alcohol and far too many are killed and injured as a result. The most recent population surveys indicate that about 15% of young people report driving after drinking (Health and Welfare Canada, 1992; Jones and Boyle, 1996). In 1995, over 77,000 drivers aged 16 to 20 were involved in alcohol-related traffic crashes (NHTSA, 1996).

Young people have been targeted for special drinking-driving countermeasure programs, in part, because it is known that they represent a particularly high-risk group. This risk is assessed through a comparison of the proportion of fatally injured drivers at various BACs with the

proportion of young drivers at comparable BACs in population at risk (i.e., in roadside surveys). This comparison reveals that although young people drive after drinking less often and at lower BACs than older persons, they are at significantly higher risk of crash involvement than older persons at all BACs, even those below the legal limit (Mayhew et al., 1986). Understanding why this is so presents a considerable challenge. The factors that have been put forward to account for this phenomenon can be divided into two groups those related to experience, and those related to age.

Experience-related factors

The increased risk of crash involvement of young drivers even at low BACs is often attributed to the inexperience of youth as drivers, their inexperience as drinkers, and their inexperience as drinking drivers. It is no secret that young people are relatively inexperienced drivers. In most jurisdictions, one cannot obtain a learner's permit until age 16. In the United States, 16 to 19 year old drivers have a crash risk per mile that is four times higher than that of older drivers (Williams, 1996). This research has also demonstrated that young drivers are more likely to be going too fast and more likely to make driving errors that contribute to the crash -- factors which may be related to their lack of experience. Graduated licensing is one approach that has been introduced with some success in an attempt to provide new drivers with essential driving experience under conditions of low risk.

To state that young people are inexperienced drinkers implies that they have not had sufficient exposure to alcohol to have acquired a degree of tolerance and, therefore, experience greater impairing effects or impairing effects at lower doses of alcohol than older, more experienced drinkers. There is, however, little scientific evidence to support such a position. First, young people are not necessarily inexperienced drinkers. Survey research indicates that although young people drink less frequently than older persons, the usual quantity of alcohol consumed reaches a peak between the ages of 18 and 22 and declines thereafter (e.g., Health and Welfare Canada, 1992). Second, and contrary to expectation, research indicates that younger persons actually show a lesser degree of alcohol-induced motor impairment than older persons (Vogel-Sprott and Barrett, 1984). Finally, although research shows that heavier drinkers experience less impairment due to alcohol than lighter drinkers (e.g., Goldberg, 1943; Moskowitz, Daily and Henderson, 1974), the development of tolerance to alcohol has been shown to involve considerably more than simply repeated exposure to alcohol (Beirness and Vogel-Sprott, 1984; Vogel-Sprott, 1992). Hence, inexperience with alcohol per se fails to provide an adequate explanation of the high relative risk of alcohol-related crash involvement among youth.

To state that young people are inexperienced drinking drivers presents an interesting paradox. If the problem were as simple as inexperience, then the obvious solution would be to ensure they acquire the experience necessary to reduce their risk -- an approach that would most likely exacerbate the problem.

Age-related factors

Age-related factors include all those aspects of youth that distinguish them from their older counterparts most notably youthful exuberance, immaturity, impulsivity, thrill-seeking, and risk-taking. The extent to which these age-related factors influence risky driving behaviours

(including driving after drinking) has been the subject of considerable study over the years (e.g., Beirness and Simpson, 1988; Jessor, 1987; Mayer and Treat, 1977; Pelz and Schuman, 1968; Schuman, et al., 1967). In general, these studies have identified a variety of psychosocial and behavioural characteristics of youth that appear to render them at greater risk of engaging in high-risk driving behaviours and crash involvement.

In the realm of traffic safety, one of the most commonly cited factors associated with the increased probability of risky driving and/or crash involvement among young drivers is some form of risk-taking. The "Sensation Seeking" construct described by Zuckerman (1979) is the personality characteristic that appears most closely associated with risk-taking behaviour. Sensation seeking is described as a personality trait, which involves: a need to experience new, novel, and exciting sensations and experiences; a predominance of strong, positive affect in situations of great novelty and risk; and the tendency to do things that others would regard as too risky (Zuckerman, 1979). Several studies have demonstrated that a propensity towards risk-taking or thrill-seeking as assessed by the Sensation Seeking dimension is strongly associated with high-risk driving behaviours, driving after drinking, and crash involvement among youth (e.g., Beirness and Simpson, 1988). In a review of the literature, Jonah (1997) concluded that there was a positive relationship between Sensation Seeking and drinking-driving behaviour. In addition, the relationship was generally stronger among men and declined with age.

Recent studies have examined the influence of age-related factors on driving behaviour from the more comprehensive framework of Problem Behaviour Theory (PBT) (Jessor and Jessor, 1977). The theory defines problem behaviours as those that violate social norms or standards and includes delinquency, excessive alcohol use, drug use, and precocious sexual behaviour. PBT focuses on three systems of psychosocial influence personality, perceived environment, and behaviour. Within each of these systems, the explanatory variables reflect an inclination to engage in problem behaviour or controls against it. Together these variables generate a dynamic state of problem behaviour proneness, which refers to the likelihood of engaging in problem behaviour.

That problem behaviours are interrelated and tend to covary suggest that there exists a problem behaviour syndrome. This propensity to engage in problem behaviours is linked to personality and perceived social environment characteristics that reflect greater psychosocial unconventionality -- e.g., lower value on academic achievement, less compatibility with parental values, lower religiosity, and greater tolerance of deviant behaviour.

Jessor (1987) was the first to present evidence that risky driving did, indeed, appear to form part of this problem behaviour syndrome. Using a composite measure of risky driving behaviours, Jessor found that engaging in risky driving activities e.g., taking deliberate risks while driving for fun, driving after drinking, driving after marijuana use -- was common among young drivers and was positively correlated with other problem and high-risk behaviours. Other researchers have since provided additional evidence in support of this hypothesis (Beirness and Simpson, 1988; Donovan, 1993; Klepp et al., 1991; Swisher, 1988; Wilson and Jonah, 1988).

There are several important implications of PBT for the understanding and control of drinking and driving and youth. First, because drinking/driving -- or more generally, risky driving -- is part of a problem behaviour syndrome, it should be possible to identify groups or individuals at

highest risk by assessing the psychosocial and behavioural factors known to be associated with the behaviour. Several studies have, in fact, demonstrated that groups at high risk of risky driving, driving after drinking, and crash involvement can be distinguished from others (e.g., Barnes and Welte, 1988; Beirness and Simpson, 1988; Donovan, 1993; Johnson and White, 1989; Klepp et al., 1991; Stoduto and Adlaf, 1997). Thrill-seeking is often a prominent dimension of these high-risk groups. Early identification and intervention with those at high risk could prove beneficial in reducing alcohol-related crashes among youth.

Second, PBT provides a developmental perspective on risky driving behaviour. As such, it enhances our understanding of the dynamics of risky driving and driving after drinking behaviour over the course of adolescence and young adulthood. In particular, PBT indicates that risky driving should increase into later adolescence as young people gain independence and adopt more psychosocially unconventional roles. Developmental declines in risky driving should occur as young adults enter into conventional adult social roles and begin to "mature out" of unconventional attitudes, beliefs and behaviours. The decline in risky driving and crash involvement between 18 and 25 years of age appears consistent with this prediction. The developmental patterns are also consistent with the linear decrease in Sensation Seeking scores with age, beginning in the mid to late teens (Zuckerman, 1979). More directly, Jessor et al., (1997) have demonstrated that involvement in risky driving behaviour declines as young adults enter into more socially conventional roles and patterns of behaviour. The developmental nature of PBT also suggests that groups or individuals at high risk of engaging in risky driving would exhibit a different developmental trajectory than those at lower risk. Hence, high-risk groups could be identified at an early stage, prior to their becoming involved in such behaviour or at least before it becomes firmly entrenched as a an enduring aspect of lifestyle.

Longitudinal research has indeed demonstrated that this is the case. In a sample of high school students followed over a three-year period, Beirness and Simpson (1988) found that young people who later became involved in traffic crashes and/or engaged in risky driving behaviour could be distinguished from others on a variety of psychosocial and behavioural variables, including sensation seeking, attitudinal tolerance of deviance, and influence of peers. Many of these differences were evident as early as age 13, well before the age of driver licensing. In addition, using data from the National Youth Survey (Elliott and Ageton, 1980), Beirness (1996) demonstrated different psychosocial and behavioural developmental trajectories between young people who subsequently reported driving after drinking and those who did not. These differences began to emerge in the years prior to the age of driver licensing and are, therefore, predictive of future driving after drinking behaviour.

Finally, that risky driving behaviour and driving after drinking emerge as part of a syndrome of adolescent problem behaviour has implications for our approach to dealing with these behaviours. For example, the observed relationships between risky driving and other health and safety behaviours would suggest that it might prove more efficient and effective to deal with these behaviours from a more general perspective focussing on lifestyle, rather than as discrete and separate behaviours.

HARD CORE DRINKING DRIVERS

Over the past several years, increased attention has been directed at those persons who repeatedly and persistently drive after drinking, especially with high BACs often referred to as "Hard Core" drinking drivers. Although a variety of labels and descriptors have been applied to this group, the following provides a working definition of the Hard Core:

- they drive repeatedly after drinking, often with high BACs;
- their drinking-driving behavior is persistent and chronic;
- they appear to be resistant to persuasive and emotional appeals and are not deterred by the threat of criminal sanctions;
- they tend to drink frequently and often to excess; and they may also have been previously convicted of a DWI offence.

Recognition of the magnitude of the problem of the hard core has become widespread and acknowledged among policy-makers and researchers alike. Many scientific reports and journal articles re-affirm the significance of the problem (Beirness et al., 1996; Holubowycz et al., 1994; Ross, 1992; Wilson, 1993; Simpson and Mayhew, 1991; Simpson et al., 1996; Sweedler, 1994).

International interest in the hard core was sparked by the finding that, to a large extent, the decreases in the magnitude of the drinking-driving problem during the 1980s appeared to be a result of changes in the behaviour of law-abiding, social drinkers who, on occasion, may have driven after consuming too much alcohol (e.g., Moskowitz, 1990; Simpson and Mayhew, 1991). If this hypothesis is correct, it suggests that a major part of the drinking driving problem that remains is accounted for by a group of drivers who are not easily affected by persuasive and deterrent measures and have continued to drive after drinking -- often with high BACs. To estimate the magnitude of the drinking-driving problem accounted for by the Hard Core, it is necessary to examine a number of data sources that provide windows on the problem. For example:

- among persons convicted of DWI offences, up to three-quarters are repeat offenders (Simpson et al., 1996);
- among fatally injured drinking drivers, over 60% had a BAC in excess of .150 (Beirness et al., 1996); 68% of injured drinking drivers had a BAC of this magnitude (Vingilis et al., 1994);
- among drinking drivers responsible for fatal crashes, one-third have been previously convicted of a DWI offence (Donelson et al., 1989);
- among self-reported drinking drivers, 62% indicated they drove after drinking on at least two occasions in the previous month and 16% said they had done so five or more times (Simpson et al., 1992); and,
- 90% of all drinking and driving trips are accounted for by persons who report driving after drinking at least twice per month (Simpson et al., 1992).

Characteristics of the Hard Core

A considerable body of research has accumulated on the characteristics of DWI offenders. While not all of the offenders included in the study populations would necessarily meet the criteria of the Hard Core, many of the repeat offenders would likely qualify. The results provide an indication of the types of persons who might possibly be included. In general, the following characteristics help to distinguish DWI offenders:

- men outnumber women by about 9 to 1;
- the model age is between 25 to 44 years;
- single, separated and divorced persons are overrepresented;
- most have at least a high school education; and,
- the majority are employed with moderate income.

Research has also identified numerous psychosocial and behavioural characteristics that distinguish DWI offenders from the general population of drivers. For example, this group often exhibit a variety of antisocial and deviant tendencies such as aggression, hostility, and thrill-seeking. They are more likely than non-drinking drivers to have a criminal history, to use drugs, and to have poor driving records (e.g., Simpson et al., 1996).

One of the most prominent and distinguishing characteristics of this group, however, is their patterns of alcohol consumption. DWI offenders drink more frequently, consume greater quantities of alcohol per occasion, experience more alcohol-related problems and are more likely than others to meet the criteria for a clinical diagnosis of alcohol abuse or dependence.

Simply listing the prominent characteristics of DWI offenders, however, belies the variability within this population. In addition, it would be incorrect and misleading to suggest that all DWI offenders -- even all repeat offenders -- are part of the Hard Core. DWI offenders are indeed a very heterogeneous group and within this population, various characteristics may be more or less prominent, creating definable subgroups or typologies. Drivers engage in DWI behaviour for a variety of reasons and the reasons for their persistence in the behaviour are likely equally varied. One approach to help understand the problem of the Hard Core offender is to separate offenders into relevant subgroups.

Several studies have used multivariate data analytic techniques as a means to identify subgroups of offenders based on common characteristics that appear to render them at risk (Arstein-Kerslake and Peck, 1986; Donovan and Marlatt, 1982; Steer et al., 1979; Sutker et al., 1980; Wells-Parker et al., 1986; Wilson 1991). Although these studies used different methods and derived somewhat different typologies of DWI offenders, there were some important similarities in their findings. First, all studies identified a large subgroup of DWI offenders who were described as relatively well-adjusted. This group displayed lower scores than other offenders on virtually every psychosocial and behavioural dimension, including alcohol consumption.

Second, there were often two subgroups that were defined as "deviant" or at particularly high risk. Although there appeared to be some overlap in the characteristics of these subgroups, one group typically scored higher on measures associated with excessive alcohol use. In three studies, this group also scored highest on measures of depression, a characteristic often

associated with alcohol dependence (Donovan and Marlatt, 1982; Sutker et al., 1980; Wilson, 1991). Compared to the former group, the latter subgroup typically displayed relatively lower levels of alcohol abuse and higher levels of hostility, aggression, sensation seeking and impulsiveness.

The findings from research on typologies of DWI offenders are by no means definitive. Considerable work remains to be done to determine which characteristics best distinguish among the various subgroups of offenders. Nevertheless, the available research clearly demonstrates that not all DWI offenders are similar. They are a very diverse group with different backgrounds, characteristics, motivations, problems and, most likely, different reasons for engaging in DWI behaviour. The immediate implication of this finding is that countermeasures that treat all DWI offenders as a homogeneous group will be less effective than those directed at specific subgroups (Timken et al., 1995; Wells-Parker et al., 1979; 1995). Clearly, the type of intervention appropriate for so-called "well-adjusted" offenders will be very different than that necessary for the alcohol dependent offender.

Research on driver typologies may also lead to greater understanding of DWI behaviour and the etiology of the impaired driving behaviour, particularly that of Hard Core offenders. The questions raised by this aspect of the research are outlined in the following section.

FROM YOUNG DRINKING-DRIVER TO HARD CORE: A DEVELOPMENTAL PERSPECTIVE

To date, the study of drinking drivers has been largely descriptive, with little effort being devoted to a comprehensive understanding of the behaviour. We know little about the motivations underlying the behaviour, its persistence, the etiology of the behaviour, and its developmental progression. Greater understanding of the factors that precipitate and/or facilitate the transition from young thrill seeker to hard core drinking driver would enhance the development of appropriate and effective interventions that could be applied at early stages to help prevent individuals from becoming part of the hard core.

From the information that is available, it is possible to examine the similarities and differences in the drinking-driving behaviour in two prominent groups -- i.e., the young, and the hard core -- to at least begin considering the developmental pathways that may lead from the former to the latter. For example, PBT considers drinking and driving among youth to be part of a more general syndrome of problem behaviour that emerges from within the context of psychosocial unconventionality. The drinking-driving behaviour of youth is but one example of a variety of socially sanctioned behaviours that may include delinquency, drug use, as well as other risky driving behaviours. As a problem behaviour, drinking and driving is purposive, functional, and instrumental in the attainment of goals. As is the case with many other problem behaviours, driving after drinking may be motivated by a desire to experience the thrill, excitement, and danger of doing so.

PBT predicts that as youth enter more socially conventional roles -- e.g., marriage, family, employment -- their extent of involvement in problem behaviour will wane accordingly. Similarly, Zuckerman (1979) indicates that levels of sensation seeking (and thrill seeking in particular) decrease linearly beginning in the late teen years. Jessor et al. (1997) have recently

demonstrated that involvement in risky driving behaviour does indeed decline as a function of young adults entering more socially conventional roles. In essence, many young thrill seekers "mature out" of their high-risk patterns of behaviour.

If this situation were universal, then it would be rare to find a drinking driver over the age of thirty. Obviously, this is not the case. The most significant drinking driving problem we face today involves hard core offenders who are typically between 25 and 44 years of age. It is possible that some young drinking drivers fail to "mature out" of the behaviour. Some may leave and then re-enter this high-risk pattern of behaviour several years later. Still others may become involved at older ages for reasons that are yet to be understood.

Research on the typologies of DWI offenders indicate that there may exist at least two distinct types of high-risk drinking drivers. An examination of the characteristics of these two groups may provide insight into the developmental pathways that led to this status. For example, a key feature of one group is high levels of thrill-seeking or risk-taking. These individuals may represent those on the upper end of the distribution of these traits. It is also possible that these individuals simply failed to "mature out" of this pattern of behaviour. The description of these individuals as "irresponsible" is consonant with this failure to follow the predicted developmental transition to more conventional psychosocial status. Unfortunately, risky driving and driving after drinking remain as outlets for expressing these traits.

The research also shows that aggression and hostility are often dominant features of this latter subgroup. Although these characteristics aren't typically considered within the context of PBT, earlier research reveals that aggression, hostility, and driving to blow off steam were factors associated with young driver crash involvement (Pelz and Schuman, 1968; Schuman et al., 1967). The emergence of these dimensions as part of a subtype of DWI offenders suggests that they may be latent factors that begin to exert a more prominent influence on drinking-driving behaviour at older ages.

The key feature of the other high-risk subgroup of DWI offenders is alcohol abuse. For these individuals, alcohol dominates all aspects of their lives. It becomes a prime motivator for virtually everything they do. That they drive after drinking is largely incidental. Their driving after drinking is less likely to be motivated by a desire to experience the thrill, excitement, and danger of doing so. For the most part, the purpose of the behavior is simply to get either to or from alcohol.

The fact that this alcohol abuse subgroup also displays elevated sensation seeking scores suggests that in their younger years they may have engaged in heavy drinking and driving after drinking within the context of the more general problem behaviour syndrome. After years of heavy consumption, they may have succumbed to the addictive nature of alcohol.

Granted, at this point the above discussion is mere speculation about the possible developmental pathways that might possibly link the drinking driving behaviour of young thrill seekers and older hard core offenders. Further longitudinal research that follows a large group of adolescents through to middle age is necessary to help understand the progression to hard core status.

CONCLUSION

Over the past decade and a half, tremendous changes have occurred in the magnitude and nature of the drinking-driving problem. It is also clear that these changes have not been consistent across all groups of drinking drivers. Young drinking drivers appear to have responded more favourably than their older counterparts and moderate social drinkers have reduced their involvement in drinking-driving more so than heavier drinkers. Why this is so is not particularly clear.

Although considerable research has been instrumental in identifying problem areas for targeted interventions, little has been learned about the motivations for the behaviour or its persistence. On the basis of research on the characteristics of groups of drinking drivers, it would appear that at least some of the drinking and driving behaviour among youth is motivated by risk-taking -- a desire to experience the thrill, excitement, and danger associate with doing so. As young drinking drivers mature and enter more socially conventionally roles, their involvement in drinking and driving and other problem behaviours decreases.

Research on older groups indicates that thrill-seeking contributes to the persistence of drinking-driving behaviour in at least one deviant subgroup of offenders. While it is conceivable that this subgroup consists of those individuals who failed to mature out of a high-risk adolescent lifestyle, the actual developmental pathways have yet to be uncovered. The question can only be answered through large-scale longitudinal studies that follow individuals from adolescence through middle age.

Alcohol abuse is the key feature of the other high-risk subgroup of offenders. It is unlikely that risk-taking per se contributes directly to their drinking-driving behaviour. Although this group shows elevated levels of the sensation seeking trait, it is not known whether this initially contributed to their excessive drinking which led to dependence or whether the dependence developed through some completely independent pathway.

In conclusion, over the past two decades, a great deal has been accomplished in the are of drinking and driving. A tremendous amount of research has also been done. But this research has been largely descriptive. Our understanding of the behaviour -- e.g., the motivations that underlie its occurrence and persistence -- is limited. Our knowledge of the developmental progression from young thrill seeker to hard core offender is based almost entirely on speculation. Further reductions in the overall magnitude of the problem may well depend on our ability to understand the behaviour and the factors that contribute to its origins, its progression, and its persistence.

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SENSATION SEEKING AND RISKY DRIVING

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ABSTRACT A review of the research on the relationship between sensation seeking and risky driving consistently demonstrated that high sensation seekers (SS) are more likely to report impaired driving, non-use of belts, speeding, as well as more violations and collisions. In the first study, college students completed a questionnaire concerning their driving behaviour and level of sensation seeking. Results indicated that high SS's were significantly more likely than low SS's to speed, not wear belts, drink frequently, drive after drinking, perceive a low risk of detection for impaired driving, and perceive that they could drink more beer before being impaired. High SS's were also more likely to report aggressive driving habits. High SS's were significantly more likely than low SS's to say that they would drive faster on highways and on wet roads and drive after drinking, if operating a vehicle equipped with anti-lock brakes. A driving experiment, in which high and low SS's responses to a fatigue warning device were assessed, revealed little evidence of behavioural adaptation, although there was some evidence that high SS's may have adapted to the situation by taking fewer rest breaks.

INTRODUCTION

Ever since Tillman and Hobbs (1949) stated that "a man drives as he lives", there has been interest in the driver's personality as a potential underlying causal factor in driver behaviour. One personality trait that has received considerable attention is sensation seeking. According to Zuckerman (1994), sensation seeking (SS) "is a trait defined by the seeking of varied, novel, complex, and intense sensations and experiences and the willingness to take physical, social, legal, and financial risks for the sake of such experiences" (p.27). Central to this trait is "the optimistic tendency to approach novel stimuli and explore the environment" (p. 384). The possibility that SS underlies risky driving has been the subject of a considerable amount of research (cf. Jonah, 1997).

Sensation seeking is operationally defined in terms of scores on the Sensation Seeking Scale (SSS) which was first published by Zuckerman et al. (1964). Form V of SSS is currently the most commonly used measure of sensation seeking (Zuckerman, 1994). The 40 forced choice items on this scale require subjects to choose between a statement which reflects a desire for

sensation ("I like wild and uninhibited parties") and one that reflects a more cautious predilection ("I prefer quiet parties with good conversation"). The SSS consists of four subscales: Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Boredom Susceptibility (BS), and Disinhibition (Dis). It is important to note that there are no items on the SSS which refer to driving behaviour.

This paper a) summarizes a recent review of the literature on the relationship between SS and risky driving, b) presents the results of a study of drivers concerning risky and aggressive driving and their likelihood of adapting to anti-lock braking, and c) provides an overview of the results of an experiment which examined the driving behaviour of high and low SS's subjects and their propensity to adapt to new technology (i.e., a fatigue warning system).

REVIEW OF LITERATURE ON SS AND RISKY DRIVING

The review of the literature is organized into three sections focusing on drinking and driving, other risky behaviours such as non-use of seat belts and speeding, and the consequences of risky behaviour (i.e., collisions and citations for traffic violations). Given the limited space, only 12 of the 40 reviewed studies are presented to illustrate the findings of the full review which can be found in Jonah (1997).

Sensation Seeking and Drinking and Driving

Arnett (1990) administered the complete Sensation Seeking Scale (SSS) to high school students, who also indicated whether they had driven drunk during the past year. Those reporting drunk driving had higher scores on the total SSS. Students who drove drunk were also less likely to perceive that such behaviour would result in collisions or traffic tickets. Interestingly, high SS's expected to be able to drive drunk on more occasions before being involved in a collision or getting a ticket compared to low SS's (r's=.44, .27, respectively).

Donovan et al. (1985) compared three groups of drivers: driving while impaired arrestees, high risk drivers (i.e., multiple accidents or violations) and drivers from the general population on a wide variety of personality, attitudinal, and drinking variables. Impaired and high risk drivers had higher SS scores than general drivers but did not differ from each other.

Johnson and White (1989) combined the scores on the Disinhibition and Experience Seeking subscales with subscales of Jackson's PRF to form a risk taking/impulsive orientation measure. Regression analyses were performed on the subjects' reported driving after drinking or smoking marijuana. The SS measure significantly contributed to the variance explained among 18 year old males for drinking and driving (coefficients ranged from .27 to .43) and marijuana use and driving (coefficients ranged from .27 to .33). For 18 year old females and older males and females, the relationships were in the same direction but weaker.

Stacy et al. (1991) explored the relative importance of three general explanations of the effects of sensation seeking on self-reported drinking problems which included driving while impaired: direct effects on drinking problems; mediational effects (i.e., personality influences alcohol consumption which creates problems); and moderating effects (i.e., personality and consumption

interact to affect problem behaviours). Impaired driving increased with SS for men (r=.54) and for women (r=.32). Path analyses revealed that SS influenced impaired driving directly for men but indirectly through alcohol consumption for women and SS interacted with alcohol consumption.

In summary, of the 16 studies examined by Jonah (1997) which looked at SS and drinking and driving, all but 4 found positive relationships such that, as SS increased, reported impaired driving increased or convicted impaired driving offenders had the higher SS scores than drivers from the general population.

Sensation Seeking and Other Risky Driving Behaviours

The full SSS was completed by university students, as were measures of driving behaviour in a study by Clement and Jonah (1984). Controlling for age, distance traveled and driving experience, men's reported usual speed on a highway with a 100 kph limit increased as a function of SS scores (r=.23) For women, speed increased with SS (r=.14) and reported seat belt use declined with SS (r=-.15).

In one of the few experiments on driving that has examined sensation seeking, McMillen et al. (1989) looked at risky driving performance on a simulator which measured lane changes, cars passed, and amount of time at maximum speed as a function of alcohol consumption, alcohol expectancy and sensation seeking. Overall, high SS's passed more cars and changed lanes more often than low SS's. More importantly, SS and alcohol expectancy interacted such that regardless of actual consumption, high SS who thought they had consumed alcohol, passed more cars and changed lanes more often than those who did not think that they had been drinking. In contrast, low SS who thought that they had been drinking actually took fewer risks compared to those who expected no alcohol, suggesting that low SS's may drive more carefully if they feel that their performance is impaired.

Wilson (1990) explored the relationship between SS and seat belt use among three groups of drivers: impaired driving offenders, drivers with multiple collisions/ violations and a group of drivers from the general population. In all three groups, those drivers claiming to wear seat belts all the time had lower SS scores than those who never wore belts or wore them inconsistently.

Yu and Williford (1993) tested impaired driving offenders on a measure of driving risk and a measure of sensation seeking which included items from the SSS. Driving risk correlated .45 with SS. Also, high SS's felt that they could handle more drinks and still drive well than did low SS's (r=.28), suggesting lower perceived risk by high SS.

In summary, all of the studies reviewed by Jonah (1997) have found positive relationships between SS and risky driving other than drinking and driving, particularly for men.

Sensation Seeking and Driving Records

The ultimate measure of risky driving is involvement in collisions, particularly where the driver has been deemed at fault. Traffic violations are often used as an intermediate measure of risky

driving between behavioural measures and the ultimate measure of collision involvement. Wilson and Jonah (1988) predicted scores on a risk index consisting of responsible collisions, traffic violations and licence suspensions, among convicted impaired drivers, high risk drivers and a sample of drivers from the general population. Scores on the risk index correlated .32 with the thrill-seeking scale.

A Finnish study by Hilakivi et al. (1989) related the scores on the Cattell 16 PF test (a measure akin to SSS) of army conscripts at induction with their reported collisions over their subsequent 11 month military service. Logistic regression identified the H factor (carefree, impulsive, danger ignoring personality) and the L factor (readiness to take chances) as being significant predictors of collision involvement. When predicting collisions where the subject was considered as being responsible, the L factor and the Q3 factor (uncontrolled behaviour) were significant.

Furnham and Saipe (1993) had British students and professionals complete the Thrill and Adventure Seeking and Boredom Susceptibility subscales of SSS, as well as a risky driving questionnaire which included measures of reported collisions and traffic violations. Thrill and Adventure Seeking and Boredom Susceptibility correlated significantly with violations (r's=.19 and .31, respectively) but not with collisions.

Beirness (1996) conducted a multi-year cohort study whereby high school students completed a lifestyle questionnaire annually over four years. The Thrill and Adventure Seeking and Experience Seeking subscales were included as part of the questionnaire, as were self-reported collisions. Based on their driving record during the fourth year, the students were classified into Crash and No Crash groups. The Crash group had higher sensation seeking scores in each of the three preceding years than the No Crash group.

In summary, of the 11 studies that have related SS to traffic violations, 9 have reported a positive relationship and of the 12 studies examining collision involvement, 9 have observed a positive relationship.

Discussion

Of the 40 studies reviewed by Jonah (1997), only 4 did not find a positive relationship between sensation seeking and some aspect of risky driving. Where correlations have been reported, they tend to be in the .30 to .40 range indicating that SS may account for about 10 to 15% of the variance in risky driving. This relationship has been observed among drivers from Canada, the United States, Great Britain, the Netherlands, Sweden and Finland. The relationship has been found for both men and women but is weaker among the latter. Collision involvement has been less strongly associated with SS, possibly because being in a collision does not necessarily mean that the driver behaved incorrectly. There is also evidence that high SS's perceive less risk in various situations than low SS's.

Zuckerman (1983, 1994) and his colleagues have studied the biological bases of sensation seeking and have amassed considerable support for the argument that high SS's have different levels of norepinephrine, dopamine, and monoamine oxidase than low SS. According to Zuckerman, it is the brain's limbic system which provides rewards and punishments in terms of pleasure and pain and hence is the biological site of sensation seeking. The limbic system is

activated by brain norepinephrine and dopamine, both of which have been found to vary with level of SS. Dopamine appears to control the readiness to explore and the approach to novel stimuli, while norepinephrine appears to regulate the expectation of positive reinforcement from novel stimuli. Low monoamine oxidase is believed to be the neurochemical source of SS and appears to be an antagonist to dopamine and norepinephrine such that high levels of it inhibit the accumulation of dopamine and norepinephrine.

There is also fascinating evidence to suggest that differences in SS may be genetically based and that these genetic differences are reflected in the different biological makeup of high and low SS's. Eysenck (1983) has estimated, using twin study data, that as much as 70% of the reliable variance of the underlying trait of sensation seeking is genetic in origin. In recent studies by Ebstein et al. (1996) and Benjamin et al. (1996), novelty seeking has been found to be related to the dopamine receptor gene.

Taken together, the results of previous research on the relationships among SS and risky driving, neurochemical differences in the brain, and possible differences in genetic structure, suggest that risky driving may be, at least to some extent, genetically predisposed. This suggestion leads one to consider the implications for road safety of such a predisposition, if in fact it is borne out by further research. Is it possible that some risky drivers cannot be influenced by education or enforcement? Do these drivers actually enjoy the thrill of risky driving and avoiding negative consequences (e.g., collisions, citations). If so, this group may only respond to engineering solutions, whereby they do not have to alter their behaviour.

It could be argued, however, that these sensation seeking drivers would adapt to perceived technology induced reductions in risk by taking greater risks? Is it possible that such behavioural adaptation is not a general phenomenon observed among all drivers, as purported by Wilde (1994), but rather one that is pursued mainly by those drivers who seek to optimize their level of risk and the potential rewards from those risks? It is hypothesized that SS may moderate behavioural adaptation to risk such that high SS's are more likely to "spend" any safety benefit afforded by vehicle design improvements by engaging in risky driving, while low SS's are more likely to "bank" the safety benefit by not altering their behaviour, thereby enhancing their safety. Indeed, it may be the very drivers who would benefit the greatest from safety enhancements who are most likely to adapt their behaviour to perceived reductions in risk.

Some support for this hypothesis has been reported by Ward et al. (1997) who evaluated driver response to an Adaptive Cruise Control (ACC) device which automates speed and headway maintenance. High and low SS's drove a vehicle along a set route on a highway with and without the ACC device. Measures of arousal, effort, situational awareness and driving behaviour were taken. The results indicated that the use of the device resulted in lower arousal and effort being reported by high SS's as well as higher measured peak speeds, compared to low SS's.

There is considerable debate of late concerning "road rage" and the aggressive driver (American Automobile Association, 1997). While there have been studies of aggressive driving behaviour and aggressive personality traits of drivers, no attempt has yet been made to link SS with aggressive driving. It is possible that aggressive behaviour toward other drivers on the road is another manifestation of high SS's thirst for excitement. A driver who screeches his tires as he

races away from other drivers at an intersection and then gives those left in his dust the golden finger may find their aggressive behaviour stimulating.

STUDY 1: RISKY DRIVING, AGGRESSIVE DRIVING, BEHAVIOURAL ADAPTATION, AND SENSATION SEEKING

This study investigated the relationship between SS and risky and aggressive driving, as well as the likelihood of adapting to anti-lock braking systems by driving in a more risky manner. Since most previous research on SS and risky driving has used male subjects, both men and women were included in this study to determine whether gender moderates these relationships.

Method

Subjects: The subjects were 279 male and female students in psychology, design, marketing, or dental assistant courses at two colleges in Montreal and Ottawa.

Procedure: The students completed a two part questionnaire during class time. The first part included questions about, distance traveled, seat belt use, preferred speed, perceived risk of motor vehicle collision injury, drinking, driving within 2 hours of drinking, legally impaired driving, perceived likelihood of apprehension for impaired driving, drinking capacity before one's ability becomes impaired, drinking capacity before one's blood alcohol concentration is over legal limit, and collisions and traffic violations during the past 2 years. A measure of aggressive driving was also included where drivers indicated their agreement or disagreement with statements about engaging in various aggressive driving behaviours (e.g., swear at other drivers, beating other drivers from getaway, driving close behind other vehicles to get driver to move over, etc.).

To measure behavioural adaptation, the subjects were given an hypothetical scenario where they were driving a vehicle equipped with anti-lock brakes, which they were told increase safety, and asked to indicate how likely they would be to drive faster on highways, drive closer behind other vehicles, drive after drinking, not wear a seat belt, speed up if the light turned yellow or drive faster on wet roads.

The second part of the questionnaire was Form V of Zuckerman's Sensation Seeking Scale which consists of 40 forced choice items (Zuckerman, 1994). The distribution of total sensation seeking scores was split at the median so that subjects with scores below 20 were classified as low sensation seekers and those with scores 20 and higher were considered as high sensation seekers.

Analyses: The discrete data was analyzed using multiple chi-square to test for the effects of SS, gender and their interaction. Rating scales were analyzed using an SS x gender analysis of variance.

Results

High and low sensation seekers did not significantly differ on age, gender, kilometres traveled, college attended or owning a computer (i.e., proxy measure for socio-economic status). Given the main interest of the study was SS, only main effects of SS and interaction effects of gender with SS are reported.

Risky Driving and Risk Perception: Table 1 presents self-reported risky driving behaviour for high and low sensation seekers. High sensation seekers were significantly ($p < .05$) more likely than low sensation seekers to say that they do not always wear seat belts, they would drive 120 kph or faster on an expressway if there was no speed limit, drink 2-7 times per week, drive while they thought that their BAC was over the legal limit, believe that they could drink 5 or more drinks before their ability to drive was impaired, and believe that the chances of an impaired driver being caught by the police are low. There was a trend for high sensation seekers to be more likely to report a traffic violation within the last two years but there was no difference on collision involvement. There were no interaction effects with gender, indicating that the differences between high and low SS's existed for both men and women.

Table 1. Percentages of Young Women and Young Men With Each High-Risk Driving Outcome on Their Driver License Records

DRIVING OUTCOME:	Offense	Offense	Serious Offense	Crash	Crash	Single Vehicle Crash	Injury Crash
Years of Licensure:	1	2	2	1	2	2	2
WOMEN n @ 1 year = 375 n @ 2 years = 773	11.5	19.4	4.1	20.3	25.6	4.4	9.8
MEN n @ 1 year = 419 n @ 2 years = 887	25.0	33.8	13.1	22.2	33.3	7.4	11.3

Aggressive Driving Habits: The degree to which drivers agreed that they engage in various aggressive driving habits is exhibited in Table 2. High sensation seekers were more likely than low's to agree that they swear at other drivers, they like to beat other drivers at the getaway, think it is fun to weave through traffic, they like passing other cars, driving at high speeds is exciting, they like to outsmart other drivers, and they often lose their temper. Additionally, there were marginally significant differences ($p<.10$) on not being easily provoked or angered when driving, never using the horn when annoyed and making rude signs to other drivers. There were no significant differences on never entering intersections when the light is red or on driving close behind other vehicles to get the driver to move over. There were significant SS by gender interactions on only two items, passing and making rude signs. For the passing behaviour, there was no difference between high and low SS's among males but among female drivers, high SS's reported more aggressive passing than low SS's. For making rude signs, the opposite pattern emerged with no effect of SS among females but high SS's among males reporting more of this behaviour than low SS's.

A principal components factor analysis of the aggressive driving items extracted two factors, one reflecting positively keyed items (i.e., agreement indicates aggressive driving) and the other reflecting primarily negatively keyed items (i.e., disagreement indicates aggressive driving). Two composite scales were created by averaging the scores on the items loading on each of the two factors. An analysis of variance indicated that on both scales, the high sensation seekers were more likely than low sensation seekers to indicate that they usually drive in an aggressive manner, as can be seen at the bottom of Table 2. There were no interaction effects of SS and gender on these composite variables of aggressive driving.

Table 2. Summary of Predictors of Young Women's High-Risk Driving Outcomes

DRIVING OUTCOME:	Offense	Offense	Serious Offense	Crash	Crash	Single Vehicle Crash	Injury Crash
Years of Licensure:	1	2	2	1	2	2	2
Predictor Grade:	8th	12th	12th	8th	12th	12th	12th
PREDICTORS							
DEMOGRAPHIC							
Living situation		*					
Race			*				*
PERSONALITY							
Cigarette propensity					*	*	
PERCEIVED ENVIRONMENT							
Friends' alcohol involvement				*			*
Friends' marijuana involvement							*
Substance availability					*		
BEHAVIOR							
Substance use							
Alcohol use		*	*				
Alcohol misuse			*				*
Marijuana use					*		
School							
Grades		*					
Driving							
Frequency		*			*		

* Significant predictors found

Behavioural Adaptation: The subjects' likelihood that they would engage in various risky driving practices if they were driving an ABS equipped vehicle is presented by their level of sensation seeking in Table 3. High sensation seekers were significantly ($p<.01$) more likely to say that they would drive faster on highways, drive faster on wet roads, and drive after drinking. High SS's were also marginally more likely to say that they would not wear their seat belt ($p<.09$) and that they would drive closer behind other vehicles ($p<.12$). There was significant SS by gender interaction only on the likelihood of driving faster on highways. Male subjects exhibited no difference as a function of SS but among female subjects, high SS's were more likely to say that they would drive faster.

Table 3. Summary of Predictors of Young Men's High-Risk Driving Outcomes

DRIVING OUTCOME:	Offense	Offense	Serious Offense	Crash	Crash	Single Vehicle Crash	Injury Crash
Years of Licensure:	1	2	2	1	2	2	2
Predictor Grade:	8th	12th	12th	8th	12th	12th	12th
PREDICTORS							
DEMOGRAPHIC							
Living situation	*	*		*			*
Race		*					
PERSONALITY							
Marijuana propensity						*	
ENVIRONMENT							
Parents' attitude/drinking	*	*		*			
Substance availability		*	*			*	*
BEHAVIOR							
Substance use							
Alcohol misuse						*	
Smokeless tobacco			*				
Marijuana						*	*
School							
Grades		*	*				
Driving							
Frequency						*	

* Significant predictors found

The behavioural adaptation items were factor analyzed and only one factor emerged, including all six items. The ratings on these six items were averaged to create a composite measure of behavioural adaptation. An analysis of variance performed on this composite scale revealed that high sensation seekers were more likely than low sensation seekers to indicate that they would drive in a risky manner if they thought that the vehicle that they were driving was equipped with ABS ($p<.05$). There was no interaction effect on the composite measure.

Discussion

The results of this study clearly demonstrate that high sensation seekers report engaging in more risky driving than low sensation seekers and are consistent with previous research (Jonah, 1997). High SS's also reported more aggressive driving habits than low SS's, suggesting that aggressive driving may be a means of stimulation for high SS's. In a hypothetical situation where the subjects were driving a vehicle equipped with ABS, high SS's indicated that they would be more likely than low's to engage in risky driving behaviours, particularly faster driving and driving after drinking. This may reflect greater potential behavioural adaptation among high SS's.

Although there were a few sporadic SS by gender interactions, there was no clear indication that the relationship between SS and risky driving, aggressive driving and potential behavioural adaptation was moderated by gender.

STUDY 2: AN EXPERIMENT ON SENSATION SEEKING, RISKY DRIVING AND BEHAVIOURAL ADAPTATION

The results of the previous study are based on the reports of what high and low SS's say they do or would do in a particular driving situation. An opportunity arose to include sensation seeking as a factor in an experiment investigating the response of drivers to a fatigue warning system. It was hypothesized that high SS's, when operating a vehicle over an extended period of time (5 hours), would display greater behavioural adaptation to a fatigue warning device by taking fewer breaks, driving faster, and exhibiting greater lane deviation, compared to low SS's.

Method

Subjects: Thirty-two subjects (24 male, 8 female) were recruited from among the Montreal respondents participating in the previous study.

Experimental Design: The design was four factorial: session (pre-test/post-test), fatigue warning device (FWS) being present or absent, time period (half hour periods), and sensation seeking (high/low based on a median split of the SS scores). In the pre-test session, all subjects drove without the fatigue warning device but during the post-test session, half of the subjects drove with a fatigue warning device whereas the other half did not.

Procedure: The subjects drove an instrumented vehicle on a test track at the Blainville Test Centre north of Montreal on two separate occasions separated by a week. For each session, each subject came to the Centre at about 22:00 having carried out their normal activities during the day (i.e., worked or gone to school). After completing pencil and paper measures of sleep quality and quantity, the Stanford Sleepiness scale, the participants drove a 7 kilometre closed loop track for a maximum of 350 kilometres. The subjects were instructed to complete the distance without

exceeding 70 km/hour. The subjects could stop for a break as often as they wanted and for as long as they wanted. Typically, the subjects drove for five or six hours to complete the distance.

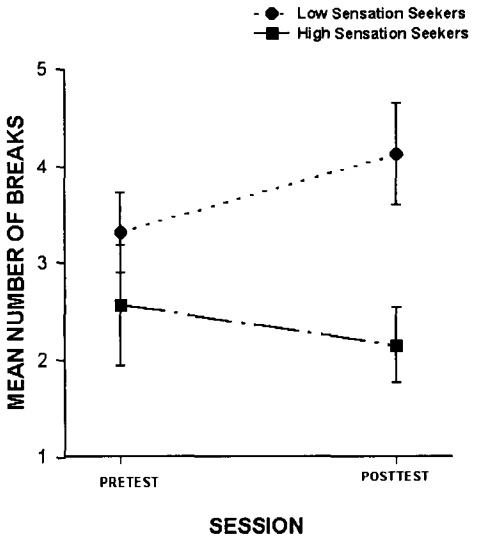
Measures: A number of variables were measured during the experiment including, subjective fatigue, number of rest breaks taken, number of fatigue warnings given, lane deviation, speed, and the number of traffic cones struck. Measures from the instrumented vehicle were also taken but are not yet available.

Results

Overall, there was little evidence that the subjects adapted to the fatigue warning device. However, there were a number of differences between high and low SS's on several measures.

Rest Breaks: There was a marginally significant SS by Session (Pre vs Post-test) effect on the number of rest breaks taken during the driving session ($F(1,28)=3.61$, $p< 0.07$). As shown in Figure 1, during the pre-test, highs and lows did not differ, but during the post-test one week later, the lows took more breaks than they did during the pre-test while the highs took fewer. These results suggest that the high SS's may have adapted to the experimental situation such that once they had completed the driving task during the pre-test, they felt more confident with the situation such that they could complete the distance with fewer breaks.

Figure 1: Number of Rest Breaks as a Function of Sensation Seeking and Session



Subjective Fatigue: There was a significant interaction effect between SS, group membership (i.e., FWS/Control) and time period ($F(12,32)= 2.57$, $p< 0.003$). For all subjects, subjective fatigue increased with length of time driving but in the control condition, the high SS's had higher levels of fatigue than low SS's for all time periods until the last two at which point there was no difference. For the group with the FWS, the low SS's had higher levels of fatigue than high's for all time periods except the last two.

Fatigue Warning Signals: In the FWS condition only, drivers were given a signal during the post-test session whenever it appeared that they were fatigued (e.g., eyes closed). Low SS's

received more warnings than the high SS's during all time periods except 1,2, 10 and 13 ($F(12,168)= 5.59$, $p< 0.001$). These results are consistent with the subjective fatigue ratings.

Major Lane Deviations: There was a significant SS by group membership by session interaction ($F(1,32)=4.73$, $p< 0.04$) on major lane deviations (i.e., standard deviation > 1.5 feet) such that during the pre-test high SS's exhibited more of these deviations than low SS's. However, during the post-test session, high SS's had more large deviations than low's in the control group but the low's had more of these deviations in the FWS condition than the highs. The greater incidence of major lane deviations by the low SS's in the FWS condition is consistent with the greater fatigue reported by the low SS's and the greater incidence of fatigue warning signals given to the low SS's in this condition.

Other measures: There were no significant differences on distance traveled, speed measures nor on the number of cones hit.

Discussion

The results of this experiment provide little support for behavioural adaptation to the FWS nor for the hypothesis that high SS's would adapt more to the FWS. However, the observation that the high SS's tended to take fewer breaks during the post-test session suggests that they may have felt more comfortable with the experimental situation during the post-test so that they decided to complete the driving task faster by taking fewer breaks. Lows, perhaps realizing how tired they felt after the pre-test session, may have compensated during the post-test by being more cautious and taking more breaks. There was some consistency in the other results such that the low SS's in the FWS condition had higher subjective fatigue ratings during the post-test, received more fatigue warnings, and displayed more major lane deviations than the high SS's, all indicative of the low SS's being more tired than the high SS's. However, it is not clear why this pattern of results occurred **only** for the FWS during post-test condition. Perhaps low SS's who generally do not sleep as well as high SS's (Zuckerman, 1994), were more stressed by the presence of the FWS which resulted in greater feelings of fatigue.

GENERAL DISCUSSION

The results of the research presented in this paper strongly support the argument that high sensation seekers are more likely to drive in risky manner and exhibit aggressive behaviour while driving. While high SS's are more likely to indicate that they would adapt to a vehicle perceived to be safer by driving faster, driving without wearing seat belts and driving impaired, when given an opportunity to adapt to a fatigue warning system, neither high nor low SS's exhibited any apparent adaptation but they may have displayed some adaptation to the driving environment.

There is a need for further research on behavioural adaptation by high and low SS's to other safety devices (e.g., antilock brakes). Furthermore, further research should be conducted on the biological bases of risky driving behaviour to determine the extent to which such behaviour is biologically predetermined. If a significant proportion of high risk drivers' behaviour is biologically determined, considerable thought should be devoted to how these drivers should be dealt with. Should licensing authorities be screening drivers for such characteristics? Can risky

behaviour which is biologically based be treated by medication? Clearly, there are more questions than answers.

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DISCUSSION OF "SENSATION SEEKING AND RISK DRIVING" BY JONAH ET AL.

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ABSTRACT This discussion of the Jonah et al. paper makes the following points:

- The paper makes a valuable and timely effort to connect the concepts of 'sensation seeking' and 'behavioral adaptation' on a theoretical as well as on an empirical level.
- The fact that the predicted interaction between these variables was found in questionnaires, but not in actual (test track) driving, may be due to (1) bias in the questionnaires because of over-reliance on self-reports and (2) a choice of device tested for behavioral adaptation during actual driving that may, in hindsight, have been inappropriate.

INTRODUCTION

Traffic psychology is not a mature science. Its theoretical structure is loose, the operationalization of its concepts looser, and its empirical basis not unlike a beginner's stamp album: the cheapies are there, but mostly empty pages sadly stare you in the face.

As a result of this we are not able to answer simple questions from policy makers ("What will the effect of this countermeasure on traffic safety be?"), and invariably have to resort to extensive measurement and evaluation programs.

The paper by Jonah et al. is, however, an example of research that tries to provide the underpinnings of what, some day, could develop into a mature theoretical framework enabling us to answer these simple questions on the spot. It does this by not starting all over again, but by linking concepts that have as yet been considered independently. For this reason, it deserves our serious attention.

INDIVIDUAL DIFFERENCES AND TRAFFIC PSYCHOLOGY

The paper examines 'sensation seeking' as a factor contributing to an individual's propensity to display behavioral adaptation.

Taking sensation seeking first, this is a variable reflecting certain differences between people. The thing about individual differences is that there are so many of them. This is what makes it easy to do research on them - just make your pick - but also what makes them difficult to handle by researchers trying to develop theoretical superstructures.

Is 'sensation seeking' just one of the myriad individual differences that we can think of, or is it here to stay?

The evidence to be taken into account is of various types, of which several are covered in the paper.

The weakest type of evidence, in my view, is where sensation seeking scores are related to self-reported driving habits, including self-reported collisions and traffic violations. If it is true that high sensation seekers derive at least some of their sensation from the reactions of others (cf. the 'golden finger' effect) they might as well try to impress the interviewer by exaggerating certain aspects of their imagined driving performance. The bias this would produce would obviously artificially inflate the correlation one is looking for.

Although it may to some degree suffer from the same bias, experimentation on actual driving behavior is capable of providing stronger evidence on the true nature of the underlying relationship. To my knowledge three published studies of this type have been performed. One is the McMillen et al. (1989) simulator study mentioned in the paper. the second one is the closed-track study reported in the paper, and the third one is an instrumented-vehicle on-the-road study by Heino (1996). The first study showed that high sensation seekers passed more cars and changed lanes more often than low sensation seekers. Jonah et al.'s own study - some measures of which are not yet available - demonstrated that high sensation seekers exhibited more major lane deviations than low sensation seekers. And in the Heino experiment it was found that high sensation seekers followed at closer headways on motorways than low sensation seekers, at least when traffic density would not 'force' a headway upon following drivers. The average headway under those conditions was 1.18 s for high sensation seekers and 1.82 s for low sensation seekers, a highly significant difference.

Taken together, the evidence from experimental studies thus clearly points to sensation seeking as a factor that significantly affects driving behavior. It appears that it is, indeed, a variable which is here to stay.

Incidentally, in order to eliminate any bias that may still occur even in this type of study - of the high sensation seeking subject trying to impress the experimenter by his driving behavior - one would have to resort to a design in which drivers are monitored on the road, as members of the general driving public, and are only post hoc identified as either sensation seekers or sensation avoiders. Certainly not a 'cheapy' to perform.

BEHAVIORAL ADAPTATION AND SENSATION SEEKING

The 'extra' of Jonah et al.'s paper is that the authors attempt to relate one concept, sensation seeking, to another: behavioral adaptation.

It is good to realize that behavioral adaptation - to any change made in a driver's task environment - can become manifest in different ways. First, there may be the 'direct' behavioral changes like increasing driving speed, decreasing following headways, exhibiting greater lateral deviations, etc. Decreases in level of attention and effort also belong in this category. Second, the effects may be on 'mobility', in the form of increasing mileage driven or driving relatively more under adverse conditions. Third there may be the 'strategic' effect, that is, affecting the decision whether to take part in traffic at all.

There is no body of theory which predicts when to expect which - if any - of these effects, nor at what time after the change it should become visible. As far as 'direct' behavioral effects are concerned - which is what Jonah et al. were looking for - one would intuitively expect a fatigue warning device to be a candidate for adaptation. I am less sure, however, about the time interval at which adaptation should be expected to occur. This could well be related to how often the user notices an action of the device. Jonah et al. do not give the numbers, but from the fact that a statistical analysis on them could be performed we can infer that warnings must have occurred in reasonable numbers. One would then expect adaptation to the fatigue-warning device to have occurred reasonably soon, if it would occur at all. The fact that it did not demonstrates that we have still little clues as to why some devices produce (immediate) behavioral adaptation, while others don't.

A point of criticism that may be raised in this connection - and in hindsight - is that it would have been wiser had Jonah et al. not tried to do two new things at once. Taking a device already shown to be subject to (counterproductive) behavioral adaptation, and in this experiment differentiating this known adaptation effect according to level of 'sensation seeking', would have been close to ideal. Now, by taking the risk that this could be a device showing no immediate behavioral adaptation at all, the authors also deprived themselves of finding a possible differential effect of sensation seeking that could have been obtained with a different device.

To my knowledge there are two devices for which counterproductive behavioral adaptation effects have been substantiated, one being antilock brakes (Aschenbrenner et al., 1992), the other driver seat belts (Janssen, 1994). It would be extremely interesting to see Jonah et al.'s study replicated with one of these.

Lastly, in the questionnaire part of Jonah et al.'s study there was indeed evidence of the predicted sensation seeking x behavioral adaptation interaction (to an antilock braking system, incidentally). High sensation seekers were more likely than low sensation seekers to indicate that they would drive in a risky manner if they thought that the vehicle they were driving was equipped with ABS. For reasons mentioned earlier, however, this result can be suspected to suffer from a certain bias.

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HIGH-RISK DRIVING AMONG ADOLESCENTS: PSYCHOSOCIAL AND SUBSTANCE USE CORRELATES AND PREDICTORS[4]

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Objectives: This project used psychosocial and substance use data from students' self-completed questionnaires to explain by gender their subsequent and concurrent high-risk driving behavior.
Methods: A previous longitudinal evaluation of school-based substance abuse prevention provided questionnaire data and subjects for this project, which added matched driver history records to the existing data base. Offenses and crashes in the first year of licensure, and offenses, serious offenses, crashes, single-vehicle crashes, and injury crashes in the first two years of licensure, were analyzed with logistic regression to identify the important measures predicting each driving outcome.
Results: For both women and men, living with both parents was a protective factor, and propensity to use substances was a risk factor for high-risk driving. For women, friends' involvement with substances, and for men, parents' leniency toward teenagers' drinking were risk factors, while the availability of substances was a risk factor for both genders. Substance use and poor school performance were risk factors for high-risk driving as well.
Conclusions: Significant predictors of high-risk driving that differed by gender were identified. Early prevention programs that focus on the findings are needed.

INTRODUCTION

Motor vehicle crashes continue to be the major cause of death and serious disability in adolescents and young adults. Although fatality and injury rates have declined, those for young people stand out as significantly higher than the overall rates for the population. In 1996, teenagers accounted

[4]Project supported in part by grant RO1 AA09026 from the National Institute on Alcohol Abuse and Alcoholism to Drs. Patricia Waller and Jean Shope. Additional project colleagues include Dr. Sylvia Lang and Ms. Laurel Copeland.

for 10% of the US population, but 15% of the motor vehicle deaths (Insurance Institute for Highway Safety, 1997). High-risk driving behavior contributes to that fatality rate, whether it is intentional or not. For example, 36 percent of male drivers 15 to 20 years old involved in fatal crashes were speeding (US Department of Transportation, 1996).

This paper addresses adolescent driving, using indicators of high-risk driving available in driver history records. Risk-taking per se, the focus of this symposium, is hard to identify in driver history records. While some adolescents take risks, others who become involved in traffic offenses or crashes, fatal or not, may not be taking risks consciously, as much as they are behaving in a risky manner for a whole range of possible explanations. Those reasons might include inexperience, immaturity, poor risk perception, poor risk assessment, poor probability assessment, lack of knowledge, or lack of skills. A better understanding of the predictors and correlates of high-risk driving is needed, so that effective prevention efforts based on research findings can be initiated.

High-risk driving has been considered a problem behavior that adolescents exhibit, similar to smoking, the use of alcohol and other drugs, delinquency, and violence, all of which put adolescents at risk (Jessor, 1987). In several studies, these behaviors have been correlated and can be considered a syndrome or constellation of problem behaviors (Donovan, 1993; Jessor, Donovan, Costa, 1991). The few studies that have examined adolescent driving behavior as well as other psychosocial or lifestyle factors suggest that there are important correlates and predictors (Beirness, Simpson, 1991; Gregerson, 1994; Simpson, Beirness, 1993). Jessor's problem behavior theory (Jessor, Jessor, 1977) provides a useful approach to explaining adolescent high-risk driving behavior. In this theory, three important systems interrelate and lead to "proneness" or the likelihood of the health-compromising behavior: the personality system, the perceived environmental system, and the behavioral system. Measures representing each of these systems, among others, were included in the research presented herein.

An ongoing, ambitious, multi-year project, funded by the National Institute on Alcohol Abuse and Alcoholism, affords an excellent opportunity to explore some of the predictors and correlates of high-risk driving among a group of adolescents in the state of Michigan, USA. In this project, subjects were available from two previous longitudinal evaluations of school-based substance abuse prevention programs in which the author was involved. Questionnaires that had been completed by several thousand student subjects over several years included psychosocial and substance use measures. With the new project funding, matched driver history records for each subject were then added to the existing data base, allowing for analyses that used information collected before and after the students became licensed to drive in Michigan (which occurs typically at age 16). Although one would like to use these data to explain much about adolescent driving behavior, that possibility is limited by the measures that were collected previously for a different purpose. The dataset does afford a valuable opportunity, however, to use the longitudinal data to identify predisposing factors, and associated characteristics of high-risk driving behavior among young people.

The project is beginning its sixth year of funding, and a telephone survey will be conducted to collect additional, current information from the subjects who are now 23-24 years old. This paper summarizes and integrates the findings from several analyses and reports that were done on one of the population subsets as their driver history records were being accumulated. The

findings across the various analyses will be integrated, and used to suggest prevention strategies to enhance safer driving behavior among young people.

METHODS

Subjects and Data Collection

In 1987, the subset of project students in the analyses reported in this paper were in six public school districts, in grades 5, 6, 7, and 8 (about 10-13 years old). A comprehensive substance abuse prevention program was delivered by classroom teachers to the treatment portion of the study students. Questionnaire data were collected from all subjects in winter 1987 prior to the program, and in spring 1987, and spring 1988, as well as from 12th grade students (about 18 years old) in spring 1992, spring 1993, and spring 1994. Students in one grade, the graduating class of 1991, were not surveyed in 12th grade due to the unavailability of funding. In all, at least one questionnaire was obtained from 6,363 subjects.

In 1993, the names of participating students time were submitted to the Michigan Secretary of State's Office, and driver history data were obtained for 4,481 matched names/birthdates of the original students (78%). This process was repeated in 1994, matching 5,305 names, or 83.4% of the original students, and in 1995 matching 5,349 names, or 84.1%, and obtaining their updated driver histories. Because the transmission and data entry of some driving infractions is delayed, especially in the case of serious infractions involved in court appeals, the most recent three months of the data were not used, thereby ensuring records of equal accuracy and completeness for all subjects. In the reports summarized in the Results section below, different subsets of the database are used for the various analyses, so the number of subjects is given for each summary.

Measures

Two categories of measures were used - those from the students' self-reported questionnaires, which were used primarily as independent, predictor measures, and those from the state's driver history records, which were used primarily as dependent, outcome measures. The *questionnaire measures* reflected fairly well the factors in Jessor's problem behavior theory (Jessor, 1977), and included demographics (age, gender, living situation, and race); personality measures such as propensity (susceptibility and intention) to use cigarettes, alcohol, or marijuana; perceived environment measures (others' involvement with substances, parents' attitude regarding teenagers' drinking, the availability of substances); and behavior measures (substance use, school performance, and the frequency of several types of driving).

Driving measures used to indicate high-risk driving behavior in the analyses to date included offenses, serious offenses (i.e., negligent homicide, excessive speeding, alcohol/controlled substance offenses), crashes, single vehicle crashes, and injury crashes. Because these are relatively rare events (even though too many of them occur), each subject was coded for analysis purposes as having had none, or at least one of these negative driving outcomes. The rates of alcohol-related offenses and crashes on the driving record for this age group were too low (1% or less) to conduct meaningful analyses.

Data analyses

Analyses were done using the Statistical Analysis System (SAS) for Windows. Significant differences between those with and without problem driving outcomes were sought, in some analyses as predictors of subsequent behavior, and in others as correlates of concurrent behavior. Bivariate analyses included chi square, student's *t*-tests, and Pearson product moment correlations. Multivariate analyses to determine the important predictors were conducted using logistic regression. This multivariate modeling technique is the accepted method for regression analysis when the dependent variable is dichotomous. Parameter and standard error estimates were calculated for each predictor variable in the model equations. The Wald test outcomes (comparison of the maximum likelihood estimate of the slope parameter to its estimated standard error) and the associated probability values show the significance of each parameter. Likelihood ratio test results describe the fit of the models and provide a means for comparing nested models. In order to describe the likelihood of a driving outcome in terms of a percentage, predicted probabilities were calculated, in addition to the odds ratios. Analyses were conducted by gender because of different results found for women and for men. The details of each of the analyses and the precise findings are referenced and available in their original reports. Summary findings only, reporting the significant predictors of each driving outcome and the associated probabilities, are included in this paper in order to maintain the focus on the patterns of the overall findings.

RESULTS

Young Women

Driving outcome rates. In terms of driving *offenses* in the first year of driver licensure, 11.5% of 375 women with matched records (Table 1) had at least one offense on their driving records (Shope, Waller, Lang, 1996a). After two years of driver licensure when the average age was 18.2 years, 19.4% of 773 matched women had at least one offense on their driving records (Shope, Waller, Lang, 1997), with 4.1% having had at least one serious offense (Shope, Waller Lang, 1996b).

Table 1. Percentages of Young Women and Young Men With Each High-Risk Driving Outcome on Their Driver License Records

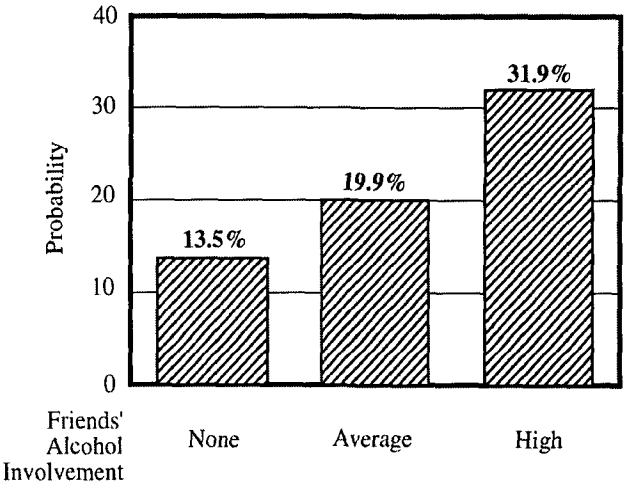
DRIVING OUTCOME:	Offense	Offense	Serious Offense	Crash	Crash	Single Vehicle Crash	Injury Crash
Years of Licensure:	1	2	2	1	2	2	2
WOMEN n @ 1 year = 375 n @ 2 years = 773	11.5	19.4	4.1	20.3	25.6	4.4	9.8
MEN n @ 1 year = 419 n @ 2 years = 887	25.0	33.8	13.1	22.2	33.3	7.4	11.3

In terms of driving *crashes* in the first year of driving (Table 1), 20.3% of 375 women with matched records had at least one crash on their driving records (Shope, Waller, Lang, 1996a). After two years of driver licensure, 25.6% of 773 women had at least one crash on their driving records (Shope, Waller, Lang, 1997), with 4.4% having had a single vehicle crash and 9.8% having had an injury crash (Lang, Waller, Shope, 1996).

Young women had nearly twice as many crashes as offenses in their first year of driver licensure. By the second year, their offense rate had increased and was three-quarters of their increased crash rate. Their rates of serious offenses and single-vehicle crashes were low - only about half the rate of their injury crashes.

Eighth-grade predictors of driving outcomes. Data collected from eighth-grade students (about age 13) were used in logistic regression to determine the important predictors of subsequent first-year driving offenses and crashes (about age 17) (Shope, Waller, Lang 1996). No model could be found of significant measures predicting offenses, therefore the predicted probability of an offense for young women is the same as their overall offense rate, 11.5%. For crashes, a good-fitting model included only friends' involvement with alcohol. As shown in Figure 1, young women who had reported that their friends were not involved with alcohol were least likely to have crashes, with a predicted probability of 13.5%. For those with friends with average alcohol involvement, the probability was 19.9%, and for those who reported that their friends were highly involved with alcohol, the probability of a crash was 31.9%.

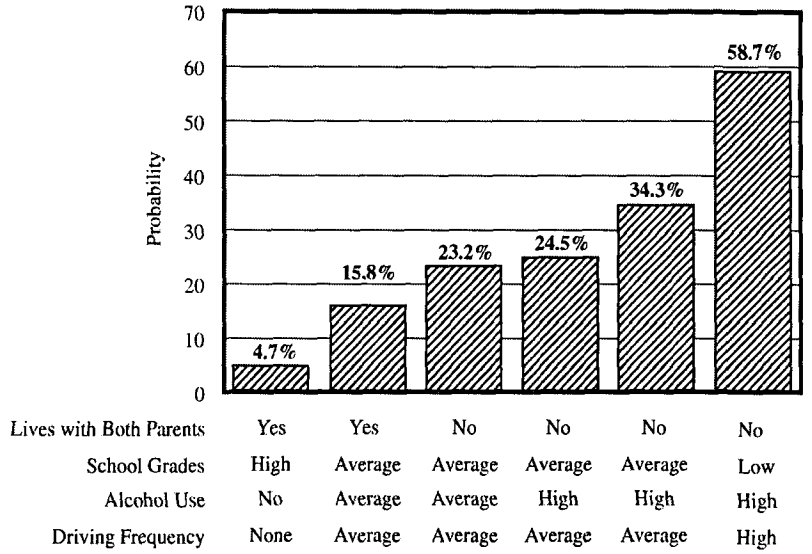
Figure 1



Twelfth-grade predictors of driving outcomes. Data collected from twelfth-grade students (about 18 years of age) were used in logistic regression to determine the predictors of several different driving outcomes for young women in their first two years of driver licensure: offenses, serious offenses, crashes, single vehicle crashes, and injury crashes. There were 773 women in the following analyses, 94.4% of whom were white. The important predictors that were found for each and the related predicted probabilities follow.

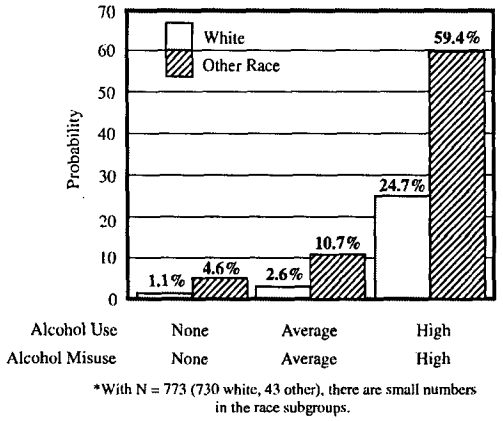
Offenses. Important indicators of offenses for young women found in model development were living situation, grades earned in school, driving frequency, and alcohol use (Shope, Waller, Lang, 1997). Using the final model's parameter estimates, predicted probabilities showed the likelihood of an offense for various subgroups of young women (Figure 2). The lowest offense probability (4.7%) was produced by this profile: lived with both parents, had all high grades, no alcohol use, and low driving frequency or no driving (respondents did not select any of the types of driving listed on the questionnaire). The highest offense probability (58.7%) was produced by this profile: did not live with both parents, had all low grades, high alcohol use, and high driving frequency.

Figure 2



Serious offenses. A good-fitting, parsimonious model predicting serious offenses among young women included alcohol use, alcohol misuse, and race (Shope, Waller, Lang, 1996b). Serious offenses among women with average alcohol use and misuse were more likely for those of other-than-white races (10.7%) than for whites (2.6%), although the number of subjects in the other-than-white category was small, and these results should be interpreted with caution (Figure 3). Predicted probabilities for the extreme prototypes revealed that white women with no alcohol use or misuse had a 1% likelihood of a serious offense, while those who were other-than-white had a 5% likelihood. White women who reported high alcohol use and misuse had a 25% likelihood of a serious offense, and other-than-white women had a 59% likelihood.

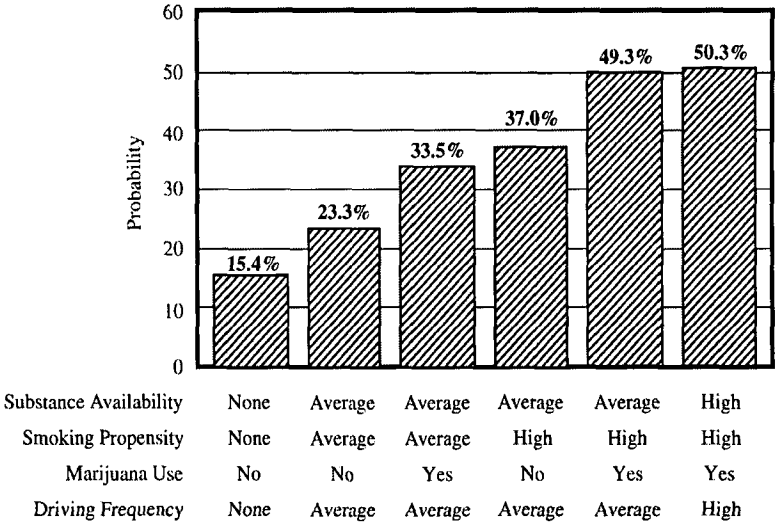
Figure 3



*With N = 773 (730 white, 43 other), there are small numbers in the race subgroups.

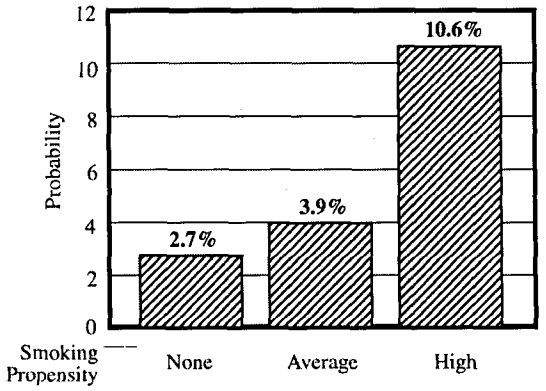
Crashes. Important model indicators of crashes for young women were substance availability, smoking propensity, marijuana use, and driving frequency (Shope, Waller, Lang, 1997). Predicted probabilities showed the likelihood of a crash for various types of young women (Figure 4). The lowest crash probability (15.4%) was produced by a profile of no substance availability, no smoking propensity, no marijuana use, and none of the types of driving listed. The highest crash probability (50.3%) was produced by a profile of high substance availability, high smoking propensity, marijuana use, and high driving frequency.

Figure 4



Single vehicle crashes. Logistic regression model testing using single-vehicle crashes as the dichotomous dependent variable resulted in a simple model that fit the data well (Lang, Waller, Shope, 1996). Cigarette smoking propensity was the only important variable. Young women who had average cigarette smoking propensity had a 3.9% chance of having a single-vehicle crash, whereas those with no propensity for cigarette smoking had a 2.7% probability, and those with high propensity had a 10.6% chance of having a single-vehicle crash (Figure 5).

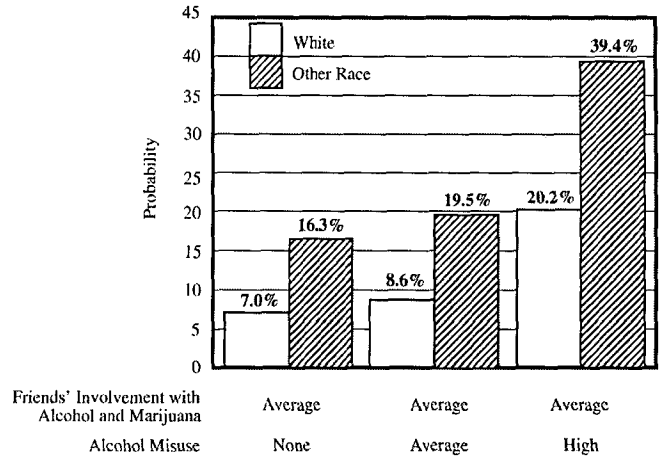
Figure 5



Injury crashes. Model-testing resulted in race, friends' involvement with alcohol and marijuana, and primarily alcohol misuse as key measures predicting injury crashes in the first two years of driver licensure (Lang, Waller, Shope, 1996). Women who were other-than-white, with average

friends' involvement in alcohol and marijuana, had a 16.3% chance of an injury crash with no alcohol misuse, but a 39.4% chance with high alcohol misuse (Figure 6). White women's injury crash probabilities for the same profiles were lower, 7.0% and 20.2%. The finding for race, however, should be regarded as tentative because of the small numbers of other-than-white subjects in each subgroup.

Figure 6



*With N = 773 (730 white, 43 other), there are small numbers in the race subgroups.

Summary of predictors for women. To summarize the findings for young women, logistic regression models were successfully developed, with important predictors identified for all but one of the high-risk driving outcomes analyzed. It was not possible to identify model predictors of first-year offenses from eighth-grade data. Several predictor measures were important, however, in predicting all the other driving outcomes analyzed, as can be seen in Table 2, which summarizes the findings for young women.

Table 2. Summary of Predictors of Young Women's High-Risk Driving Outcomes

DRIVING OUTCOME:	Offense	Offense	Serious Offense	Crash	Crash	Single Vehicle Crash	Injury Crash
Years of Licensure:	1	2	2	1	2	2	2
Predictor Grade:	8th	12th	12th	8th	12th	12th	12th
PREDICTORS							
DEMOGRAPHIC							
Living situation		*					
Race			*				*
PERSONALITY							
Cigarette propensity					*	*	
PERCEIVED ENVIRONMENT							
Friends' alcohol involvement				*			*

Table 2. Summary of Predictors of Young Women's High-Risk Driving Outcomes (continued)

DRIVING OUTCOME:	Offense	Offense	Serious Offense	Crash	Crash	Single Vehicle Crash	Injury Crash
Years of Licensure:	1	2	2	1	2	2	2
Predictor Grade:	8th	12th	12th	8th	12th	12th	12th
Friends' marijuana involvement							*
Substance availability					*		
BEHAVIOR							
Substance use							
Alcohol use		*	*				
Alcohol misuse			*				*
Marijuana use					*		
School							
Grades		*					
Driving							
Frequency		*			*		

*Significant predictors found

Demographic measures highlighted primarily the protective effect of living with both parents as of twelfth grade, which resulted in fewer offenses in the first-two-years of licensure. While race was important in the models for both first-two-year serious offenses and injury crashes, the numbers of women who were not white were very small, and this finding is not conclusive. From the personality measures, propensity to smoke cigarettes was important in predicting both women's crashes and single vehicle crashes from their twelfth-grade data.

From the perceived environment measures, friends' involvement with alcohol was important in predicting women's first-year crashes from eighth grade data and women's first-two-year injury crashes from twelfth grade data. Friends' involvement with marijuana was also important in predicting first-two-year injury crashes from twelfth grade data. The perceived availability of substances was important in predicting first-two-year crashes from women's twelfth grade data.

From the behavioral measures, several findings were significant regarding substance use among women. Alcohol use from twelfth-grade data was an important predictor for both offenses and serious offenses in the first two years of driver licensure. Alcohol misuse at twelfth grade was also important in predicting first-two-year serious offenses, as well as injury crashes. And twelfth-grade marijuana use was an important predictor of first-two-year crashes.

School grades that were low in twelfth grade were related to offenses in the first two years of driver licensure. Higher driving frequency was important in both offenses and crashes.

Overall for women, substance use was an important theme tied to high-risk driving outcomes. The propensity to smoke cigarettes, friends who were involved with alcohol and marijuana, and the availability of substances were predictors of several negative driving outcomes, as were alcohol use and misuse, and marijuana use. Poor school performance, and frequent driving round out the profile of the young woman driver at risk for negative driving outcomes.

Young Men

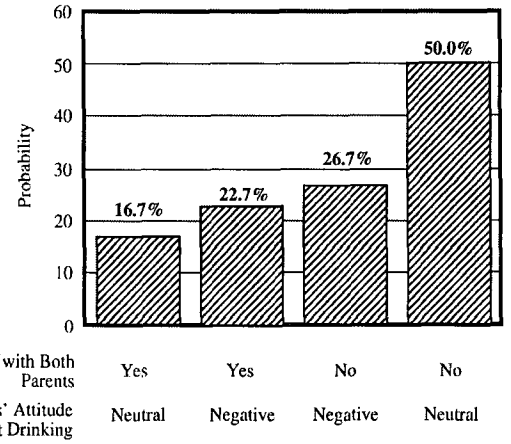
Driving outcome rates. In terms of driving *offenses* in the first year of driver licensure, 25% of 419 men with matched records had at least one offense on their driving record (Shope, Waller, Lang, 1996a). After two years of driver licensure, 33.8% of 887 matched men had at least one offense on their driving records (Shope, Waller, Lang, 1997), and 13.1% had at least one serious offense (Shope, Waller, Lang, 1996b) (see Table 1)..

In terms of driving *crashes* in the first year of driving, 22.2% of 419 men with matched records had at least one crash on their driving record (Shope, Waller, Lang, 1996). After two years of driver licensure, 33.3% of 887 men had at least one crash on their driving records (Shope, Waller, Lang, 1997), with 7.4% having had a single vehicle crash and 11.3% having had an injury crash (Lang, Waller, Shope, 1996).

Young men had slightly more offenses than crashes in their first year of driver licensure. By the second year, both rates were similar. The rates of serious offenses and injury crashes were somewhat similar, with single-vehicle crashes slightly lower.

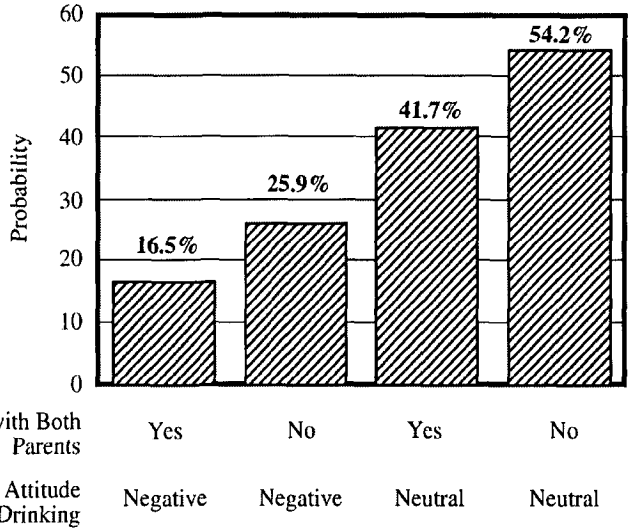
Eighth-grade predictors of driving outcomes. Data collected from eighth-grade students (about age 13) were used in logistic regression to predict subsequent first-year driving offenses and crashes (about age 17) (Shope, Waller, Lang 1996). The best model predicting young men's offenses included only the interaction term of the two measures, living situation and parents' attitude toward eighth graders' drinking. The predicted probability of an offense for young men who lived with both parents and whose parents were negative regarding teenagers' drinking was 22.7%; whereas the probability of an offense for those who did not live with both parents and whose parents' attitudes were neutral regarding teenagers' drinking was 50.0%)Figure 7).

Figure 7



For crashes, a good-fitting model also included both living situation and parents' attitude. Young men who lived with both parents and whose parents expressed a negative attitude regarding teen drinking were least likely to have crashes, with a predicted probability of 16.5% (Figure 8). Those who did not live with both parents, and whose parents were neutral regarding teenagers' drinking had a 54.2% probability of a crash.

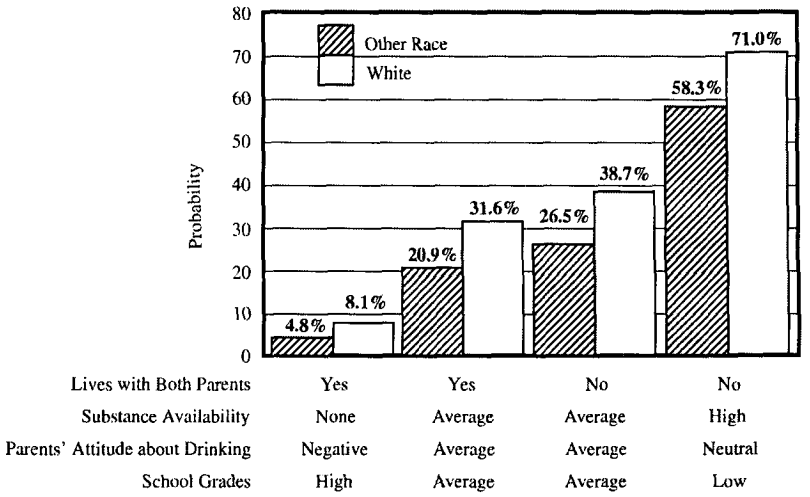
Figure 8



Twelfth-grade predictors of driving outcomes. Data collected from twelfth-grade students (about age 18) were used in logistic regression to predict several different driving outcomes for young men in their first two years of driver licensure: offenses, serious offenses, crashes, single vehicle crashes, and injury crashes. There were 887 men in the following analyses, 92.1% of whom were white. The important predictors that were found for each and the related predicted probabilities follow.

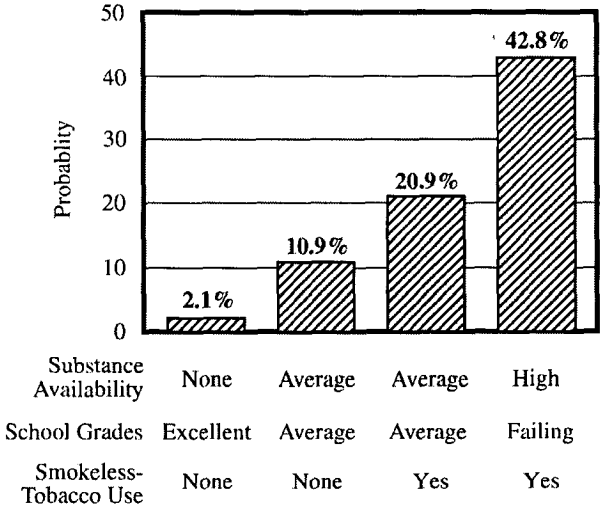
Offenses. Model development to predict men's offenses identified race, living situation, substance availability, perceived parents' attitude regarding teenagers' drinking, and grades as important measures (Shope, Waller, Lang, 1997). Figure 9 shows the probability of an offense for young men based on these predictors. The lowest chance of an offense occurred among young men who reported living with both parents, no substance availability, parents who were negative regarding teenagers' drinking, and high grades (8.1% for white men; 4.8% for men of other races). In contrast, the highest probabilities for offenses occurred among young men who reported not living with both parents, high substance availability, parents who were neutral on teenagers' drinking, and low grades (71.0% for white men; 58.3% for men of other races).

Figure 9



Serious offenses. A good-fitting, parsimonious model predicting young men's serious offenses included substance availability, school grades, and smokeless tobacco use (Shope, Waller, Lang, 1996b). Men who reported average substance availability and grades were twice as likely (20.9%) to have a serious offense on their records if they used smokeless tobacco than if they did not (10.9%). Predicted probabilities for the extreme prototypes revealed that men who reported no substance availability, excellent grades, and no smokeless tobacco use had a 2% likelihood of serious offense, while men who reported high substance availability, failing grades, and smokeless tobacco use had a 43% likelihood (Figure 10).

Figure 10

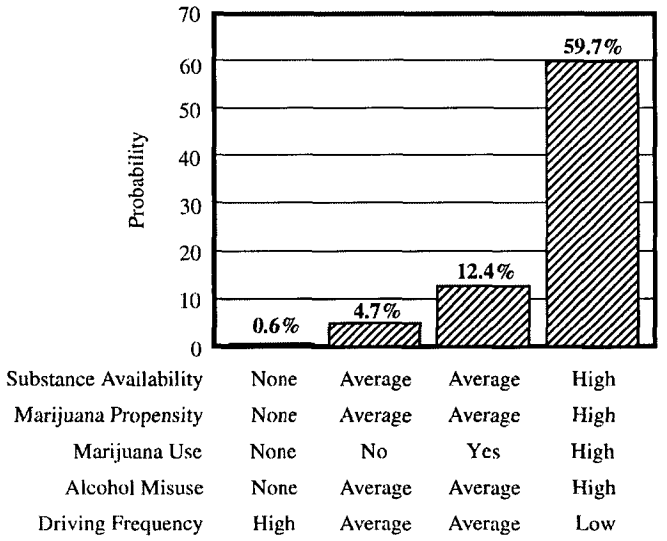


Crashes. Young men's crashes were not significantly correlated with any independent measure (Shope, Waller, Lang, 1997). Logistic regression also revealed no associations or good-fitting model. The best estimate of the crash likelihood for young men, therefore, is the overall crash rate of 33.3%.

Single vehicle crashes. Important measures predicting single vehicle crashes for men were substance availability, the propensity to use marijuana, marijuana use, alcohol misuse, and driving frequency (Lang, Waller, Shope, 1996). Marijuana use was an especially important

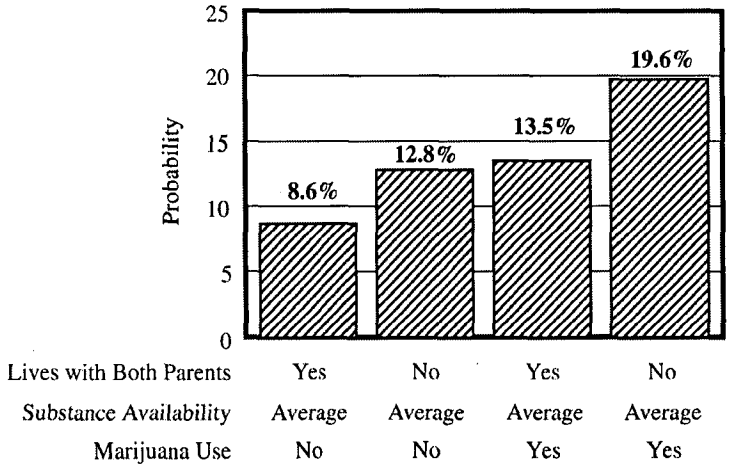
factor - young men with average scores on other predictor measures who used marijuana had a 12.4% likelihood of a single-vehicle crash, whereas those who did not use marijuana had only a 4.7% likelihood (Figure 11). The extreme prototypes for lowest and highest probabilities were as follows: those young men with no substance availability, no marijuana propensity, no marijuana use, no alcohol misuse, and high driving frequency had the lowest probability of a single vehicle crash, 0.6%. Young men with high substance availability, high propensity to use marijuana, marijuana use, high alcohol misuse, and low driving frequency had the highest probability of a single vehicle crash, 59.7%.

Figure 11



Injury crashes. After deleting nonsignificant parameters and calculating likelihood ratio test for several models, the final model for predicting young men's injury crashes included living situation, substance availability, and marijuana use (Lang, Waller, Shope, 1996). As with single vehicle crashes, marijuana use was a key predictor for injury crashes (Figure 12). Young men who lived with both parents, had average substance availability, and did not use marijuana had a 8.6% chance of having an injury crash, whereas those who did not live with both parents, had average substance availability, but did use marijuana had a 19.6% chance of having an injury crash.

Figure 12



Summary of predictors for men. To summarize the findings for young men, logistic regression models were successfully developed, with important predictors identified for all but one of the high-risk driving outcomes. It was not possible to identify model predictors of first-two-year crashes from twelfth-grade data. Several predictor measures were important, however, in predicting all the other driving outcomes analyzed, as can be seen in Table 3, which summarizes the findings for men.

Demographic measures strongly highlighted for young men the protective effect of living with both parents as of eighth grade, resulting in fewer first-year offenses and crashes, and twelfth grade, resulting in fewer first-two-year offenses and injury crashes. Race was important only in the model for first-two-year offenses, with white men more likely than men of other races to have offenses on their driving record. From the personality measures, only propensity to use marijuana in the twelfth-grade was important in predicting men's first-two-year single vehicle crashes.

The perceived environment measures were very important in predicting young men's driving behavior. Parents' attitudes toward young people's drinking alcohol was of key importance in predicting men's first-year offenses and crashes from eighth grade data, and their first-two-year offenses from twelfth grade data. The perceived availability of substances at twelfth grade was also key in predicting first-two-year offenses, serious offenses, single-vehicle crashes, and injury crashes, all of which are clear indicators of high-risk driving behavior.

Table 3. Summary of Predictors of Young Men's High-Risk Driving Outcomes

DRIVING OUTCOME:	**Offense**	**Offense**	**Serious Offense**	**Crash**	**Crash**	**Single Vehicle Crash**	**Injury Crash**
Years of Licensure:	1	2	2	1	2	2	2
Predictor Grade:	8th	12th	12th	8th	12th	12th	12th
PREDICTORS							
DEMOGRAPHIC							
Living situation	*	*		*			*
Race		*					
PERSONALITY							
Marijuana propensity						*	
ENVIRONMENT							
Parents' attitude/drinking	*	*		*			
Substance availability		*	*			*	*
BEHAVIOR							
Substance use							

Table 3. Summary of Predictors of Young Men's High-Risk Driving Outcomes (continued)

DRIVING OUTCOME:	Offense	Offense	Serious Offense	Crash	Crash	Single Vehicle Crash	Injury Crash
Years of Licensure:	1	2	2	1	2	2	2
Predictor Grade:	8th	12th	12th	8th	12th	12th	12th
PREDICTORS							
Alcohol misuse						*	
Smokeless tobacco			*				
Marijuana						*	*
School							
Grades		*	*				
Driving							
Frequency						*	

* Significant predictors found

Several behavioral measures were also among the significant findings for young men. For substance use, alcohol misuse at twelfth grade was important in predicting first-two-year single-vehicle crashes. Smokeless tobacco use at twelfth grade was important in predicting first-two-year serious offenses. Twelfth-grade marijuana use was an important predictor of both first-two-year single-vehicle and injury crashes.

School grades that were low in twelfth grade were related to offenses and to serious offenses in the first two years of driver licensure. Interestingly, *lower* driving frequency was associated with first-two-year single vehicle crashes.

Overall for men, living with both parents and perceiving parents' attitudes that are negative toward teenagers' drinking were important themes tied to lower risk for negative driving outcomes. The availability of substances predicted several negative driving outcomes, as did alcohol misuse, smokeless tobacco use, and marijuana use. Poor school performance, and infrequent driving round out the profile of the young man at risk for negative driving outcomes.

DISCUSSION

In summary, the rates of negative driving outcomes or high-risk driving are quite high. They are higher among young men than among young women, as noted elsewhere (US Department of Transportation, 1996). Indeed, offense rates for men in the first year of licensure were twice as high, and in the first two years of licensure nearly twice as high, as for women. In the first two years of licensure, men's serious offenses were more than three times as high as those for women and single vehicle crashes were nearly twice as high. The crash rate in the first year, and the

crash and injury crash rates in the first two years, however, were just slightly higher for men than for women.

Logistic regression analyses, based on psychosocial and substance use questionnaire data, successfully identified important predictors of high-risk driving outcomes among young people, thereby confirming and extending the findings of others that lifestyle factors and other problem behaviors are related to driving behavior (Beirness, Simpson, 1991; Donovan, 1993; Gregerson, Berg, 1994; Jessor, 1987; Simpson, Beirness, 1993). These analyses were conducted by gender, however, and different predictors were identified as significant for women and for men. *Demographic measures*: for both young women and men, but more often for young men, living with both parents was a protective factor against negative driving outcomes. Race was not consistently related to high-risk driving, possibly due to the small number of subjects of races other than white. *Personality measures*: women's propensity to smoke cigarettes, and men's propensity to use marijuana were of some predictive importance. *Perceived environment* measures were of considerable importance. For women, friends' involvement with substances (especially alcohol, but marijuana as well), and for men, parents' leniency toward teenagers' drinking predisposed them to high-risk driving. The perceived availability of substances was an important predictor of high-risk driving for both genders, but particularly so for young men. Among the *behavioral measures*, substance use was very important in predicting high-risk driving - alcohol use and misuse, and marijuana use among women; and alcohol misuse, smokeless tobacco use, and marijuana use among men. For both women and men, poor school performance predicted high-risk driving. Higher driving frequency was associated with increased offenses and crashes among women, but was associated with lower risk of single vehicle crashes among men.

The findings from these analyses highlight the important role of parents in conveying their high behavioral expectations to young people, especially young men (and two-parent households may be more successful). For young women, friends seem to be a stronger influence. For both young men and women, the perceived availability of substances and the use of substances clearly was related to high-risk driving outcomes, as it was to other behavioral problems. Poor school performance was also a risk factor for problem driving as well as for other adolescent risk behaviors. The findings regarding the driving frequency measure were mixed, and may have to do with limitations of the items used. However, it is possible that young women have more driving problems when they drive more, and that young men who have had single vehicle crashes no longer have a vehicle to drive, or had little driving experience before that incident. Further exploration of this finding is needed. Although frequencies were too low in this age group to study alcohol-related driving from driver history records, regression analyses were done to predict self-reported driving after drinking, reported by one-third of the subjects (Copeland, Waller, Shope, 1996). The important predictor measures of this driving behavior were male gender, binge drinking, cigarette smoking, riding with a drinking driver, the use of a motor vehicle, years of licensure, and an offense on the driving record.

There are several implications for future research from these findings. It is important to replicate, confirm, and expand the work, which will be done with the other population dataset in the study described, and should be done by other researchers as well. Now that the study subjects are older, and have been driving for more years, analyses can be conducted with larger numbers of subjects and a longer length of licensure. The subjects are now in their early twenties, which

should provide a wide variety of driving activity to study. In-depth research on new drivers would be of value, as would the evaluation of intervention and prevention trials to affect high-risk driving among adolescents.

There are many implications for prevention programs and policy development from these findings. It is clear that the factors related to high-risk driving are developing years before driving actually begins, and prevention at several levels should also begin early. Parents, families, and schools are ideal settings for early and ongoing prevention and intervention efforts. Parents should be encouraged to be more actively involved with their young people. Health care providers can monitor young people's development and also make their expectations clearly known. Community norms and expectations can be clarified and reinforced through active coalitions of community agencies. Graduated licensing and zero tolerance programs for young people, that are understood and enforced, will be helpful. All these efforts, and others from multiple sources, together will provide comprehensive, consistent, and powerful messages to young people about behavior that affects their own safety and welfare as well as that of others.

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CHANGING THE BEHAVIOR OF HIGH RISK TAKERS BY MODIFYING COMMUNITY NORMS: TAKING ADVANTAGE OF POWERFUL SOCIAL CONTINGENCIES

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ABSTRACT This paper takes the view that the mechanism underlying adjustments in risk taking are contingencies of social reinforcement and punishment, imitation learning, and rules, that collectively define the social norms of the community. It is further argued that people differ in regard to the level of discomfort they experience when they deviate from these norms, with high risk taking drivers only experiencing discomfort when their behavior significantly deviates from the norm. It is further argued that people attempt to maintain a comfortable discrepancy between their driving behavior and community standards. It follows from this analysis that one can change the behavior of risk drivers by moving the mean performance of the community away from them and toward safer driving. Evidence is presented to show that community norms can be influenced by programs designed to alter community safety culture.

INTRODUCTION

In this paper we will make the case that the mechanism underlying adjustments in risk taking are based on social contingencies of reinforcement and punishment, as well as rules describing social norms that are collectively observed by members of the community. Hence, norms related to driving behaviors can best be understood in terms of the selectionist principles of variation, selection, and retention that operate on the individual level as behavioral selection (learning) and the community level as cultural selection (Skinner, 1988). Because the safety related behaviors exhibited within any community show some level of variation, the action of social reinforcement and punishment can select or reinforce behaviors that are retained and codified as rules within the social community or culture. From this analysis we would argue that the risk of crash, or injury is perhaps less influential in shaping the distribution of risk taking behavior than the approval or disapproval of members of the community.

Several principles follow from the above position. First, if driver performance is to a large degree a function of contingencies acting at the community level, deviant drivers will attempt to maintain a relative distance from the mean performance of the community of drivers that is based on the level of comfort with social disapproval and censure. Second, that one can reduce extreme levels of risk taking behavior by decreasing the mean level of risk taking toward a safer level.

The crux of this argument is that shifting the community distribution of risk taking behavior toward safer levels will produce a shift in the behavior of persons who engage in extreme risk taking behavior as they adapt their behavior to maintain what is for them a comfortable distance from community norms. It is not that these individuals are insensitive to social pressures but that their threshold is somewhat greater than average just as some members of the community exhibit a threshold to that is somewhat less that average. This argument applies equally well to any other deviant behavior such as violent crime. For example, it has been demonstrated that one can reduce the incidence of violent crime by reducing graffiti, public swearing, and other minor crimes.

An important corollary of this position is that the greater the percentage of a population of drivers that comply with a particular community safety standard the easier it is to implement stronger measures directed at the behavior of concern. In other words consensus within the community must precede legislation. Once this consensus is formed, the implementation of stronger measures will further increase the level of discomfort of high risk takers which in turn will lead to further changes in the norms setting the stage for the adoption of even stronger measures. Thus social change is seen as the emergent product of cultural evolution over time.

There are likely two reasons why stronger measures are more acceptable as the percentage of the population complying with an intervention increases. First, the greater the percentage of people who follow the rules the more deviant the risk takers appear to themselves and others. Second, the greater the percentage of people who follow the rules the smaller the percentage of people who are directly affected by stronger measures. As a general rule, the public will not accept strong measures if they risk being subject to them. For example, if most people ran a red lights, there would be little public support for strong sanctions such as photo radar. If most people comply with red lights the community is more likely to accept such measures because the measure will only be applied to a small portion of the population, the high risk taker. Following this logic, the U.S. government should have waited to introduce seat belt interlocks until other less intrusive measures had increased seat belt use to sufficiently high levels to make the measure acceptable. Because the interlock card was played too early, it may be more difficult to apply it now. Once people take strong positions in opposition to a measure, as was the case when they forced the repeal of the interlock regulation, they often find it difficult to change their position. However the level of seat belt use in Canada and some other countries may now be approaching a level that would provide the necessary support for such an intervention.

Another measure that would become more socially acceptable as use levels go up is point loss. Reinfurt, Williams, Wells, and Rodgman (1996) found that drivers who did not wear their belts in North Carolina indicated that they would be more likely to respond to point loss than increased fines. No government could enact point loss until use is at least in the middle 80% range and maybe not until seat belt use is in the 90 percent range. Finding interventions that will bring

community norms close enough to make even more effective measures socially acceptable is the strategy that safety professionals must follow if they are to effectively stimulate the gradual evolution of driving norms. If we move the norm toward more courteous driving we will reduce the frequency and severity of risk taking on our highways.

SOCIAL PROCESSES UNDERLYING SOCIAL CONTINGENCIES

Leonard Evans (1991) made the point that the term risk compensation should be avoided because it represents an example of reification. All that is observed is the user response; labelling it risk compensation implies we know why it happened which is "an implication without justification." A similar argument could be made against explaining safety improvements in terms of social norms. Instead the focus should be placed on social factors that are responsible for the change in norms. If social pressure, or contingencies of social reinforcement and punishment are assumed to produce social norms, it should also be apparent that the norms, or social environment, will vary from time to time and place to place as the characteristics of the social contingencies in place vary.

Imitation Learning. Normative behavior influences the behavior of others in a number of ways. First, drivers model acceptable behavior that other drivers may imitate. For example, research has shown that parent and friend seat belt use is correlated with adolescent seat belt use (Riccio-Howe, 1991). Models can demonstrate non-compliance as well as compliance with traffic laws. If someone walks when the crosswalk signal displays the 'Don't Walk' indication others will typically follow. Similarly, if some drivers run red lights others can be expected to imitate this behavior. When deviant behaviors in others serve as a discriminative stimulus for others to engage in similar behavior it is termed imitative learning. If many people run lights without apparent negative consequences, more can be expected to do so over time. Those individuals more comfortable with deviance from the norm will be inclined to enter the intersection much later during the red interval than the typical red light runner. If we make red light running rare, than those who do run the light will only do so very early in the red interval. On the other hand if many drivers alternate at a merge point new drivers arriving at the merge point can also be expected to merge.

Second, people are more likely to imitate behavior that leads to reinforcing consequences and they will avoid imitating behavior that leads to punishing consequences. Hence imitation is dependent and influenced by the social contingences prevalent in a community. The social status of the model will also be an important factor determining the degree of observational learning produced.

Social Approval and Disapproval. Normative behavior is directly strengthened by social approval, and directly weakened by social disapproval. The ideal situation is one where social approval follows courteous driving behavior and social disapproval follows risky driving behavior.

Rule Governed Behavior. Normative behavior is promoted by the statement of rules that are generally accepted by members of the community. Most assessment of risk is based on rule governed behavior because most drivers do not experience the risks evidenced by crash statistics directly. Individual drivers more often receive positive feedback for unsafe driving behavior.

The only way risk impinges on most drivers is when they experience a conflict or close call. Therefore it is not surprising that Svenson, and Fischhoff (1985) found that seat belt use was more strongly correlated with convenience and popularity than safety. They concluded that increasing comfort and changing social norms would likely be more effective in increasing seat belt use than providing more information on safety because drivers tended to underestimate their own individual risk.

Social Comparisons. Since members of a community can be expected to make social comparisons with other members of the community and model the behavior of other members of the community, the magnitude of an effect can be expected to depend in part on the discriminability of those norms. The discriminability of norms can be expected to be partially a function of the type of behavior observed. For example, weaving in and out of lanes is easily discriminated by passengers in the weaving vehicle, as well as other drivers on the road, as is red light running, stop sign compliance and speeding. Seat belt use and impaired driving are sometimes more difficult to observe by other drivers. One way to promote seat belt use would be to make it easier for others to see that the majority of people are wearing their seat belt. This could be achieved by making seat belts more conspicuous. If seat belts were more conspicuous drivers and passengers in other vehicles and law enforcement
officers would find it easier to discriminate who is wearing a seat belt and who not wearing a seat belt. Current seat belts are designed to blend in with the interior environment and are not easy to see during the day and are even harder to see at night.

WHAT CONTINGENCIES SUPPORT RISK TAKING?

A number of reinforcers can support risk taking behavior and in a given instance several reinforcers may operate concurrently. Although many of these reinforcers are social in nature and are related to community norms or the norms of a particular subgroup within the community, some of these reinforcers can be more direct and personal in nature.

Sensory stimulation. One powerful reinforcer supporting some risk taking behavior is sensory stimulation. Risk taking may provide a sense of excitement which may be highly reinforcing for some individuals. However, it is important to keep in mind that the degree of risk associated with a particular behavior is relative to and dependent upon cultural norms. In the U.S. getting drunk and driving a car is risky; in a strict Muslim country taking a single drink might be perceived as more risky. This is another way of saying that what constitutes risky behavior is highly dependent upon current social norms operating in the community.

Reducing the Delay in Reinforcement. Another reinforcer that can select risky driving behavior is a reduction in the delay associated with obtaining a powerful reinforcer. For example, people will speed, run red lights, and engage in other risky behaviors to get home earlier, to get to the beach sooner, etc. Although the actual amount of time saved may be small in most cases, a high risk behavior like driving on the shoulder or grass median in a traffic jam could lead to a large amount of time saved.

Social Approval. One powerful reinforcer that is culturally based is the attention and approval of peers and other members of the community. Social approval can either increase desirable

behavior. For example, groups that organize *Safe Grad* may receive a lot of social approval from the community in general, and making room for someone who needs to change lanes will often be reinforced by a smile and a wave of thanks. Social approval can also increase undesirable behavior. Young drivers 'leaving rubber' can be reinforced by the positive attention given by a peer driving in the car.

Negative reinforcement. Negative reinforcement or escape learning can also play a role in reducing or promoting rule violation. Reducing the amount of time that one is late can be a powerful reinforcer for shaving time off a journey. Getting to your destination more quickly is also dependent on establishing operations that influence motivation to get to a destination more quickly. If an employee were told that he would be fired if he is late one more time, or if the deal a saleswoman is trying to close is worth a good deal of money, the motivation will be higher. In this regard it is possible that the use of cellular phones might produce an improvement in safety by reducing the motivation to rush because the person who is late can call and explain their circumstances or apologise to the person for being later. Thus the use of the cell phone could reduce the perceived need to speed, run red lights or weave in and out of traffic.

MAJOR ADVANTAGES ASSOCIATED WITH FOCUSING ON CHANGING SOCIAL NORMS

Although many people advocate trying to directly modify the driving behavior of high risk takers through forced individual treatment, monitoring and therapy, it must be recognized that the effort involved in focusing on a segment of the population who are most resistant to change is far greater than the effort involved in focusing on the rest of the population in order to change normative driving patterns. Furthermore, unless risk taking drivers are isolated and recognized by the community as deviant, strong punitive measures are less likely to socially acceptable. It should be remembered that extreme risk takers are responsive to shifts in social norms and the social norms can be changed most rapidly by focusing on the behavior of the average driver whose behavior is more easily modified.

Dick Malott once asked why people would continue to wear seat belts if enforcement is not continued. In Nova Scotia we have not seen a checkpoint for seat belt use in many years. As the norms changed so did the social contingencies. At present over 90 percent of the drivers model seat belt use and it is common for people to prompt others to buckle up if they fail to fasten their seat belt. Sometimes people will also show mild disapproval in a concerned manner when someone fails to buckle up. These social contingencies, once established, can easily explain the maintenance of seat belt use.

Because high risk takers respond poorly to an intensive forced treatment approach, trying to bring about a change in their behavior without regard to the behavior of the rest of the community is unlikely to bear fruit unless we can shift the behavior of the entire distribution toward greater safety.

EVIDENCE SUPPORTING A COMMUNITY INTERVENTION APPROACH

Cross cultural comparisons show the powerful effect of social contingencies on driving behavior. In Japan only 5 percent of traffic deaths are alcohol related as compared to 41 percent in the U.S. What is interesting is that death rates in Japan have declined while average per capita alcohol consumption has doubled since 1970 (Deshapriya and Nobutada, 1996). Because Japanese drivers believe that it is not acceptable to drive after consuming even small amounts of alcohol, strong social pressures are brought to bear. In addition, since most people model appropriate behavior those who would flout the rules feel particularly uncomfortable doing so. It is also interesting to note that because their social contingencies function to reduce any impaired driving, it was possible for them to pass a law specifying a low level of legal impairment (BAC over .005). The passage of this law likely resulted in a potentiation of the social contingencies already in effect leading to further reductions in the acceptability of drinking and driving. It would not be possible to have so few fatal crashes associated with impaired driving, unless "high risk" individuals were also susceptible to social contingencies and standards.

The sensitivity of high risk drivers to interventions designed to modify the performance of the community of drivers is also supported by the reductions in crashes associated with reductions in driver speed. Nilsson (1990) has shown that when driver speed decreases, the reduction in the fatal crash rate is directly proportional to the fourth power of the ratio of the higher speed divided by the lower speed. These data are supported by evidence showing a 16 percent increase in fatality rates in the United States when increases in the rural interstate speed limits led to an increase of nearly 3 mph in mean vehicle speed (National Highway Traffic Safety Administration, 1989). These numbers also nearly conform perfectly to the predictions made by Nilsson based on data collected in Sweden and are in accord with the 34% reduction in the fatal crash rate associated with the 5.8 mph reduction in mean speed associated with the introduction of the nationwide 55 mph speed limit in the United States. However, it is interesting to note that reducing speed limits in the United States produced predicted reductions in fatal crashes even though the percentage of drivers who were impaired remained relatively constant during the same period. These data suggest that even impaired drivers were motivated to drive slower following these changes in speed limit, and as a result fewer of them (as well as innocent bystanders) were killed in crashes.

Slow cultural evolution can result from interventions that make risky behaviors such as red light running, drinking and driving, etc. socially unacceptable which in turn alter the prevailing practices of social reinforcement and punishment. Norms can change when behavioral engineering alters the behavior that is modelled or the prevailing contingencies of social reinforcement and punishment. Once behavior begins to change more people models the behavior helping to fuel further change. It is important to remember that changes in norms are brought about by changes in social contingencies and that the slow evolution of cultural norms that results from social selection can be accelerated by behavioral engineering.

DIRECT METHODS OF CHANGING THE SAFETY CULTURE OF A COMMUNITY

Providing Community Feedback. One way to modify the safety culture is to provide feedback on the percentage of people engaging in the safety behavior of interest. Public posting has

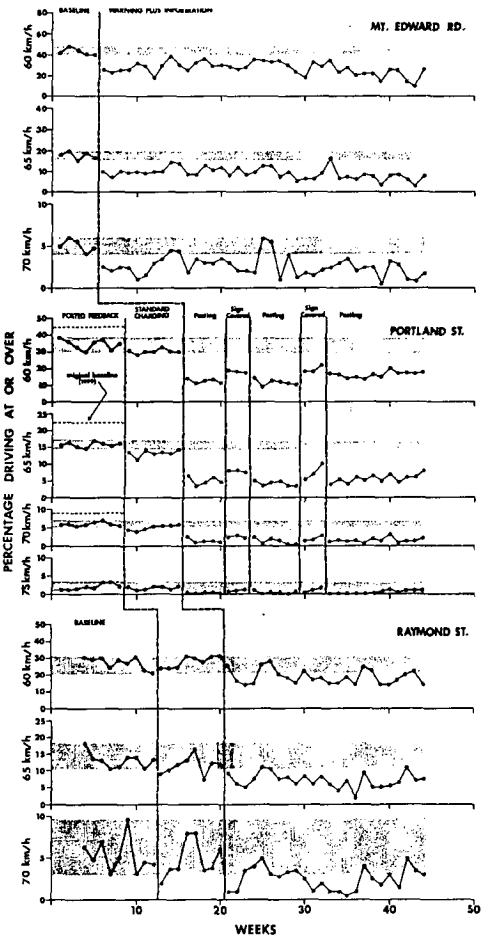
proven effective in increasing the percentage of drivers yielding to pedestrians (Van Houten, Malenfant, and Rolider, 1985), the percentage of drivers complying with the speed limit (Van Houten and Nau, 1983), the percentage of drivers wearing seat belts (Malenfant, Wells, Van Houten, and Williams, 1996), and the percentage of drivers signalling their intention to turn (Markell, Leslie, Michael, Brinckman, and Rider, 1997). Research on public posting suggest that it is most effective when the numbers posted are fairly high to begin with, and when people see the behavior as socially desirable (Van Houten, and Nau, 1983). Some evidence also suggests that the mechanism responsible for the efficacy of posted feedback is implied enforcement, and community interest. Previous work by Van Houten (1980) has demonstrated that comments about performance play a major role in mediating the effects of posted feedback. This may explain why public posting of the percentage of motorists wearing their seat belts in two communities (Malenfant et. al., 1996) produced a larger improvement in a smaller community than it did in a larger community.

Saturation Warning Enforcement Programs. Although it has been long known that it is more effective to charge violators than to warn them on an individual basis, it is possible to produce more substantial changes in behavior using a warning program provided the warning program makes contact with a substantially larger proportion of violators (Van Houten and Nau, 1983). It is possible to issue significantly more warnings because the officer is not required to prepare a ticket that will serve as a court document and are not required to spend time in court.

Another advantage that warnings offer over charging violators is that a lower criterion can be employed to select motorists to be stopped. For example, one can use a lower speed criterion to define speeding or a shorter time criterion to define red light running because officers do not have to defend their decision in court. When lower criteria are used, people come to discriminate that any speeding or red light running is unacceptable. If on the other hand one has to focus entirely on flagrant violators, the community comes to discriminate that less serious violations are acceptable. Van Houten and Nau (1983) compared a traditional enforcement blitz with a saturation warning program that included handing out flyers documenting the cost of speeding on that street during the past year and asking drivers to help make their community a safer place to live. Police officers were able to warn 7.5 times as many drivers as they were able to charge. Police were also able to employ a more persuasive approach when issuing warnings. An information sheet describing the danger and consequences of speeding in the drivers neighborhood was handed to all drivers as part of the warning program. Police found that this practice was well received by drivers who were stopped.

The data presented in Figure 1 show the percentage of motorists driving at various speeds on three streets with a 50 km/h speed limit. The data show that the effects of the warning program that lasted for only one week persisted for at least a year at all three sites.

Figure 1. The percentage of drivers travelling at or over 60, 65, and 70 km/hr during each condition of the experiment on each street. The shaded area indicates the range of performance during the baseline condition on each street.



Physical Interventions That Prevent Risk Taking. Another way to change norms is to introduce interventions that make it more difficult to take risks. For example, a speed governor on a vehicle would reduce the likelihood of speeding and a seat belt ignition interlock system could reduce the likelihood that a driver would drive without fastening the seat belt. One can also reduce the likelihood that a driver will fail to yield to a pedestrian by introducing a lead pedestrian interval that holds the driver while the pedestrian is given the 'walk' interval (Van Houten, Retting, Farmer, Malenfant, and Van Houten, 1997). An alcohol ignition interlock is another examples of a physical interventions that can influence community norms (Beck, Rauch, and Baker, 1997). One can also adopt traffic calming strategies to change the distribution of speeding behavior in a community. One area that should be the focus of further study is how in vehicle prompting systems can be designed to maximise the probability that the drivers and passengers will fasten their seat belts.

Multifaceted Interventions. One way to enhance the effect of community safety programs designed to alter social standards and contingencies is to implement a multifaceted program that addresses the problem of changing community safety culture with a number of interventions that potentiate each other. When a the program consists of a variety of interdependent interventions the probability of success is generally increased because some individuals may be more sensitive to one aspect of the intervention than others.

Examples of Programs that Have Altered Community Safety Culture. One can change the norms by implementing interventions that make the behavior less socially acceptable. Community programs have also been successful in reducing alcohol-impaired driving (Hingson, McGovern, Howland, and Heeren (1996). The community program organized multiple city departments and private citizens on alcohol-impaired driving, related driving risks and traffic deaths and injuries. The program not only reduced DWI but it also reduced the proportion of speeding vehicles in half.

Van Houten and Nau (1993) designed a multifaceted program to change community speeding behavior on residential streets. This program consisted of engineering, education, and enforcement components. Education components included large community signs that provided feedback on the percentage of motorists not speeding each week, and information flyers distributed in schools that provided feedback on the crash history on arterial routes surrounding each school. These flyers also highlighted the results of more serious crashes and asked motorists to cooperate in making their community a safer place to live. Media attention was also arranged to coincide with the implementation of this program. Enforcement components included a special saturation warning program where all vehicles travelling 12 km/h or more over the speed limit were stopped, giving a warning ticket and an flyer that described the number and types of crashes that occurred during the past year on the street the motorist was travelling on. The schedule of police enforcement was gradually thinned on a variable time schedule.

The *Safe Speed* program was implemented on a city wide basis in Haifa, Israel (Scherer, Freidmann, Rolider, and Van Houten, 1985). The introduction of the program produced a 48 percent reduction in the percentage of motorists driving 10 km/h or more over the speed limit, and a 64 percent reduction in the percentage of motorists travelling 20 km/h or more over the speed limit. The program was also associated with a 63 percent reduction in crashes and a 67 percent reduction in injuries. Both crashes and injuries increased during this same period on control streets. Crash and Injury data is presented in Table 1.

Table 1a. The number of crashes that occured in the direction that the sign and enforcement program were introduced during the 6 months following the program (1983) and during the same 6-month periods of the preceding two years, along with equivalent data for crashes that occurred in the opposite direction.

Street	Direction of the Sign			Opposite Direction		
	Before		After	Before		After
	1981	1982	1983	1981	1982	1983
Hagiborim	4	2	2	3	3	3
Hatzionut	1	2	0	2	4	2
Yad-Labanim	2	1	1	1	2	4
Hashmal-West	2	0	0	1	0	1
Allenby-East	1	7	4	3	5	7
Allenby-West	3	3	2	0	0	0
Abba Hushie	4	8	2	4	4	5
International	2	3	0	1	0	0
Haganah	2	3	0	1	1	3
Hameginim	5	4	2	6	1	4
Tchernichovsk	3	1	0	2	2	3
Golomb	1	0	0	0	2	2
Total	**33**	**37**	**13**	**25**	**25**	**36**

Table 1b. The number of people injured in crashes that occured in the direction that the sign and enforcement program were introduced during the 6 months following the program (1983) and during the same 6-month periods of the preceding two years, along with equivalent data for injuries in crashes that occurred in the opposite direction.

Street	Direction of the Sign			Opposite Direction		
	Before		After	Before		After
	1981	1982	1983	1981	1982	1983
Hagiborim	10	2	2	3	2	3
Hatzionut	2	3	0	2	5	2
Geula	2	1	0	0	0	0
Hankin	3	2	0	1	1	2
Yad-Labanim	2	1	1	2	2	6
Hashmal-West	2	0	0	1	0	1

Table 1b (continued)

Street	Direction of the Sign			Opposite Direction		
	Before		After	Before		After
	1981	1982	1983	1981	1982	1983
Allenby-East	2	10	5	3	9	9
Allenby-West	3	3	2	0	0	0
Abba Hushie	6	10	4	5	4	5
International	2	3	0	1	0	0
Haganah	2	5	0	5	2	3
Hameginim	9	4	2	9	1	3
Tchernichovsk	6	1	0	2	2	5
Golomb	2	0	0	0	2	2
Total	**53**	**45**	**16**	**34**	**30**	**41**

A similar approach was taken to yielding to pedestrians. The *Courtesy Promotes Safety* crosswalk program was designed to change driver and pedestrian behavior at crosswalks on a city wide basis (Malenfant and Van Houten, 1989; Van Houten and Malenfant, 1992). Education interventions included: School wide training programs that taught children the safest way to cross the street; an incentive program carried out by crossing guards to promote the transfer of skills learned and practised in the classroom; a community education component that made motorists and pedestrians aware of risky behaviors at crosswalks and suggested ways to reduce these risks. Feedback signs were erected in places where they would attract the most attention to inform the community on progress of the program. These sites were selected on the basis of having a high traffic flow and good visibility.

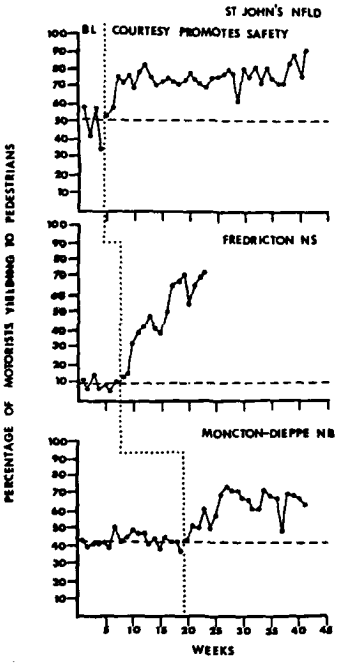
Engineering Components included the use of advance stop lines and signs to encourage motorists to yield further back behind the crosswalk; signs at problematic crosswalks to instructing motorists how to safely cross the street; more effective crosswalk marking signs that increase the probability that motorists would yield to pedestrians at crosswalks; the use of a new crosswalk sign that showed a pictograph of a person extending one arm with one foot in the road to indicate an intention to cross the street. This pictograph was also used on all printed materials provided by the program.

Enforcement interventions included an intensive police enforcement campaign that included giving out information flyers, warning tickets, and charging motorists that failed to yield and providing small incentives such as pens and bumper stickers to motorists yielding to pedestrians.

The *Courtesy Promotes Safety* program was implemented in three Canadian cities (Malenfant, and Van Houten, 1989). The introduction of the pedestrian safety package led to increases in the percentage of motorists yielding to pedestrians that ranged from 52 to 71%, an increase in the

percentage of pedestrians extending their arm and waiting for traffic to stop at crosswalks, and a 50% reduction in the number of pedestrians struck in crosswalks in the two cities where this data was available. A graph of the percentage of drivers yielding to pedestrians in each city is presented in Figure 2. The magnitude of the changes in the percentage of drivers yielding to pedestrians in each of these cities produced by the program can best be described as a change in community norms. It should be noted that these changes in community norms were produced over a relatively short interval of time by a specific highly focused program.

Figure 2. Percentage of motorists yielding to pedestrians at selected crosswalks in three cities during each condition of the experiment. The dashed horizontal lines indicate the mean percentage of yielding during baseline.



SUMMARY

The thesis of this paper is that social norms play a very large role in determining the level and degree of driver risk taking behavior. It is also proposed that driver behavior is jointly determined by community norms and other motivational factors according to the following principles.

1. Level of risk varies directly with social pressure to engage in risk taking. An examples would be attempting to impress friends who display behavior that leads one to believe that they are predisposed to reinforce risk taking. Most people already have discriminated how the group will react to their behavior before they emit it. Therefore, behavior is to large degree under strong stimulus control.

2. Level of risk varies inversely with social pressure to avoid risk taking. When members of the social community display behavior that lead them to believe that they are predisposed to punish risk taking, the incidence of risk taking declines.

3. Level of risk varies with other motivational pressures that may be present, such as when someone is late for a meeting (This is a case of a social pressure because one is responding to avoid social sanctions).

If we focus on the average driver, the easy target, we can alter the behavior of the high risk drivers while at the same time making stronger measures more socially acceptable. This strategy is cost effective because the more deviant members of society have repeatedly demonstrated that they are highly resistant to individual treatment and would require strong coercive measures to seek out and enter treatment. Psychologists have also long known that compelled treatment is not likely to prove effective. Shifting normative driving patterns toward greater safety will exert pressure on deviant risk takers causing them to shift towards the new norms or risk severe and socially acceptable forms of punishment for their non-compliance.

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CHAPTER 2

SPECIFIC BEHAVIORS

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The papers in this chapter examine in detail several specific risky behaviors exhibited by drivers and pedestrians.

Murray Mackay, in "The Use of Seat Belts: Some Behavioural Considerations," reviews the history of seat belt use laws and belt use rates in various European countries and in the United States. He notes several factors that influence belt use but finds no evidence that belt use influences driving behavior. He notes that at least 10% of front seat occupants fail to wear belts even in the countries with the highest use rates and suggests several vehicle features that may influence these reluctant belt users.

Göran Nilsson's "Speed Management in Sweden" summarizes Sweden's success in using speed limits to regulate driver behavior. He discusses the relations between speed limits and travel speeds and presents formulas to estimate how travel speed changes affect traffic accidents, injuries, and fatalities. He discusses the relative effects on safety of absolute (mean or median) speed and of speed distribution (speed variance). Finally, he summarizes Swedish speed enforcement methods.

Heikki Summala, in "Speed, Time, and Risk Taking," presents driver risk-taking, especially speeding, in the context of an overall driving task model. In this model, speed and time are critical factors determining driving behavior. This means that risky driving behavior is not limited to certain high-risk groups but is exhibited by all drivers. Clarence Greeno's observations on Missouri's experience following repeal of the United States National Maximum Speed Limit are relevant to both Nilsson's and Summala's papers.

M. M. Peden and J. W. van der Spuy, in "Crossing the Road in South Africa: A Risky Business," change the focus from drivers to pedestrians. They report that pedestrians account for approximately one-half of all traffic fatalities in South Africa. Over two-thirds of fatally injured pedestrians had been drinking, often to very high levels, and many had consumed illicit drugs. They note that standard traffic safety measures aimed at improving roads or reducing risky driver behavior will have little effect on crashes involving drunk or drugged pedestrians.

THE USE OF SEAT BELTS: SOME BEHAVIOURAL CONSIDERATIONS

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ABSTRACT This paper reviews the growth in seat belt use in North America and Europe and the role played by mandatory seat belt laws. Differences in belt usage rates within countries of the European Union, varying from 10% to 90%, result in overall front seat usage rates for the European Union of about 70%, very comparable to the current population weighted average for the United States of 67%. Rear belt usage rates are shown to be much lower with current rates for adults in the rear in the 40-50% range. There is no evidence to suggest that belt use influences driving behaviour, but there is ample evidence to suggest that a number of factors influence belt use, notably alcohol, night time driving, vehicle type and urban/rural road environment. It is concluded that some 10% of front seat occupants are non-belt users, even in countries with a long history of active enforcement and information campaign policies. Some technical proposals to address those reluctant belt users are discussed.

INTRODUCTION

The first jurisdiction with a substantial car population to introduce mandatory use of seat belts was the State of Victoria, Australia, in 1970. The success of that legislation, amongst other factors, led to an occupant fatality rate per 10,000 vehicles which fell from 8.1 to 3.4 from 1970 to 1980 (Trinca, G. 1981). One characteristic of the Australian scene at that time was that mandatory use was introduced coincident with the regulatory fitting of seat belts. Perhaps by introducing the requirements of compulsory fitting and compulsory use approximately in parallel, a natural climate for the acceptance of belt use was created. What is relevant today about the early Australian experience is that relatively high belt usage rates were obtained right from the early 1970s, with rates around 70% to 80%, in observational studies (Henderson, M and Freeman, K. 1973), without particularly strong enforcement policies or other activities to promote use. In North America and Europe today, many jurisdictions are still struggling with usage rates well below those early Australian figures.

SEAT BELT USE RATES IN NORTH AMERICA

The history of mandatory seat belt laws in the United States is well known, with a phasing in of such laws from 1984 to 1990, by which time the great majority of states had laws in place. As of 1996 usage rates for front seat occupants in observational studies range from 32% to 83%, with a population weighted average of 67% (N.H.T.S.A. 1996). In considering such data, one should recall the passive restraint requirements introduced for model years 1987 through 1990. That produced vehicles with passive shoulder belts, either mounted on the door or on the side header; a significant proportion (approximately 25%) of the total vehicle fleet on the roads in 1996/97 thus have passive shoulder belts. In observational counts those restraint systems are usually included with active belts. Hence the use of conventional active belts in the United States is somewhat less than the 67% currently quoted. In only 10 states are seat belt laws enforced as a primary, stand alone requirement. In all others the seat belt laws are secondary only, with noticeably lower belt usage rates. N.H.T.S.A. in 1995 calculated median belt usage rates for states with primary enforcement at 75% and in states with only secondary laws at 62% (N.H.T.S.A. 1995).

In Canada no passive restraint requirements were introduced. Instead, more active primary enforcement policies have been operated together with significant educational media campaigns. Those activities together give observational front seat belt usage rates of about 90% (C.C.M.T.A. 1995).

Use of rear seat belts all over the world is not well documented. This seemingly simple parameter in fact is bedevilled by confusion because about a third of rear seat occupants are children under the age of 11. A proportion of the younger ones in that group are in child restraints. Various sample studies have addressed these issues differently, but there is also the practical problem in the United States where a major proportion of the vehicle fleet have lap belts fitted. Roadside observational techniques to observe the use of a lap belt are inadequate, and thus other techniques such as questionnaires are used. Self-reporting introduces additional concerns and thus rear belt use is not well documented in North America. Using the FARS database rear belt use in 1994 for occupants 5 years of age and over was recorded to be 52% as against 7% in 1984 (N.H.T.S.A. 1995). However, there may well be a significant over estimation of belt use in that data file. For example, a shopping center observational study in 1995, recorded a 38% usage rate of rear outboard seat belts, but that number includes children in child restraints, who generally have higher restraint use levels (N.H.T.S.A. 1995).

SEAT BELT USE IN EUROPE

Any historical view of safety issues in Europe is complicated by the changing constitutional and regulatory process of what is now called the European Union. The original six countries expanded to 9 as the European Community, then to 12 and recently to 15 with the admission of Austria, Finland and Sweden in 1995. Traffic safety regulations operate at both European Union and nation state levels. European Directives are binding on all member states, yet implementation of agreed Directives sometimes lags behind for many years. For example, the installation of lap/shoulder belts in front seats was introduced with Directive 77/541/EEC in 1977. The Directive was not implemented in Greece until 1979 and not until 1988 in Italy.

Table 1 lists the implementation dates for the fitting of belts in front and rear seats for the 15 countries of the European Union. What is very different from the North American scene is the relatively late introduction for the fitting of rear belts as a requirement in Europe. (Source, E.T.S.C. 1996).

Table 1 : Implementation date for fitment of seat belts in new cars

Member State	Front Seats	Rear Seats
Austria	1974	1984
Belgium	1968	1984
Denmark	1969	1989
Finland	1971	1981
France	1970	1978
Germany	1974	1979
Greece	1979	1993
Ireland	1971	1992
Italy	1988	1990
Luxembourg	1971	1990
Netherlands	1971	1990
Portugal	1966	1990
Spain	1974	1992
Sweden	1969	1970
UK	1965	1987

Historically the mandatory use of seat belts has been addressed at the nation state level. Of European countries, France was the first to introduce a seat belt law which applied to front seat occupants in rural areas in 1973. With Gallic logic this was extended to urban areas at night in 1975, and then in 1979 to all areas, both day and night.

A number of countries introduced mandatory seat belt laws, initially without any penalty, somewhat analogous to the secondary seat belt laws in the United States. Fines were introduced later, so that in the non-fine period the only sanctions were the obrium of a police officer and second order effects limiting compensation levels if injured in a crash when unrestrained.

A typical history of seat belt usage levels is shown in Figure 1 for Finland. The law in itself had a significant effect when introduced in 1975, but that effect decayed until the introduction of a "real" law with financial or penalty point sanctions in 1982. Continuing information campaigns may or may not have been effective in maintaining observational usage levels in traffic at some 90% in rural areas and 80% in urban areas.

Table 2 : Year of introduction of compulsory use of front and rear seat belts and of child restraints in private cars in Member States

	Front Seat Belts	**Rear Seat Belts**	**Child Restraints**
Austria	1976 (without fine) 1984 (with fine)	1984	front seats : 1974 < 12 yr & 150 cm : 1994
Belgium	1975	1991	from 01.09. 1996
Denmark	1976	1990	3 years and older : 1990 less than 3 years : 1992
Finland	1975 (without fine) 1982 (with fine)	1987	front seats : 1982 rear seats : 1987
France	1973 (rural areas) 1975 (urban areas at night) 1979 (all areas day & night)	1990	less than 10 years : 1992
Germany (FRG)	1976 (without fine) 1984 (with fine)	1984 (without fine) 1986 (with fine)	1993
Greece	1979	pending	pending
Ireland	1979	1993	1993
Italy	1989	1990	1992
Luxembourg	1971 (2 points) 1990 (3 points)	1993	1993
Netherlands	1975	1992	1992
Portugal	1977 (outside urban areas) 1993 (inside urban areas)	1994	1995
Spain	1975 (outside urban areas) 1992 (inside built-up areas)	1992	1992
Sweden	1975	1986	1988
United Kingdom	1983	1991	1983 : under 1 in front 1989 : under 14 in rear 1993 : under 3 in front

Figures 3 to 6 show usage rate data for the U.K, Sweden, Germany and Australia, both before and after the introduction of usage laws for front and rear seats. All these data are from observational studies of the general traffic stream. The U.K, was somewhat different in that it was relatively late in introducing such a law, having spent over a decade, from 1971 to 1983, debating the issue at Parliamentary level, but when the law was introduced its acceptance was extraordinarily good. Enforcement is relatively benign with 106,000 fixed penalty notices being issued in 1993 (D.Tp. 1993) for a population of drivers of about 25 million.

Figure 1. The history of the promotion of seat belt use in Finland; percentage of wearing rates in front seats and key dates:

1/1/71 compulsory installation of seat belts in new cars
1/7/75 compulsory use of seat belts (>15 years)
1/4/82 fines for non-use
1/9/83 "on the spot" fines
1992-1994 information and enforcement campaigns

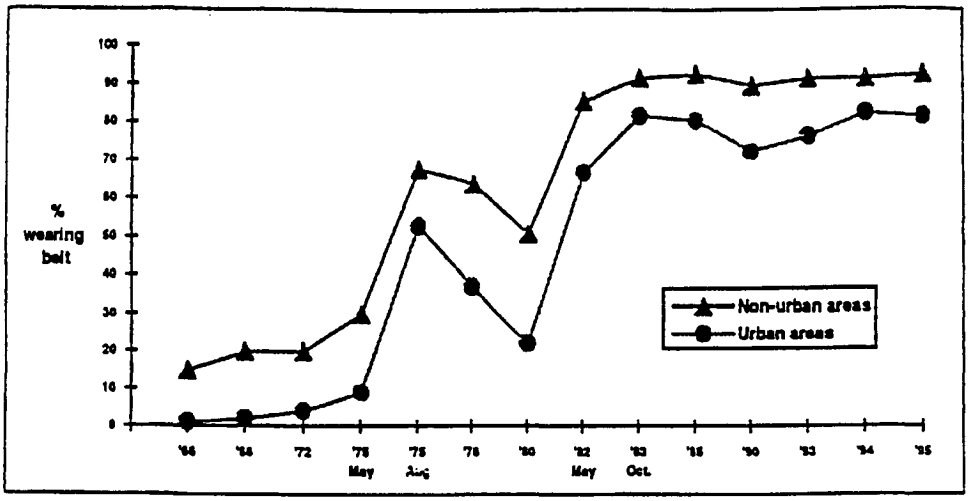


Figure 2. Seat belt use data for U.K.

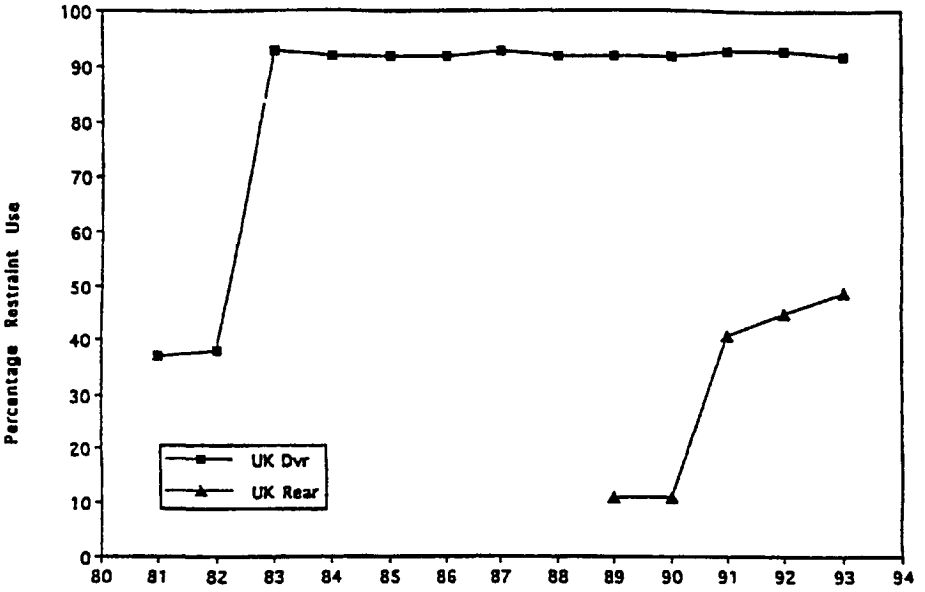


Figure 3. Seat belt use data for Sweden

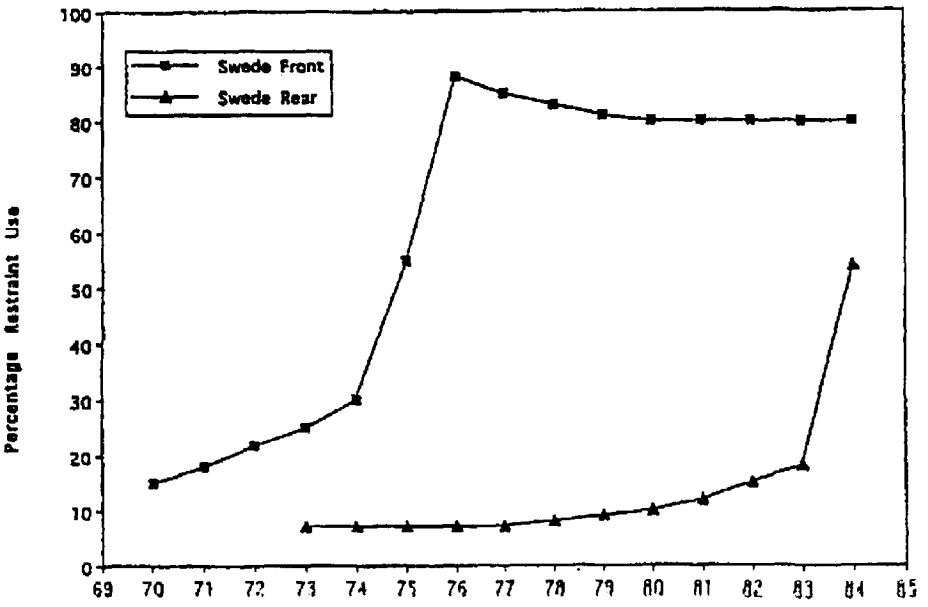


Figure 4. Seat belt use data for Germany

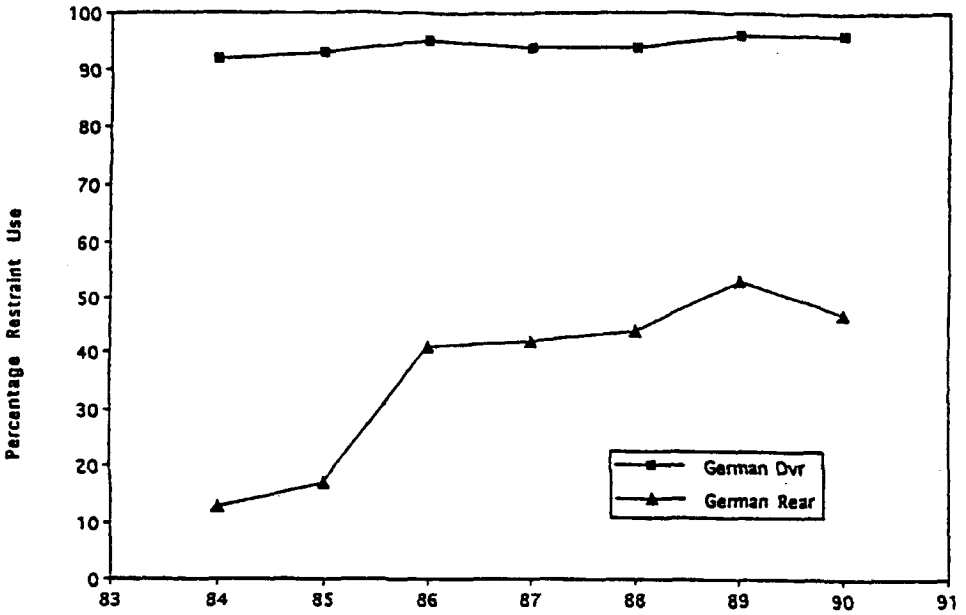


Figure 5. Seat belt use data for Australia

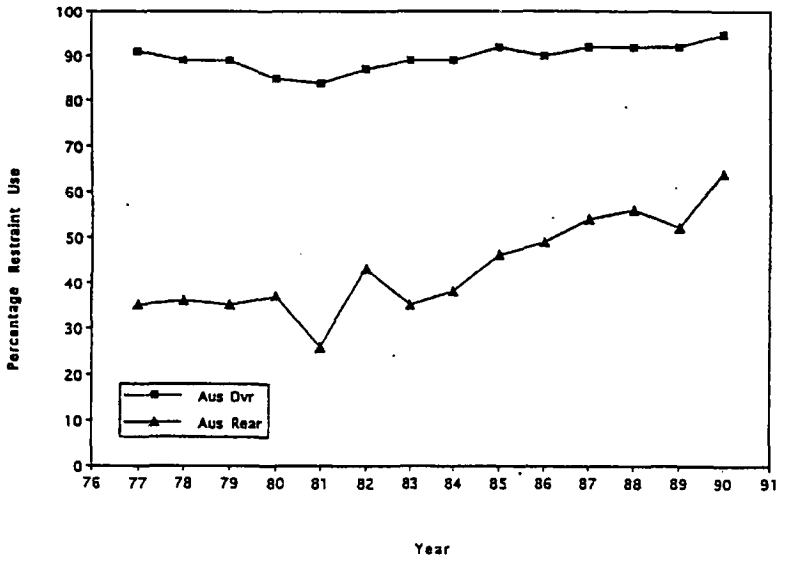
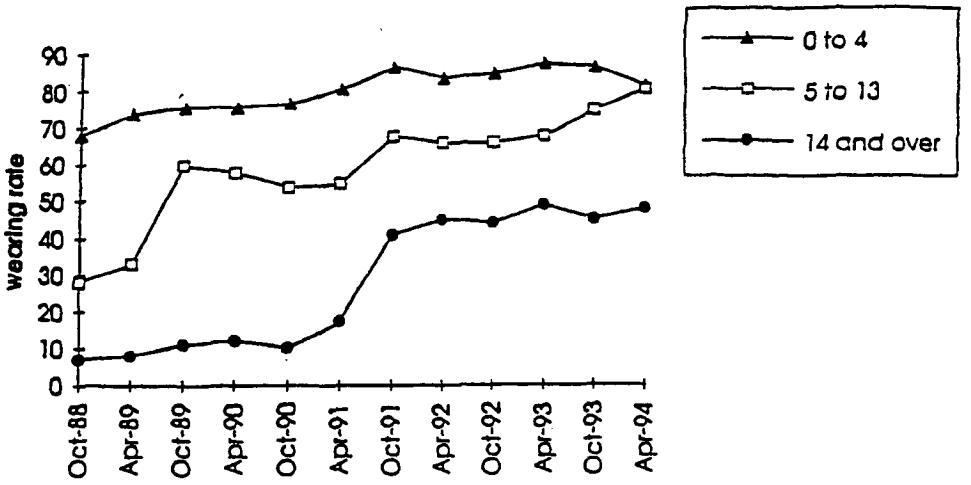


Figure 6. U.K. rear seat belt wearing rates by age group



What is of interest is that throughout the world there is a ceiling of about 90% for front seat belt usage; one in 10 chose to remain unrestrained.

Table 3 : Seat belt wearing rates amongst adults in various European countries (per cent)

Member State + year of observation	Drivers	Front seat passengers	Front seat occupants	Rear seat passengers
Austria (1994)	70	71	70	30
Belgium (1993)	54	-	-	33*
Denmark (1993)	71	-	-	35
Finland (1994/95)	87	88	87	57
France (1994)	86	84	85	-
Germany (1995)	92	92	92	68
Greece (1994)	20	15	63**	9**
Ireland (1991)	52	55	53	-
Italy	10	10	10	-
Luxembourg (1992)	85	86	85	-
Netherlands (1995)	70	76	73	37
Portugal	30	28	30	-
Spain (1995)	61	-	-	10**
Sweden (1994)	89	92	90	80
UK (1995)	91	92	91	66

* self reported rates
** motorway observations only
*** Catalonian data

That number becomes greater if belt usage rates in crashes is considered. In-depth crash investigations in the U.K, indicate that for drivers who are killed, their belt usage levels are about 75% (Mackay, 1984). Even lower numbers have been quoted in Finland at 55% (Valtonen, 1991) and 35% in Sweden (Kamren, 1992).

General belt usage levels still vary enormously throughout Europe. The northern and Scandinavian countries generally have high levels of front seat belt use. The Mediterranean countries of Portugal, Spain, Italy and Greece however have very much lower levels, see Table 3. A car population weighted average for the European Union for front seat belt usage approximates to about 70%; only slightly higher than in the United States.

In 1991 a European Union Directive was adopted which requires compulsory use of restraint systems by adults and children in all sitting positions where restraints are fitted from January 1993 (91/671/EEC). The European Commission, in 1996, published proposals for how this Directive might be implemented within the framework of various national regulations. This is a useful example of the byzantine complexity and time scale of the rule-making process in Europe.

Figures 2 to 5 illustrate rear seat belt usage levels for a number of countries. As in the United States a distinction between child restraint and adult belt use needs to be drawn. This is illustrated in Figure 6 for the U.K. Children up to 13 years of age have relatively high levels of use of child restraints and adult belts with and without booster seats. Usage rates of rear belts by adults however, are markedly lower at about 48%.

DOES SEAT BELT USE CHANGE DRIVING BEHAVIOR?

The risk compensation theory has been around for many years and has been applied by some exponents to seat belt use. Most noticeably Adams in the U.K.(1981) proposed that "protecting car occupants from the consequences of bad driving encourages bad driving".

His analysis took the form of two composite indices. 13 countries were selected which had introduced compulsory seat belt legislation and the total number of road deaths (car occupants, pedestrians, motorcyclists and others all aggregated together) were standardised to a 1973 base. The experience of those countries from 1971 to 1978 was then compared with an index from four countries which had no compulsory belt use laws, Japan, Italy, the United States and Britain, for the same period. This comparison purported to show that the greater reduction in total road deaths of all types which occurred in the four "non-law" countries in comparison to 13 "law", was because the introduction of seat belt laws increased road deaths. The methodology however is flawed because in the "law" group not all those countries introduced that law in 1973. The laws were introduced at different times between 1970 and 1977. If the analysis is conducted by shifting the countries from the "non-law" to the "law" group at the time that each country actually introduced a seat belt law, then the conclusion drawn by Adams is no longer seen in the data. In addition the statistical validity of the conclusions as to the seat belt effect have been shown to be unsatisfactory (Mackay, 1984).

The OECD (1990) conducted a useful review of the risk compensation effect in relation to seat belts. That report noted that the effect of seat belt use in reducing injury is so large that to counteract "any behavioural adaptation" effect would have to be very large and therefore easily observable. This is generally not observed and in most studies the opposite is shown. Ashton and Mackay (1985) for example, compared free flow speeds, gap acceptance and headway separations for belted and unbelted populations. For each situation the belted population had lower risk levels, as assessed by these measures, than unbelted drivers. Those results applied under both voluntary (pre-law) and compulsory (post-seat belt law) conditions. Huguenin (1993) examining the Swiss seat belt wearing experience concluded that compulsory belt wearing led to significant reductions in occupant fatalities with no transfer of risk toward rear seat passengers, pedestrians, cyclists or motorcycle riders. With the advantage of a longer time series, the uncertainties raised by Harvey and Durbin (1986) have been laid to rest (H.M.S.O. 1989).

WHAT FACTORS INFLUENCE SEAT BELT USE?

Many specific studies have examined the factors which have a bearing on seat belt use. These factors appear to be common throughout the world. The more interesting ones with universal applicability are:

- Belt use decreases markedly with alcohol use by the driver, from 46% down to 19% for a study of fatally injured drivers (N.H.T.S.A. 1989).
- Belt use decreases at night, especially late at night.
- Belt use is higher in newer cars than old cars.
- Belt use (in Europe) is higher in rural areas and on expressways than in urban areas (H.M.S.O. 1989).
- Belt use is lower in pick-ups, vans and utility vehicles than in passenger cars (Partyka, 1989).
- Belt use is influenced by good ergonomic design.

One manifestation of the reluctant belt user is the incidence of misuse of belts. Studies in Europe (Dejeames, 1990) and (Janesen et al, 1992) indicate about 2% of front seat occupants have the shoulder belt either under the arm or behind the back. In the United States a somewhat higher number of 4% is quoted by N.H.T.S.A. (1995).

TECHNICAL INNOVATIONS TO ENCOURAGE BELT USE

All of the foregoing technical review leads to the following conclusion. That even in the most advanced of countries (in the context of belt use) there is a significant proportion of the population, at least one in ten, who choose to travel unrestrained. The intrinsic limitations of conventional policing, with a relatively low level of risk of perceived detection of non-use, which is in line with the actual level of detection and prosecution for non-use, mean that in a normal democracy there is not much more to be done through education, awareness campaigns, legal sanctions and policing.

In car visual warnings for this relatively determined group of non-belt users are likely to have negligible influence; it is not an issue of mere forgetfulness, but more a conscious decision not to bother.

With the United States experience in the 1971-73 period with the mandated ignition interlock in mind, technical means to encourage belt use must clearly be more sophisticated, and a number of interesting approaches are being developed. Among these are;

- Interlocks so that the radio/CD/cassette player cannot be operated unless the belts in all occupied seats are used.
- Audible warnings which increase in frequency and loudness over a 5 minute period if belts remain unconnected.
- Altered accelerator pedal pressure response if belts remain unconnected, making the car uncomfortable to drive.
- Interlocking the belts to the heating and/or air conditioning systems for some of the setting of climate control.

To this writer these proposals have much merit, and with sensitive, human engineering development, systems could well be made which would be acceptable to the last 10% of reluctant belt users. Total three point passive belt systems have been found to be unacceptable in terms of everyday usage, reliability and comfort. Thus, the well engineered active, three point,

lap/shoulder belt remains the best design for adults. The application of a little ingenious technical encouragement towards 100% belt use is now worth attempting. This will require some regulatory changes in the United States with the removal of the 8 second audible warning limitation, and the one minute limit on an illuminated warning, as currently required in FMVSS 208, but that should not be too difficult if prototype work on technical measures to encourage belt use show promise.

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SPEED MANAGEMENT IN SWEDEN

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ABSTRACT During the beginning of the seventies a lot of speed limits on rural roads were changed in Sweden in order to establish a differentiated speed limit system and to investigate the change in speed and safety.

The experience from these changes of the speed limits and corresponding changes in other countries and later on in Sweden has resulted in a realistic calculation method. The calculations of the expected change in speed and the corresponding effect on injuries and accidents, given the speed and safety situation, is presented in this paper.

The paper also discusses the police surveillance methods in Sweden, the speed level and the speed variance problem.

SPEED LIMITS AND SPEED

Often, little attention is paid to the fact that speed is the central concept in the transport of people or goods. Normally, we speak of the time it takes for people or goods to be transported a certain distance. However, instead of constituting a measure of efficiency, higher speeds have proved to have increasingly undesirable consequences, such as more serious road accidents and increased energy consumption, car exhaust emissions, road wear and vehicle costs. These problems are of course accentuated by the fact that at the same time as speed has increased, the volume of car transports has also risen. Socioeconomic cost and evaluation calculations for car traffic show clearly that present speeds are in many cases sub-optimal with regard to the goal of minimum social cost for car transports.

The relation between on the one hand speed limits and on the other hand speed and road safety are the most analysed effect relations in the road system. Speed is expressed in different ways, for example journey speed over longer distances or momentary speeds in the road network. Since speed varies between different combinations of driver and vehicle and road and traffic environment, use is made of general concepts such as mean speed, median speed or various percentile speeds for groups of vehicles during a predetermined time period.

Speed limits

The speed limit problem has increased in importance as a result of higher road and vehicle standards. Historically, the first speed limits were introduced in the U.S.A. to achieve a better traffic rhythm. The speed limits were set at the level exceeded by 15% of the vehicles - statistically the 85th percentile in the speed distribution. The choice of the 85th percentile had the effect that it did not affect the median speed, but reduced the number of vehicles with very high speeds. Another result was that a considerable road safety effect was achieved. This applied to roads with a high standard.

As vehicle speeds increased, speed limits were introduced in urban areas. It was not until the end of the sixties that the speed performance of the majority of the vehicle fleet in Europe reached the level of today's high speed limits in rural areas. During the 70s, most countries introduced a higher speed limit on motorways and a somewhat lower speed limit on other main roads. The exception that confirms the rule can be seen on parts of the autobahn network in Germany, where the highest speed limit is only a recommendation (130 km/h).

Today, all European countries have a general speed limit of 50 km/h in urban areas. On main roads, the basis has normally been an odd or even number of kilometres per hour (60, 80, 100 and 120 or 70, 90, 110 and 130). Motorways have speed limits of between 90 and 130 km/h.

During the early seventies, the oil crisis caused many countries to reduce their speed limits. The aim was naturally to ration oil consumption, although major road safety benefits were also achieved.

This led at the same time to increasing interest in recording speed, not least in preparation for future changes in speed limits and to chart the relation between speed and road safety in greater detail. These speed measurements also clearly showed that speeds increased successively on roads of high standard and that the proportion of vehicles exceeding the speed limit increased with lower speed limits. A change in the speed limit of 10 or 20 km/h on the average resulted in a change in the median or mean speed of car traffic of 3-4 and 6-8 km/h respectively. There was an increasing realisation that speed limits and speeds were not at all the same thing.

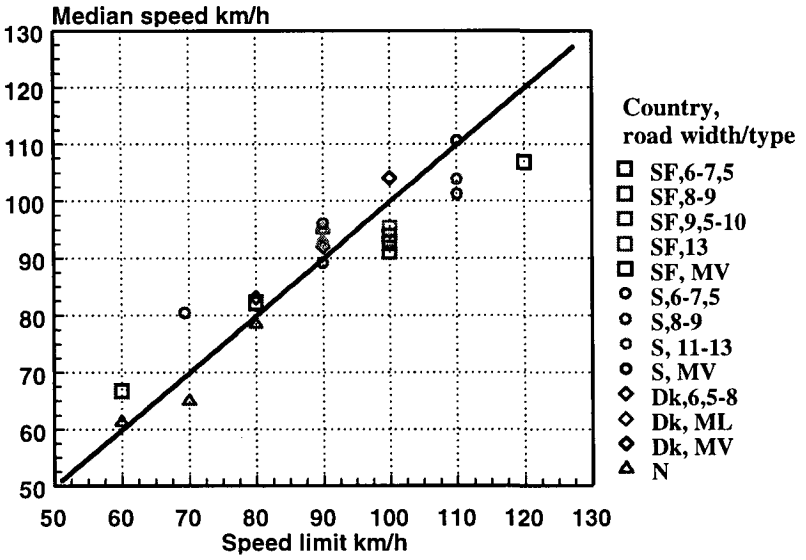
The highest speed limit in a country is found on the roads with the highest standard - usually motorways. The reductions in this speed limit as a result of the energy crisis showed a reduction in speeds not only on these roads but also on other main roads. This was interpreted as an effect of the energy crisis. However, subsequent increases or reductions of the highest speed limit in various countries showed the same tendency, which means that the highest speed limit also affects speeds in the rest of the road system. An increase in the highest speed limit also means an increased speed on roads with an unchanged speed limit, especially on roads of a relatively high standard.

In 1989, the highest speed limit in Sweden during the summer was reduced from 110 to 90 km/h following an unfavourable road safety trend on roads with a speed limit of 110 kph. The evaluation showed that speeds decreased also on those roads where the speed limit was unchanged and 90 km/h, with considerable road safety effects. This would indicate that the highest speed limit plays a part in influencing speeds and road safety on other roads. The road

safety problem on those roads with the highest speed limit is often limited (in most cases motorways) in relation to the proportion of traffic using these roads.

Since the eighties, most countries have traffic recording systems which follow the speed trend in various road environments. These measurements show that it is obvious that there is a clear relation between speed limit and mean speed and that the lower the speed limit the lower the median speed. Figure 1 demonstrates this relationship for different rural roads in the Nordic countries.

Figure 1. Median speed and speed limit in different rural roads in the Nordic countries. Dk=Denmark, N=Norway, SF=Finland, and S=Sweden.

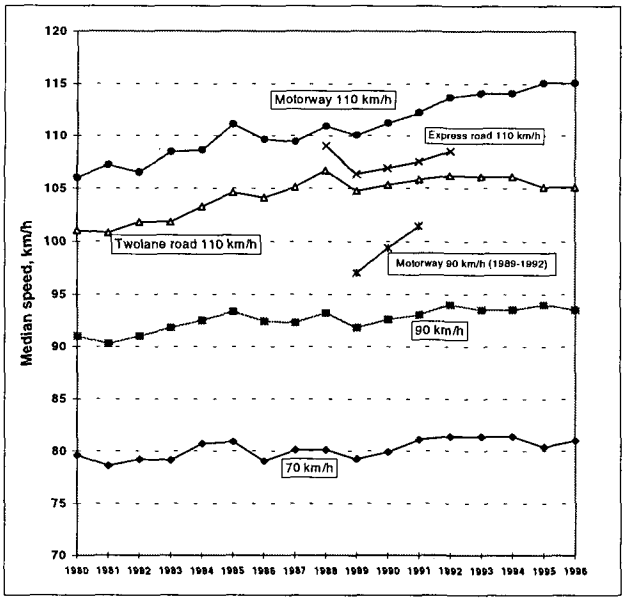


Since the number of violations increases with lower speed limits, there is a conflict between compliance with the law and road safety. This can be interpreted in different ways. One school recommends that speed limits be adapted to car drivers' chosen speeds, which leads to low speed limits being increased, resulting in increasing speeds and poorer road safety, and at the same time reduced compliance problems. Another school considers that the compliance problem is partly the foundation for the speed limits having a road safety effect and the lower the speed limit the greater the importance of the speed limit itself for the drivers' chosen speeds. With a high speed limit, only a small proportion of car drivers are influenced by the speed limit itself in choosing speed.

In recent years, the debate has for various reasons dealt only with the highest speed limit on motorways. During 1989-1992, most of the motorway network in Sweden had a speed limit of 90 km/h for environmental reasons. The introduction of catalytic emissions control on cars meant at the same time that certain reasons for the decision were successively eliminated. An increasing proportion of the vehicle fleet is now equipped with emissions control.

In Figure 2 the median speed trend is shown for rural roads and different speed limits 1980-1996 in Sweden

Figure 2. Median speed trend on rural roads in Sweden 1980-1996.



In addition to road differentiated speed limits, 50 km/h in urban areas, 70 km/h as a basic speed limit in rural areas with the exceptions of 90 km/h on rural roads of normal standard or 110 km/h on rural roads with carrigeway width 13 meter or motorways and on main roads with good alignment in the northern part of Sweden, there are also speed limits for certain vehicle types. These were changed on 1 January 1995 when an 80 km/h speed limit was introduced in Sweden instead of 70 km/h for heavy trucks and trucks or passenger cars with trailers. From the beginning, this was a national decision, but coincided with a decision by the EU to introduce speed limiters devices on heavy vehicles. As before, heavy trucks without trailers have a speed limit of 90 km/h on motorways and semi motorways. Otherwise, the speed limit system has been unchanged since 1971, apart from local "adjustments".

A local speed limit of 30 km/h applies in urban areas, mainly residential areas. In rural areas, local speed limits of 50 and/or 70 km/h are also used at major junctions or in built-up areas. Some motorways in urban areas have the speed limit of 90 km/h. A recommended speed limit of 30 km/h is also used in certain other built-up areas together with speed restriction measures such as humps and narrowed streets.

Future speed limits

The next change is that speed limits for mopeds will be raised from 30 to 50 km/h to conform with the "Europe moped". The road safety authorities have successively proposed changes in the speed limit system since the end of the seventies with regard to road safety, which means a change towards lower speed limits on the average. The trend has, however, been the opposite up to 1995. A central point in the studies has also been to use speed limits in even tens of kph (60, 80 and 100 km/h) and if possible to introduce speed limits with a certain variation in time according to traffic intensity and other external circumstances (darkness, winter road conditions,

etc.). To some extent, the proposals have also dealt with the question of speed limit indication. Since 1997 the communities are allowed and responsible to introduce the speed limit of 30 km/h in urban areas with high proportion of vulnerable road users. The choice of these areas is up to the community.

Violations of speed limits

Many studies have also dealt with the problem of speed violations themselves in relation to police resources and methods of monitoring speeds. Conventional radar surveillance was extended in 1994 with the laser gun, which requires fewer personnel for stationary surveillance and is more flexible. Mobile surveillance is carried out with Police Pilot instruments in police cars, now mainly marked cars, and police motorcycles. Earlier, these cars were not always marked. Helicopters are used to a small extent, as is manual timing.

Surveillance of speed violations means that no action is taken in the case of violations less than 10 km/h over the speed limit. The tolerance limit applied by the police normally increases with higher speed limits, owing partly to the distribution of surveillance among methods other than radar surveillance. The strict tolerance limit of 10 km/h is known to and normally exploited by motorists, which means that a majority keep within this tolerance interval. Researchers have suggested that a lower tolerance limit would have the same effect as a corresponding speed limit reduction. In this case, it should be complemented with a more flexible penalty system where the fines are directly proportional to the number of km/h over the speed limit and possibly a progressivity (SEK 50-100 per km/h over the speed limit).

During 1990-1992, experiments were carried out with stationary automatic speed surveillance on 16 roads in Sweden. Vehicles exceeding the speed limit by 13-14 km/h were photographed from the front to record the registration number and identify the driver. The experiment resulted in a proposal that the automatic surveillance equipment should be mobile and moved from place to place. During the experiment, a vehicle equipped for this purpose was developed and some vehicles has been delivered to the police forces. However, the legal "transition" between driver responsibility and owner responsibility has still not been resolved, as in Australia for example. At present, owner responsibility exists only in connection with parking violations.

In recent years, the surveillance methods used have resulted in over 120,000 motorists per year being stopped. Table 1 shows the number in 1994-1996 according to various methods:

Table 1. Reported violations by year from different enforcement methods

Surveillance method	Reported violations		
	1994	**1995**	**1996**
Radar	55,128	34,859	26,399
Police Pilot in police car	2,366	2,063	2,164
Police Pilot in unmarked car	9,100	9,902	10,189
Police Pilot on police motorcycle	1,690	1,335	1,747
Police Pilot on unmarked motorcycle	1,226	730	902
Manual recording	281	46	44
Helicopter	2,719	5,594	5,197
Automatic (foto)	-	231	561
Laser instrument	44,114	65,108	81,305
Other methods (car following)	3,221	2,271	2,026
Total	23,845*	122,139	130,534

*One out of 24 units is missing.

The number of drivers stopped must be seen in relation to the number of motor vehicles in Sweden, about 4 million, and the number of licensed drivers, 5.3 million. The probability of a holder of a driver's licence being stopped is about once during active driving age. For the normal motorist (15,000 kilometres per year and an average speed distribution) the probability of being stopped by the police is about once in 30 years. The use of the radar is decreasing and the use of the laser instrument is increasing

The fines in 1997 are SEK 800 (<16 km/h) and SEK 1,000 (16-30 km/h) over the speed limit and SEK 1,200 for a speed 31-40 km/h over the speed limit in rural areas. Major violations are reported to the prosecutor. Speed violations of 20 km/h and more in a speed limit of 30 km/h in a built-up area or 30 km/h or more in other speed limits lead additionally to a suspension of the driver's licence lasting from 2 months to 1 year. In the latter case, the driver must pass a new driving test before being given a new licence.

Each year, about 9,000 driver's licences are suspended as a result of speed limit violations. Compared with other Nordic countries, the level is low.

Enforcement strategy

During 1994 and 1995 the annual amount of random breath tests has been of the magnitude of 1,5 million for preventive reasons. This is more than twice compared to earlier years. This is together with speed surveillance the dominating part of the enforcement strategy. A general strategy is also that the police shall be visible , in uniform and using police cars. Enforcement of other rules is decided on county or local level as for example seat belt use or lights on bicycles during darkness.

Massive controls of driver (licence) and vehicles (equipment) are organised a couple of times per year and police unit (30-40 policemen). Along main roads control sites are prepared for control of commercial vehicles and are used regularly. As the police is organized on a county level (23 counties with 2-5 traffic police units) the influence of the National Police Board is based on recommendations and/or short term agreements.

SPEED AND SAFETY

This is a favourite topic of debate in which road safety authorities are caught between research results and influence both from the car industry and motoring organisations who lobby politicians and market cars to the public.

At present, there are about 100 extensive scientific studies in the world which report road safety changes as a result of changes in speed limits and thereby changes in speed. Most of these are summarised in the Road Safety Handbook published by TÖI in Norway.

The accumulated results are very reliable and only one or two of these studies have failed to clarify that increased speeds lead to poorer road safety or vice versa. In some cases, there have been no changes either in speed or road safety.

At an early stage, the VTI developed a model for estimating the effect of speed changes on road safety which was based on the experiments with different speed limits carried out in Sweden during 1968-1971. One of the features of these experiments was that the same road population was the object of repeated reductions and increases in speed limits.

The model has subsequently been validated with later changes in Swedish speed limits in 1979 and 1989, as well as various foreign studies including a reduction in the speed limit in urban areas in Denmark from 60 to 50 km/h and an increase on motorways in the U.S.A. from 55 to 65 mph. The model has been used to analyse the consequences of planned changes in speed limits or improved compliance with speed limits. It also makes it possible to express the change road safety situation both in personal injury accidents and casualties.

The background was that the empirical results proved to a large extent to be adaptable to the physics law that kinetic energy = mass x $(\text{speed})^2$ /2 on the basis of two complementary hypotheses:

1. The probability of a personal injury accident in the road system reported by the police is proportional to the square of the speed (v^2) - the kinetic energy

and

2. The probability of a fatal accident resulting from a personal injury accident is also proportional to the square of the speed (v^2), which means that the number of fatal accidents is proportional to the fourth power of the speed (v^4).

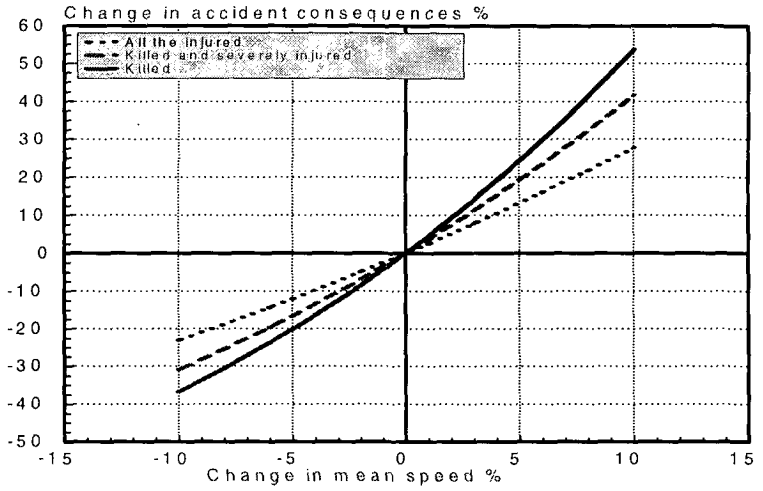
The theory has subsequently been developed on the basis of the hypotheses that the reporting of road accidents is proportional to the speed (v) in the road environment and that the reporting of a

personal injury accident resulting from an accident reported by the police is also proportional to the speed (v), which leads to hypothesis (1) above.

Finally, the model has been developed so that the change in road safety can be expressed both in accidents and casualties. The basis is the empirical accident and injury statistics from a defined road environment with known mean speed or median speed. The model then states the estimated effect on road safety of a change in speeds (mean speed) alone. The estimate has then been compared empirically with corresponding after-periods where a correction has been made for changes in traffic or other measures/changes between the before-period and after-period. The model has been found to provide very good agreement with reality.

The model's transformation of accidents into casualties is a result of the number of injured per personal injury accident or the number of killed per fatal accident being on average greater than one (1) and higher in rural areas than urban areas. The model is illustrated in Figure 3.

Figure 3. Relationship between changes in speed and safety.



Relationship between speed and safety - calculation model

Change in mean (median) speed v_0 to v_1

Accidents (y)	Casualties (z)
Fatal accidents	Fatalities
$y_1 = (v_1/v_0)^4 y_0$	$z_1 = (v_1/v_0)^4 y_0 + (v_1/v_0)^8 (z_0 - y_0)$
Fatal and severe accidents	Fatalities and severely injured
$y_1 = (v_1/v_0)^3 y_0$	$z_1 = (v_1/v_0)^3 y_0 + (v_1/v_0)^6 (z_0 - y_0)$
All injury accidents	All injured (fatalities included)
$y_1 = (v_1/v_0)^2 y_0$	$z_1 = (v_1/v_0)^2 y_0 + (v_1/v_0)^4 (z_0 - y_0)$

Example 1. Speed increases from 85 to 90 km/h. The number of fatal accidents is 100 and the number of fatalities is 110 at 85 km/h.

$$y = 1.059 \times 100 = 125.7 \quad \text{Increase } 25.7\%$$

$$z = 125.7 \times 1.059^{8} (110\text{-}100) = 141.5 \quad \text{Increase } 28.6\%$$

Example 2. Speed reduction from 100 to 90 km/h. The number of personal injury accidents is 1000 and the number of injured is 1500 at 100 km/h (fatalities included).

$$y = 0.9^{2} \times 1000 = 810 \quad \text{Decrease } 19\%$$

$$z = 810 + 0.94^{4} (1500\text{-}1000) = 141.5 \quad \text{Decrease } 24.1\%$$

These calculations have been used to investigate the safety effect of different measures to reduce speeds in different speed limit environments with and without changing the speed limit and with changed speed surveillance strategies - increased use of speed surveillance or reduced tolerance interval.

In Sweden's national road safety programme, one intermediate target is to reduce the proportion of drivers exceeding the different speed limits with 35 % before the year 2000. The speed situation expressed by the proportion of drivers exceeding the speed limit and the corresponding safety situation (all injured expressed in fatality units) is presented in the following figures for different speed limits and urban and rural areas. The figures show the safety potential of reducing the proportion of drivers exceeding the speed limit in different speed limit environments. Behind the calculations is of course a model which transforms the above proportion into mean speeds so that the model can be used for calculating the above change in safety. Figures 4, 5, 6 and 7.

Figure 4.

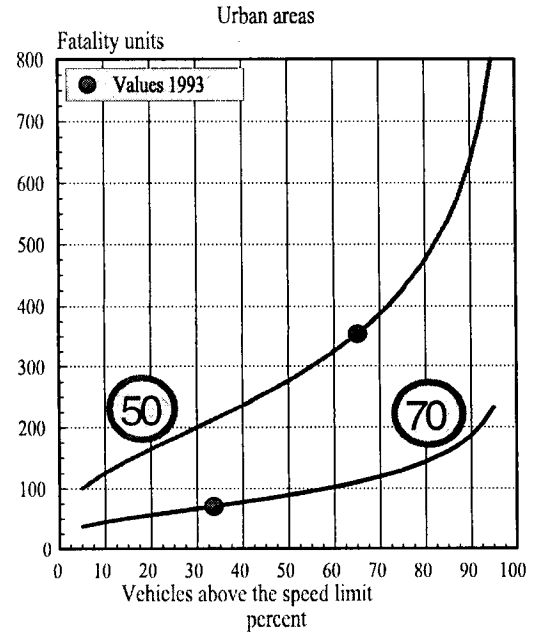


Figure 5.

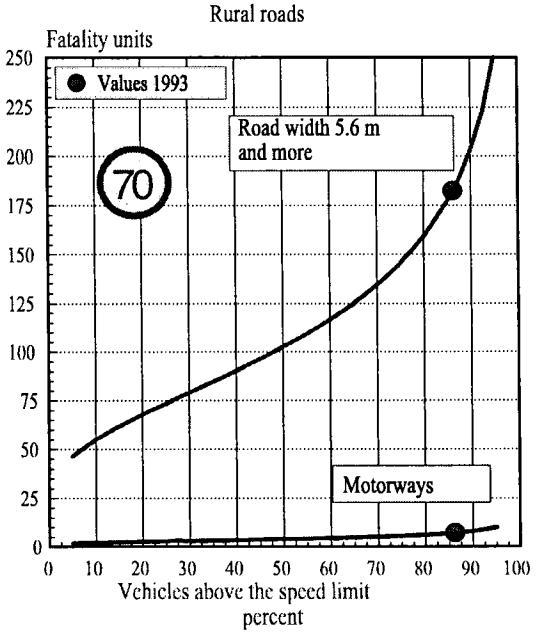


Figure 6.

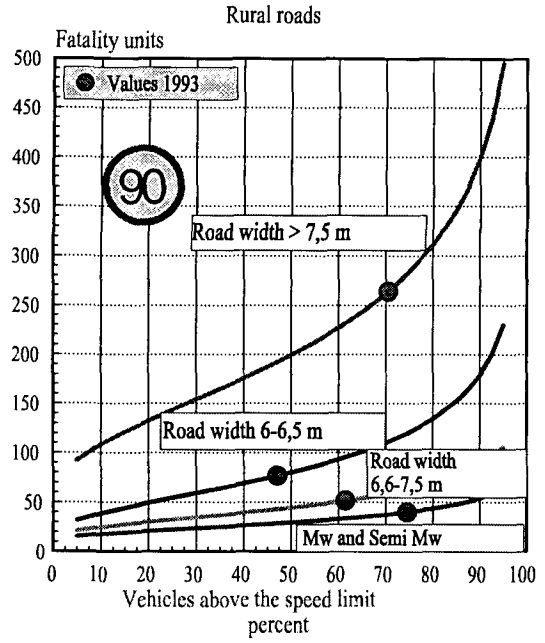
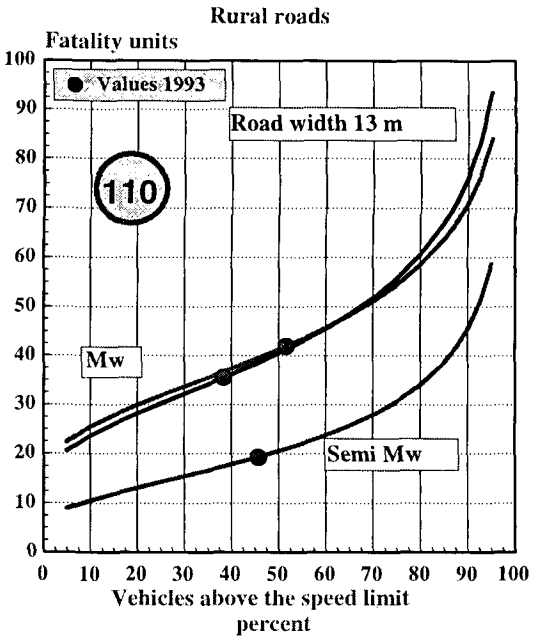


Figure 7.



Figures 4 - 7 Safety consequences due to speed limit adaptation

Speed variance and safety

As suggested above, speed vary between different combinations of driver and vehicle on roads with the same speed limit. Often, it is stated that this variation is the dominating cause of road accidents and that the speed level itself is of less significance. It is also relatively easy to show that vehicles traveling at the same speed in the same direction do not come into contact with or influence each other and that this could provide a solution to the road safety problem. It is also comparatively logical that vehicles often traveling slowly and quickly respectively come into conflict with other vehicles and especially with each other, resulting in higher accident risks for both in connection with overtaking or catching-up situations. This is illustrated by Solomon's well-known U-form for the accident risk for vehicles traveling slower and faster than the average speed.

Investigations of accidents reported by the police in most countries show however that accidents in connection with overtaking and catching-up are very limited and that the majority of the latter occur at or near junctions. The major road safety problem in the case of fatalities among motorists is single vehicle accidents and meeting accidents, whose consequences depend on the speed level. The same applies to major accidents between crossing vehicles at junctions, especially in urban areas.

One explanation for the U-relations obtained is probably that both the vehicles driving extremely slowly or extremely fast to a larger extent than others are involved in other road accidents than those that can be related to speed variation (elderly and younger drivers).

In the same way as when measuring speeds on the basis of different characteristics of the speed distribution, the same distribution is used for calculating the speed variance. This is a measure comparing vehicle speeds which are distributed in time and not between pairs of vehicles. The measure of variance is thus not related to the traffic situation since the speed level on a section of road varies during the day. Normally, the speed variance is small during peak traffic periods and large at other times, which corresponds to the same relations between speed level and traffic.

To sum up, it can be stated that it is hardly possible to isolate the effect of the statistical descriptions of speed level and speed variance for analysis of road safety. The speed variance can be attributed to a limited part of the road accident problem, while the speed level affects every accident, particularly injury consequences. As always when using derived statistical measures, they are used as explanatory factors in the field of road safety, although they are only general one-dimensional descriptions of various characteristics of traffic. Here, however, road safety research does not differ from other areas.

An attempt have been made using the VTI traffic simulation model to investigate the importance of speed variance depending on accurate speedometers, no lorries in traffic and only three possible speed choices for passenger cars. The number of overtakings were reduced with about 25 % for each factor on rural roads. A study in Sweden in which the interviewed drivers were asked to state whether they normally drove faster, slower or at the same speed as the indicated speed level (90 kph) and at the same time indicate why they did not drive slower, showed that the strongest reason in all groups was that they did not want to hinder others. This might be interpreted in several ways.

SPEED, TIME, AND RISK TAKING

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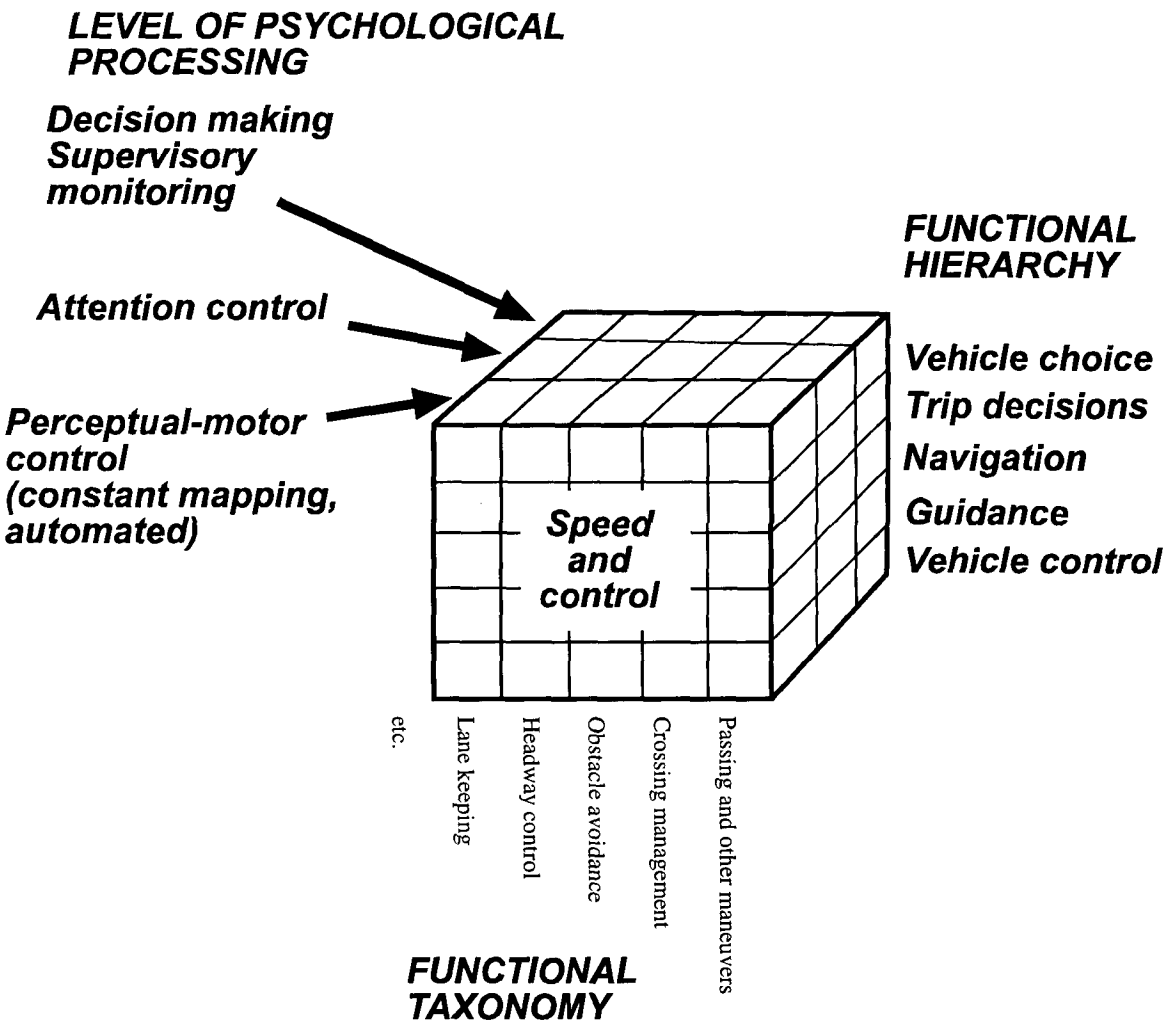
ABSTRACT This paper considers the risky behavior of drivers in a hierarchical model in which exposure to risk, in both quantity and quality, is influenced by trip decisions and on-road control. Speed and time can be seen as major control factors in explaining both trip generating processes and on-road control processes as well as the motivational factors influencing them. Risk taking and risky behavior is not limited to certain "risky drivers", such as young male drivers; instead, we can find different forms of risk taking and habitual risky behavior in all driver groups at all levels of traveling behavior. Making trip decisions when impaired, drivers' tendency to maintain a target speed, and time sharing between traffic and non-traffic targets exemplify risk taking and habitual risky behavior.

INTRODUCTION

A traditional way of looking at the driver's task is to divide it into subtasks, such as lane keeping, headway control, obstacle avoidance, crossing management, passing, lane change and other maneuvers (Fig. 1). Such a functional taxonomy is familiar from early analyses of driver on-road tasks, and has traditionally been applied in driver education: a notable taxonomy of McKnight and Adams (1970) consisted of 45 major tasks and not less than 1700 different subtasks. Each of these elementary driver tasks can be thought of as an elementary unit of exposure to risk. Thus, lane keeping through a certain curve or a stretch of road, meeting another vehicle on a two-lane road, merging into a priority road, reacting to closing headway situations, and so forth, can all be seen as units of exposure which may or may not result in an accident (Chapman, 1973; Summala, 1996).

The second dimension is a functional hierarchy which also follows earlier hierarchical classifications of driving behaviour and information processing proposed in the early 1970's (Allen, Lunenfeld, and Alexander, 1971; Michon, 1979; Michon, 1985; Mikkonen and Keskinen, 1980) . From bottom up, vehicle control level includes the use of controls which gradually becomes integrated in sensomotor control of the vehicle speed and position in a lane. The guidance level refers to the way we steer the car in traffic, interact with other vehicles and keep control of safety margins. Navigation includes route finding and selection, although the latter is

Figure 1. A cube model of the driver's task. (Adapted from Summala, 1996)



often done during trip decision making at home, at the strategical level of traveling behavior. Trip decisions include short-term and long-term transport mode selection, and choice of vehicle greatly influence the trips people take. Higher level decisions largely influence exposure, that is, how many miles one has to drive in good and how many in adverse conditions, how many priority roads one has to cross, and so on.

The third dimension focuses on the distinction between automated perceptual-motor control and conscious decision-making and monitoring, with the attention control in between as an important intervening element. The higher the task in the functional hierarchy, the more often conscious decision making and supervisory monitoring is applied. How much so, however, depends on each individual driver's level of skill and automatization; drivers also learn to perform trip decisions and navigation habitually without conscious consideration. This distinction is also relevant when we define risk taking. Among many definitions, that of Levenson (1990) says that risk taking is an active purposive, conscious choice of an activity that entails changes or novelty

and creates anxiety in most people. However, just like frequent confrontations with different traffic situations extinguishes fear towards them (Näätänen and Summala, 1976; Summala, 1988), such risk taking easily changes with practice to habitual risky behavior.

The "driver's task cube" is a method for dividing driver behavior into subtasks, in a hierarchical structure, with a rough psychological classification. We can also see it as a multi-level sieve through which citizens' mobility aims are poured, and the filtered output is elementary driver tasks or exposure units. Every level influences the quantity (and quality) of total exposure to risk, and should sift out hazardous exposure.

Thus, such decisions as buying a car vs not doing it, choice of a car model, choice of safety equipment greatly influence both exposure to risk and consequences of exposure; trip decisions are of central importance when reduced driver ability are likely to increase risks, whether due to age and poor health, impaired weather conditions or temporarily impaired driver conditions for example caused by intoxication or fatigue. The navigational level includes making decisions about where to drive, and whether to avoid roads and environments which may be too demanding. Similarly, the guidance level and vehicle control levels refer to how to drive: pacing driving properly, decision making at crossings, and managing sensomotor performance. Risk taking and risky behavior exist at all levels of the hierarchy.

SPEED AND TIME

Speed and time have a specific role in governing the whole driver task cube, as traveling behavior can be described in terms of speed and time at all levels.

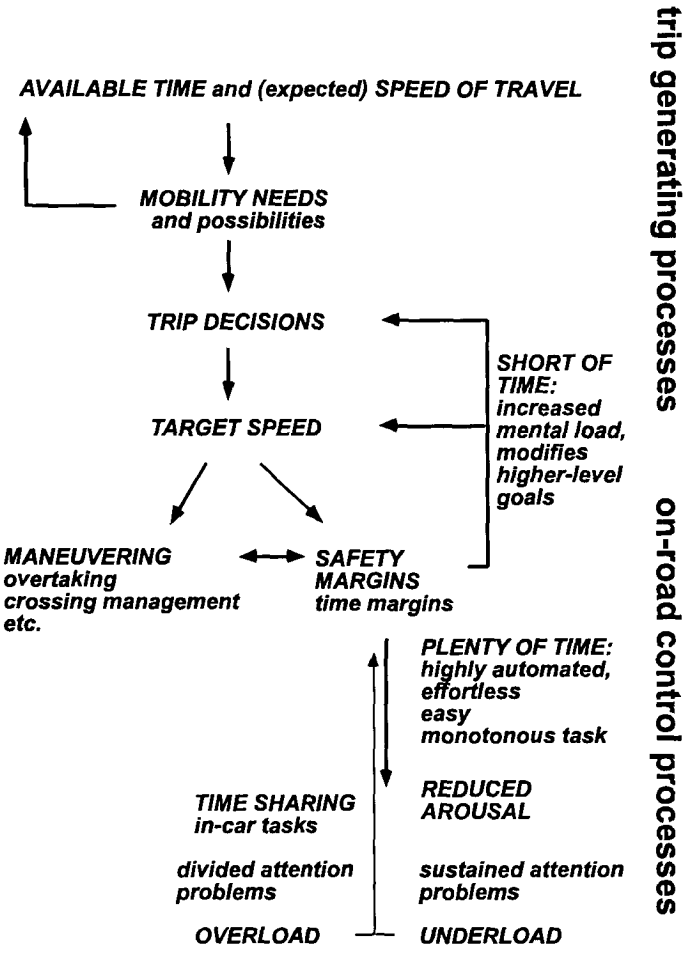
The primary high-level goal of the transportation system is mobility, and mobility is necessarily related to speed and time. Covering a certain distance in a reasonable time, to fulfil a mobility need, requires a certain speed. Speed and time also largely determine the quality of exposure, that is, how safely drivers perform the elementary tasks.

As proposed in Fig. 2, available time and available transport mode (and the speed it provides) together influence mobility needs and possibilities, which again affect vehicle choice and the way people allocate their time. Thus, the motor car meant an enormous change in both fulfilling and generating mobility needs, in comparison to horse-driven coaches or walking. The average person's mobility has increased and is still increasing, in terms of distance, while time used for traveling appears to show a more constant pattern (e.g. Himanen, Järvi-Nykänen, and Raitio, 1997). The increased range of travel one can do in a certain time unit naturally increases travel opportunities and engenders mobility needs.

Mobility needs and possibilities further determine trip decisions, while trip decisions largely determine the speed we plan and try to maintain on a trip. This is called target speed, different from the concept of desired speed which in traffic engineering literature typically refers to the speed drivers choose at optimum circumstances, on an empty road when not impeded by other vehicles (Highway Research Board, 1965; McLean, 1989).

Different parts of road and street network suggest different target speeds, while proper speed selection can be supported by proper road design and speed limits. However, there is still plenty of individual variance in speed due to driver background and the nature of his/her trip, among other factors. On a given road, target speed can be influenced by driver (and vehicle) variables, trip variables and traffic flow (Kiljunen and Summala, 1996).

Figure 2. A synthesis of traveling behavvior which considers time and speed as central control variables that generate and shape traffic behavior. (Adapted from Summala, 1997)



On the next level down, target speed determines maneuvering and safety margins. The higher the speed variance among drivers, the more overtaking occurs on the road. Also, the higher the target speed an individual driver tries to maintain, the more vehicles he/she has to pass to keep that speed. So a higher target speed creates more maneuvering which, especially on two-lane roads, is a major process increasing risk taking and exposure to serious risk.

SAFETY MARGINS

While one link from the target speed to safety margins goes through maneuvers, speed also determines safety margins directly.

Safety margins have become a key concept in modeling driver behavior and safety although Gibson and Crooks (1938) used a related concept already in the 1930's. In particular, the recent efforts to develop intelligent driver support systems have required proper modeling of the driver task, and focussed on the safety margin measures controlled by drivers (Brown, 1990; Janssen and Nilsson, 1992; Godthelp and Schumann, 1993; Michon and Smiley, 1993; Onken, 1993; Summala, 1994).

The driver's task can be seen as maintaining safety margins, such as headway, clearance between cars in passing or meeting, even lane keeping. Safety margins can be defined in time or space. However, this gives rise to an important question, both theoretical and practically: what scale do the drivers actually use (Summala, 1985)?

The last decade or two have witnessed major efforts to search for the supposedly time-based mechanisms which drivers use in maintaining safety. One is the concept of time-to-collision which refers to the time margin, at any point of time, until the moment when a driver crashes an obstacle or the back of the car ahead if he/she continues at the present rate.

Time-to-collision estimation appears to be a very basic human ability. Accumulating evidence shows that the human visual system has different detectors, which give the necessary time-to-collision information instantly without any cognitive computational processes. (Active debate on this issue is still going on, however.) First, the human visual system is efficient in perceiving edge lines of objects in the visual field, second, in perceiving the local movement of the edges; third, whether the edges are closing or moving apart which indicates movement away or toward and, last, a neural mechanism which provides the time-to-contact information, the time within which an approaching object reaches the eye (Regan and Hamstra, 1993). This is important when human beings (as well as lower species) dodge approaching objects, move between obstacles, for example in a forest or on a crowded sidewalk or in traffic flow, follow another car, or perform other tasks relying on their eyesight (Lee, 1976; Lee and Lishman, 1977).

Another time-based measure in continuous car control concerns lane keeping. Godthelp, Milgram and Blaauw (1984) proposed that lane keeping performance can be modeled with a concept of time-to-line-crossing. It refers to the time margin, at any point of time, until the moment when the car crosses either of the lane boundaries if the present course is maintained. This measure takes into account the fact of lane keeping behavior that drivers are free to move laterally within certain limits. Such a time-based measure implies a **quality of availability**, that is, a driver has time at his/her disposal to control and share between different activities. A low speed and a wide and straight road mean more time, and the time which is used for in-car tasks is directly related to speed (Wikman, Laakso, and Summala, 1997a).

There is increasing evidence that lane keeping skills become more efficient with experience, enabling drivers to keep their cars in the lane without using foveal vision, leaving the task to peripheral vision instead (Mourant and Rockwell, 1972; Riemersma, 1981; Smiley, Reid, and

Fraser, 1980; Summala, Nieminen, and Punto, 1996). This development of resource sharing provides drivers with more time to keep their attention on other traffic and critical objects at a distance, thus promoting anticipation of dangers. It may also be a major mechanism which provides drivers with spare time to be used for looking at the scenery and doing in-car tasks.

Time-to-collision and time-to-line-crossing provide measures for estimating available time in continuous on-road control by drivers. Time is also a critical measure in discrete maneuvering such as gap acceptance at intersections, lane change, and merging or overtaking behavior, in which gaps of different sizes are opened to a driver and he/she has to make a decision on whether to accept or reject them (Gibbs, 1968; McDowell, Darzentas, and Wennell, 1981). Again, we can define a gap either in space or time, while in certain cases time estimates may be biased as our visual acuity is not sufficient for estimating speed of an oncoming vehicle at distance (Björkman, 1963; Brehmer, 1990; Hills, 1980). Merging or crossing over a major road with heavy traffic may particularly be a very time-pressed task, and elderly people may find that they do not have enough time to scan both directions adequately (Hakamies-Blomqvist, 1993).

It is proposed here that speed and time margins have a central role in on-road traffic control tasks. Two important implications follow.

First, like any skilled behavior, driving becomes automated, effortless, easy and monotonous with extensive practice, and drivers have plenty of time available - subjectively. This often results in time-sharing between traffic and non-traffic targets, such as performing in-car tasks, which easily results in divided-attention problems and overload when traffic attention demands suddenly changes. On the other hand, a well learned monotonous task like commuting or driving on a freeway may lead to reduced arousal, problems in sustaining attention, underload, drowsiness, and sleeping at the wheel (Fig. 2).

Second, if we feel that we have too little time and too much information to be processed, we normally reduce speed to reduce mental load. Continuous difficulties also modify higher level goals at the trip-decision level. Thus, for example, elderly people start avoiding downtown areas, heavy traffic, and driving at night.

Mental load is a widely used concept in human factors literature, which has several dimensions (Hancock and Meshkati, 1987; Hart and Staveland, 1987). In traffic, a time-related workload concept is easily at hand as movement forces the driver to keep track of all the relevant information in limited time, or reduce speed, or even stop if necessary. We can say that from the point of view of a driver, traffic is full of closing time gaps. A close relationship between time-measures and workload is apparent, and it may therefore be a major psychological mechanism which explains how lower-level on-road control translates to upper-level decisions (Summala, 1996). This is in line with the dynamic conceptualization of mental workload by Hancock and his co-workers (Hancock and Caird, 1993; Hancock, Chignell, Vercruyssen, and Denhoff, 1989), who propose three major dimensions for mental load: the amount of time for action, the perceived distance from the desired goal state, and the level of effort that will be required to achieve the desired goal, given the time available.

VARIETIES OF RISK TAKING

Risk taking in traffic is often linked to young male drivers. They do indeed drive dangerously, not because of inferior skill but due to problem behavior, inferior socialization and an abundance of the so called extra motives such as showing off and sensation seeking (Jessor, 1987; Jonah and Dawson, 1987; Näätänen and Summala, 1976; Summala, 1987), which may also result in deliberate risk taking. However, risk taking is not exclusive to young male drivers. In addition to speeding, typical to young male drivers, we can define several other types of risk taking - in other driver groups as well - and at many levels of traveling behavior.

Speeding, and maintaining speed. While speeding and high speed as such are intrinsically rewarding as sensations (Fuller, 1984; Rothengatter, 1988; Summala, 1988), maintaining a certain speed is rewarding as well, just as maintaining the pace of any well-going activity is (Summala, 1988). Thus, while young male drivers may choose a speed which is much too high for the conditions, and therefore take deliberate risk, experienced middle-aged drivers take risks as well when trying to maintain their "legal" target speed: such occasions occur, for example, in a lane change when one approaches a slower vehicle on a freeway while a faster car is coming from behind on the left lane. Rather than slowing down sufficiently, keeping a sufficient headway, and waiting for a safe opportunity in this temporary "lane trap", a driver may be inclined to minimize deceleration and changes lane just behind the passing car. This results in short margins, both to the slower vehicle ahead and to the fast passing car.

Another related situation occurs when a pedestrian crosses the street in front of the approaching driver, and the driver again applies an optimizing strategy, that is, minimizing deceleration and accepting a short margin. For yet another example, running red lights presumably stems from the same tendency to keep the pace.

Time sharing. With automated skills in car control and guidance, drivers can share time between the driving task and other in-car activities. According to some estimates drivers use 30-50% of their time, or visual attention, to non-traffic targets (Hughes and Cole, 1986) and, respectively, in experimental settings drivers accept occlusion of vision in 40% of total time (Godthelp and Kappler, 1988; Godthelp, et al., 1984). Time allocation is obviously dependent on traffic conditions, so that in more complicated situations drivers allocate more time to the driving task or reduce speed (Hada, 1994; Harms, 1991; Hella, 1987; Rockwell, 1988; Wierwille, 1993; Wikman, Nieminen, and Summala, 1997b). Both driving speed and the location of a secondary task affect the time available for the task. In our recent on-road study (Wikman, et al., 1997a) drivers had to keep the car in the lane, at different speeds, while naming as many number fours as they could from a random digit series shown on an in-car display (at a rate of four digits per second). The location of the display was alternated to change parafoveal/peripheral information of the road environment available for drivers. The average glance length and proportion of gaze on task did, indeed, decrease at higher speeds and when the eccentricity of the in-car task was increased. When the display was at the speedometer level, 27 degrees below the horizon the experienced drivers could look at it as much as 85 % of time at the speed of 80 km/h. Road curvature also influenced off-road glance length, just as predicted.

Certain types of time-sharing in traffic constitute true risk taking, for example when the driver is running his/her office from his/her car, or reads either a traditional map or a navigation system,

often improperly placed and equipped with an interface not suitable for use in a moving vehicle. When performing normal in-car tasks such as using a radio or a mobile phone, experienced middle aged drivers appear to be able to share attention properly if they put an effort to it, that is, the length of their glances off the road does not exceed 2-2.5 s. However, novices appear to have problems with time-sharing control, apparent in occasional too long glances, presumably because for them, vehicle control and guidance still requires a lot of resources (Wikman, et al., 1997b). For elderly drivers, neurological problems make time sharing difficult again so that he/she may fixate to an in-car task for a longer time or even to forget where he/she is (Haikonen, Wikman, Summala, Nieminen, Kalska, Vilkki, Hietanen, 1996).

Underload. Time sharing easily becomes a sudden overload situation which is difficult to control. Another trap awaits a driver who continues driving although too tired to do it safely, making the situation (conscious) risk taking on his part. Driving on freeways in light traffic does not provide sufficient stimulation to keep drivers alert while deeply automated routines also make daily commuting highly predictable, monotonous, and induce drowsiness, promoted by the circadian drowsiness pattern.

Trip decisions. Risk taking does not only occur in on-road driving but in higher level decisions as well. Driving when intoxicated is only one example of a risky trip decision. Trips taken in adverse weather and road conditions go to another category of risk taking and, finally, trip decisions determine target speed, and sometimes set time schedules which force high target speed and risk taking in maneuvering.

Table 1 collects some types of risk taking in traffic by age group. While speeding is a major risk taking category for young (male) drivers, even more so if intoxicated, maintaining a self-assessed target speed is a common source of risk taking with middle aged drivers, and trying to keep up with the speed of other drivers among elderly drivers.

Table 1. Varieties of risk taking in traffic.

Young	Middle aged	Elderly (and non-healthy)
Speeding	Maintaining a target speed	Keeping to the speed of others
Time sharing	Time sharing	Taking a trip in adverse weather conditions
Fatigue, driving at night	Fatigue, day and night	Fatigue, daytime (after-lunch dips; secondary drowsiness peak in the afternoon)
Alcohol	Alcohol	Driving when no more capable to drive

Time sharing between traffic and non-traffic targets is another category, typical for experienced drivers while especially hazardous for novices. At an older age, and especially with neurological diseases, time sharing and attention shift between relevant traffic targets becomes more and more difficult as such, without any additional tasks, due to general slowness in operation and attention problems (Cerella, 1990; Parasuraman and Nestor, 1993). In particular, risks arise if elderly drivers do not stop driving when they find the task too demanding, or if they fail to find being short of time and missing critical information. Another danger, overconfidence in one's driving ability, is involved in certain diseases especially. Thus, for example, Parkinson and demented patients express too optimistic a view of their driving ability, which is too often shared by their doctors (Heikkilä, Turkka, Korpelainen, Kallanranta, and Summala, in press; Hunt, Morris, Edwards, and Wilson, 1993).

Fatigue is a risk factor in all age groups, resulting to delayed reactions and even falling in a sleep at the wheel, and real risk taking when people continue driving when tired; the desire to continue the pace and complete the trip is likely to be a motivational factor behind it. Some 10% of fatalities can be ascribed to fatigue in all age groups, when alcohol cases are excluded, while they distribute differently for time of day for different age groups (Summala and Mikkola, 1994). Middle-aged car drivers have fatigue-related fatalities evenly distributed over day and night, young drivers in early morning hours and elderly drivers during the secondary drowsiness peak in the afternoon.

CONCLUSION

Two major points were presented in this paper. First, speed and time appear to be major control factors in explaining both trip generating processes and on-road control processes, as well as motivational factors influencing them. Secondly, risk taking and risky behavior is present in other groups than just those generally conceived as "risky drivers": we can find different forms of risk taking and habitual risky behavior in all driver groups. Drivers' tendency to maintain a target speed is likely to result in risk taking, as is reduced arousal, and time sharing between traffic and non-traffic targets when plenty of time is subjectively available. The latter problem is bound to exacerbate as the nature of car driving is changing with mobile telecommunication. For example, nearly one half of Finnish adults have a cellular phone, and they use it increasingly while driving, and all the while new functions are coming into the car to fight over the drivers' attention and time. Risk taking and risky behavior occur at all levels of traffic behavior, in trip decisions as well as in on-road driving, and influence the quantity and quality of exposure to risk.

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THE RELATIONSHIP OF SPEED - A LAW ENFORCEMENT PERSPECTIVE

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A REPRESENTATIVE VIEW?

We often think the challenges with which we are confronted are unique to us or our environment, only to realize there are no truly unique experiences, but rather a seemingly global commonality within disciplines that brings people together. And it is this coming together that is so important because it is through these interrelationships that we join to resolve these challenges for the welfare of people everywhere.

I have found in law enforcement the challenges we face in Missouri are no different that those faced in California, or Canada, or Sweden. Driver beliefs, behaviors, and attitudes are very much the same in the United Kingdom, or Australia, or France, as they are in the United States. And the effects of kinetic energy are the same in Finland as they are in the U.S. So, even though my knowledge concerning speed as it relates to risk-taking behavior and traffic safety is limited to my experiences in the state of Missouri, I am confident these experiences are not unique to the state of Missouri, but are shared by traffic safety specialists universally.

Missouri, with its 5.2 million residents, ranks 15th in population among the fifty United States; it ranks 21st in size with 69,709 square miles (180,593 sq.km.), and 6th in miles of state maintained roadways with 32,368 (52,123 km). As one might expect, traffic crash experience among the states closely mirrors population density, and Missouri ranks 13th in traffic fatalities (1,148 in 1996).

WHY SPEED LIMITS?

The basic intent of speed "zoning," as it is referred to by traffic engineers, is to identify a safe and reasonable limit for a given road section based upon such factors as traffic crash experience, roadway geometrics, parking, pedestrians, curves, adjacent property development, and engineering judgment. When all variables are considered and a speed limit is established, traffic should flow in a safe and efficient manner. Limits should encourage drivers to travel at the speed where the risk of crash involvement is the lowest, and should give a clear reminder of reasonable and prudent speeds not only to non-conforming violators, but to drivers unfamiliar with the roadway upon which they are traveling. The most widely accepted method is to set the limit at

the speed at which 85 percent of free-flowing traffic is moving at or below, feeling traffic laws that reflect the behavior of the majority of motorists will be successful, while laws that arbitrarily restrict the majority of motorists encourage violations, lack of public support, and usually fail to bring about desirable changes in driving behavior.

SPEED LIMITS - HOW FAST?

Missouri's first speed limits were enacted in 1957. The limit on federal divided highways was set at 70 mph day and night; federal undivided highway limits were 70 mph during the day and 65 mph at night; limits on all other roadways were 65 mph during the day and 60 mph at night. These limits remained intact until 1973 when, in response to the oil crisis, Missouri adopted the National Maximum Speed Limit (NMSL) of 55 mph on all highways. The speed limit on rural interstates was adjusted to 65 mph in 1987 upon amendment of the NMSL.

Repeal of the national speed limits in 1995 again left the establishment of speed limits to the states and, on March 13, 1996, legislation was enacted in Missouri establishing "uniform maximum speed limits" for specific highway types. A provision of the law, however, empowered the Missouri Department of Transportation (MoDOT) to set speed limits on any highway higher or lower than the uniform maximum speed limit based upon engineering and safety considerations, provided no speed limit could be set higher than 70 mph. This has resulted not only in speed limits which vary for particular types of highways, but speed limits which vary upon a single highway type.

MoDOT speed monitoring indicates average speed has increased 3 to 8 percent on those highways on which the speed limit has been raised and 2.3 percent on those highways on which the limits remained unchanged. Clearly, this demonstrates the relationship between speed limit and minimum speed, as well as the spillover effect created by higher limits. Their speed monitoring also indicated an increase in the 85th percentile speeds of 1.5 to 7.7 percent. Ironically, a MoDOT publication on establishment of speed limits states it is a "widely held misconception" that "reducing the speed limit will slow the speed of traffic" and conversely that "raising the posted speed limit will cause an increase in the speed of traffic."

SPEED LIMITS - CRASH EXPERIENCE

In each of the years 1968, 69, 70, 71, 72 and 73, more than 1,400 people were killed in traffic crashes in the state of Missouri. In 1974, the very first year in which the 55 mph speed limit was in effect, more than 400 fewer people were killed on Missouri's highways, and highway deaths have not approached 1,400 in the 22 years since that time. The death rate in the state of Missouri has gone from 4.7 per 100 million miles of vehicle travel in 1973 down to 1.9 in 1996, in spite of the fact the number of licensed drivers has increased by more than 850,000; registered vehicles have increased by approximately 1.6 million; and miles of vehicle travel in the state have increased by more than 30 billion. The highway infrastructure has not kept pace with this growth, significantly increasing the exposure and interaction among vehicles and drivers.

Obviously, this downward trend is not entirely attributable to the decrease in the speed limit. The advancements and efforts in the engineering, education, and enforcement arenas have played a

significant role, not to mention the vast improvements in emergency medical services. But it is unarguable that in 1974, the first year of the 55 mph speed limit, highway deaths decreased by more than 400.

In 1996, there were 191,164 traffic crashes reported to the Missouri State Highway Patrol; 1,148 people were killed and more than 82,000 were injured in these crashes. That equates to one person being killed or injured every 6.3 minutes in a traffic crash on Missouri roadways in 1996. More than 16 percent of all traffic crashes in the state were speed-related; however, 39 percent of all fatal crashes were speed-related. These crashes killed 444 people and injured 18,027. Of all speed-related traffic crashes, 55.1 percent involved a motor vehicle striking a fixed object. Of all 1996 speed-related traffic crashes, 51.2 percent occurred in urban areas of the state and 48.8 percent occurred in rural areas. Interestingly, however, 74 percent of the fatal speed-related crashes occurred in a rural area.

A preliminary impact analysis (Table 1) conducted by the Missouri State Highway Patrol's Statistical Analysis Center revealed a 33.6 percent increase in fatal crashes on Missouri's interstate highways during the first year following the increase in the speed limit when compared to the average for a like time period for the three preceding years. The rate of change for all highways in the state was 7.2 percent. Alarmingly, total crashes (Table 2) on interstates were almost three times the rate of change for all highways in the state (15.4 to 5.3), and fatal and personal injury crashes (Table 3) almost four times (13.2 to 3.4). The interstates were the only roadways on which the limits immediately increased, and on which we have experienced an entire year at the increased limits. While these data may be only an indication of short-term impact and may not be indicative of the long-term effect, they should seize the attention of highway safety advocates. Only time will reveal the outcome on all highways.

SPEED AND SAFETY

The relationship between the speeds at which vehicles are allowed to travel and road safety is undeniable. It was dramatically demonstrated in 1974 when speed limits were uniformly decreased to 55 mph, and unfortunately it is being realized today with increased speed limits, speeds, death, and injury. Highway safety efforts during the past twenty years have been successful in achieving a significant reduction in the death rate, but it appears those efforts have reached the point of diminishing returns. The death rate on Missouri highways has remained static the past five years.

Table 1. Missouri Increased Speed Limit - Preliminary Impact Analysis Fatal Traffic Crashes

HIGHWAY CLASSIFICATION	3/14/93 - 3/13/96 AVERAGE	3/14/96 - 3/13/97	DIFFERENCE	RATE OF CHANGE
INTERSTATE	125	167	+ 42	+ 33.6
U.S. HIGHWAY	175	184	+ 9	+ 5.1
U.S. ALT/BYPASS	2	3	+ 1	+ 50.0

Table 1. Missouri Increased Speed Limit - Preliminary Impact Analysis Fatal Traffic Crashes (continued)

HIGHWAY CLASSIFICATION	3/14/93 - 3/13/96 AVERAGE	3/14/96 - 3/13/97	DIFFERENCE	RATE OF CHANGE
STATE NUMBERED	220	227	+ 7	+ 3.2
U.S. BUS. ROUTE	4	4	0	0
STATE BUS. ROUTE	0	0	0	0
SINGLE LETTERED	126	116	- 10	-7.9
DOUBLE LETTERED	44	47	+ 3	+ 6.8
OUTER ROAD	9	12	+ 3	+ 33.3
COUNTRY ROAD	95	94	- 1	- 1.1
CITY STREET	121	133	+ 12	+ 9.9
INTERSTATE LOOP	4	2	- 2	- 50.0
OTHER	8	11	+ 3	+ 37.5
TOTAL	**933**	**1,000**	**+ 67**	**+ 7.2**

March 14, 1996 was the date the speed limit increase became effective in the State of Missouri. As a result, this date was used as the initial date for the study.

Data reflect all crashes entered in the Statewide Traffic Accident Records System (STARS) as of August 26, 1997.

Table 2. Missouri Increased Speed Limit - Preliminary Impact Analysis All Traffic Crashes

HIGHWAY CLASSIFICATION	3/14/93 - 3/13/96 AVERAGE	3/14/96 - 3/13/97	DIFFERENCE	RATE OF CHANGE
INTERSTATE	20,085	23,184	+ 3,099	+ 15.4
U.S. HIGHWAY	20,156	21,902	+ 1,746	+ 8.7
U.S. ALT/BYPASS	124	153	+ 29	+ 23.4
STATE NUMBERED	28,278	29,766	+ 1,488	+ 5.3
U.S. BUS. ROUTE	2,225	2,391	+ 166	+ 7.5
STATE BUS. ROUTE	242	265	+ 23	+ 9.5
SINGLE LETTERED	9,554	10,006	+ 452	+ 4.7
DOUBLE LETTERED	3,955	4,179	+ 224	+ 5.7
OUTER ROAD	1,906	1,946	+ 40	+ 2.1
COUNTRY ROAD	16,439	17,340	+ 901	+ 5.5
CITY STREET	75,872	77,964	+ 2,092	+ 2.8
INTERSTATE LOOP	1,120	1,035	- 85	- 7.6

Table 2. Missouri Increased Speed Limit - Preliminary Impact Analysis All Traffic Crashes (continued)

HIGHWAY CLASSIFICATION	3/14/93 - 3/13/96 AVERAGE	3/14/96 - 3/13/97	DIFFERENCE	RATE OF CHANGE
OTHER	2,303	1,876	- 427	- 18.5
TOTAL	**182,259**	**192,007**	**+ 9,748**	**+ 5.3**

March 14, 1996 was the date the speed limit increase became effective in the State of Missouri. As a result, this date was used as the initial date for the study.

Data reflect all crashes entered in the Statewide Traffic Accident Records System (STARS) as of August 26, 1997.

Table 3. Missouri Increased Speed Limit - Preliminary Impact Analysis Fatal and Personal Injury Traffic Crashes

HIGHWAY CLASSIFICATION	3/14/93 - 3/13/96 AVERAGE	3/14/96 - 3/13/97	DIFFERENCE	RATE OF CHANGE
INTERSTATE	5,794	6,558	+ 764	+ 13.2
U.S. HIGHWAY	6,413	6,855	+ 442	+ 6.9
U.S. ALT/BYPASS	41	42	+ 1	+ 2.4
STATE NUMBERED	9,016	9,221	+ 205	+ 2.3
U.S. BUS. ROUTE	657	696	+ 39	+ 5.9
STATE BUS. ROUTE	70	81	+ 11	+ 15.7
SINGLE LETTERED	3,606	3,585	- 21	- 0.6
DOUBLE LETTERED	1,487	1,618	+ 131	+ 8.8
OUTER ROAD	551	570	+ 19	+ 3.4
COUNTRY ROAD	5,234	5,382	+ 148	+ 2.8
CITY STREET	18,384	18.518	+ 134	+ 0.7
INTERSTATE LOOP	369	339	- 30	- 8.1
OTHER	426	367	- 59	- 13.8
TOTAL	**52,048**	**53,832**	**+ 1,784**	**+ 3.4**

March 14, 1996 was the date the speed limit increase became effective in the State of Missouri. As a result, this date was used as the initial date for the study.

Data reflect all crashes entered in the Statewide Traffic Accident Records System (STARS) as of August 26, 1997.

The highway infrastructure has not kept pace with the demands placed upon it by a society whose passion for the motor vehicle seems unrivaled. The growth in the number of licensed drivers, registered vehicles, and miles of vehicle travel places roadway use on many highways at near capacity. This arterial congestion, not sympathetic to driver error, is even more unforgiving at higher speeds. Infrastructure improvements are needed. They cannot, however, just be aimed at

remedying existing problems, but must be long-range plans designed to accommodate future growth. Improvements do not come without costs; drivers must be willing to make sacrifices in terms of traffic congestion, delays, detours, and increased user fees.

Highway and automotive engineers, highway safety specialists, and law enforcement must be innovative in developing and implementing approaches that will stimulate a reduction in traffic crashes and their associated death and injury. Law enforcement, overtaxed not only by the increased use of our highways but by the many other duties and responsibilities with which tasked, must critically evaluate their manpower allocation to ensure resources are being utilized effectively and efficiently. Prosecutors and courts, too, must assess their role in highway safety and be accountable for their contribution, or lack thereof, in reducing traffic crashes. Highway users themselves must assess their role and be supportive of efforts to make our highways safer for everyone. Only an aggressive, coordinated effort by all will significantly impact the dilemma with which we are faced.

CROSSING THE ROAD IN SOUTH AFRICA: A RISKY BUSINESS

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ABSTRACT South Africa has a major pedestrian traffic problem - nearly half of all traffic-related fatalities involve pedestrians.

Until now the risk factors focussed on for pedestrian collisions in South Africa have been those pertaining to the motorist or the road. In the light of recent findings we have to ask ourselves how realistic such an approach is.

Several studies have indicated that the major risk factors for pedestrian collisions lie with the pedestrian him/herself. Alcohol, in particular, has been found to be contributory in 72% of fatal and 61% of non-fatal pedestrian collisions. Current studies indicate that illicit drugs, such as cannabis and methaqualone, also play a significant role, as do other risky behaviours such as walking in the dark, wearing dark clothing and the impromptu crossing of freeways.

There are three elements to the equation of pedestrian traffic trauma: the motorist, the road and the pedestrian. Our problem will not be solved by concentrating on the first component, giving some attention to the second and ignoring the third.

INTRODUCTION

Non-natural causes of death in South Africa (SA) represent just over 16% of the overall mortality (Bradshaw et al., 1987) - three times the global average of 5.2% (World Health Organisation, 1987). When compared with the USA, where injuries rank fourth as a cause of overall mortality (Baker et al., 1992), non-natural causes of death in South Africa are outstripped only by circulatory diseases such as cardiac conditions, vascular diseases and strokes. Furthermore, in 1984 premature deaths in SA accounted for the loss of some 2.43 million potential years of life lost (PYLL) and non-natural causes were the single largest cause category (32%).

After violence, traffic is the second leading cause of non-natural deaths in South Africa (SA Central Statistical Services, 1992). "South African roads are a major disaster area, and the annual mortality and morbidity figures are a national disgrace" (Lee, 1990). The country's 1991 road

death rate of 11.7 per 100 million kilometres travelled is more than 10 times that of the USA (International Road Federation, 1991). According to the Directorate of Traffic Safety (1994), nearly half a million collisions occurred in South Africa in 1993 and caused more than 9 000 people to be were killed, more than 33 000 to be seriously injured and nearly 85 000 to suffer lesser injuries.

But these summary statistics obscure what can be considered the "hallmark" of South Africa's excessive traffic injury and mortality rates, namely the very high pedestrian component (Van der Spuy, 1993). Every year approximately 4 500 pedestrians are killed and a further 26 000 are injured on South African roads.

Pedestrian collisions are one of the country's most serious and preventable community health problems. The pedestrian problem is a multifaceted one. Rapid urbanisation, poor facilities for pedestrians, poor traffic education and a lack of effective law enforcement are compounded by the fact that, for a large percentage of our population, walking is the cheapest and most convenient means of transportation.

South Africa has one of the highest per capita alcohol consumption rates in the world and the consequences of drinking alcoholic beverages is rapidly becoming a serious problem, particularly because of the high number of alcohol-related deaths and injuries. The financial implications of abusing alcohol is of great concern to the government since these costs are not only borne by the misusing individual and his family, but by the health care services and the society as a whole. In 1994 it was estimated that the economic burden of alcohol abuse was R5 billion (US$ 1.2 billion) per year (Cape Times, 1994).

According to the Drug Counselling Centre in Cape Town, the most commonly abused substances in this region are alcohol, cannabis (locally called dagga) and methaqualone (Mandrax), all of which are known to cause neuropsychiatric effects (Karasellos, 1994).

Methaqualone is a quinazoline derivative which was introduced as a non-barbiturate sedative-hypnotic in 1965. Initially it was thought to be non-addictive but in 1966 reports of physical and psychological dependence began emerging in the United Kingdom. By 1984 the drug was removed from the market because of its extensive misuse (Litovita, 1988). Although its use has been almost entirely eliminated from the USA (Brenner et al., 1996) it is still manufactured illicitly and is of particular concern in South Africa where it is often smoked in combination with cannabis. This combination, referred to as a "white pipe", appears to be unique to South Africa and is usually smoked in the neck of a broken bottle. The methaqualone, which is sprinkled on top of the cannabis, apparently causes the smoker to experience a short euphoric "rush" followed by a tranquil state which can last up to six hours (Jaffe, 1985).

Cannabis is cultivated in large quantities in Southern Africa, particularly in KwaZulu-Natal and Lesotho, and is often referred to as "Durban Poison" by locals because it has particularly high Tetrahyrocannabinol (THC) levels - the isomer believed to be responsible for most of the characteristic psychological effects. Cannabis and methaqualone are relatively cheap in

comparison to other street drugs. One gram of cannabis costs R1 (25 US cents) and one methaqualone tablet R25 - R35 (US$5 - 6) (Geldenhuys, 1997). Cocaine, "crack", heroin, "brown sugar" and Ecstasy are available in South Africa but at present their abuse is limited because they are prohibitively expensive.

Alcohol has been proved to play a significant role in most traffic trauma in South Africa. It is an attributable factor in non-fatal and fatal traffic trauma involving both drivers and pedestrians. The role of drugs in these collisions has not been clearly defined.

Pedestrian collisions are clearly associated with a number of risk factors. To date, the only risk factors which have been identified are those pertaining to the motorist and/or the road. Although in some circumstances pedestrian collisions may be attributed to the reckless or negligent behaviour of motorists or the poor road infrastructure, in many cases the pedestrian is not blameless or is clearly at fault. This paper gives a brief overview of very recent data and studies on pedestrian morbidity and mortality in South Africa with particular emphasis on substance abuse among these subjects.

THE MAGNITUDE OF PEDESTRIAN TRAFFIC TRAUMA IN SOUTH AFRICA

In the USA pedestrian deaths are the second largest category of motor vehicle-related fatalities after passengers (Baker et al., 1992). This is a sharp contrast to the situation in South Africa, where pedestrian deaths are the largest category of traffic-related fatalities, accounting for between 45% and 55% of all traffic deaths annually (Directorate of Traffic Safety, 1993). This means that twelve pedestrians are killed and a further 71 injured per day in a population of around 40 million people (Table I).

Table I : National statistics for pedestrians (1989-1993)

YEAR	DEATHS	SERIOUS INJURIES*	LIGHT INJURIES**	TOTAL
1989	5,118	9,374	19,124	**33,616**
1990	4,985	9,374	19,967	**34,326**
1991	4,897	10,249	19,636	**34,782**
1992	4,437	9,079	18,684	**32,200**
1993	4,115	9,555	19,479	**33,149**

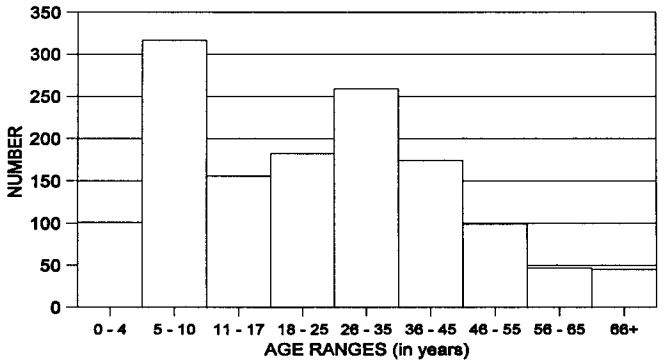
* Serious injuries = requiring hospital admission

** Light injuries = treated on an out-patient basis (no admission required)

DEMOGRAPHIC PROFILE OF INJURED PEDESTRIANS

Substantial numbers of adults are injured or killed in pedestrian collisions (Figure 1) but until recently most research focussed on childhood pedestrians.

Figure 1 : Pedestrian collisions in Cape Town by age group (1993)



In an in-depth study on pedestrians aged 13 years and older, males aged 20 to 29 years appeared to be the most at-risk age group and this was particularly the case amongst black people (Table II). Unlike the situation in developed countries, SA does not have a large geriatric component but the number of young adults and teenagers injured while intoxicated raises concern.

Table 2 : Demographics of injured pedestrians aged >13 years in Cape Town

Age	
Mean (years ±SD)	35.9 (±13.4)
Range	13-77
Gender (%)	
Male	70.0
Female	30.0
Population group (%)	
Black	46.7
Coloured	50.7
White	2.6
Average income/month (US$)	165
Living in "informal settlements" (%)	40.2

Pedestrian collisions appear to be related to low socio-economic status and are predominantly an urban phenomenon although there is growing concern over the number of pedestrians who live and are struck by vehicles in "informal settlements" in the peri-urban areas (Peden, 1997). The majority of such "informal settlements" have inadequate lighting and road structures, i.e. cars and pedestrians share the same 'pathways'.

RISKY BEHAVIOURS

According to the Cape Town City Traffic Department (1993), many pedestrians are injured or killed while making impromptu road crossings (Table III), which is the same pattern as is seen in other developing countries such as Nigeria, Ethiopia and Saudi Arabia.

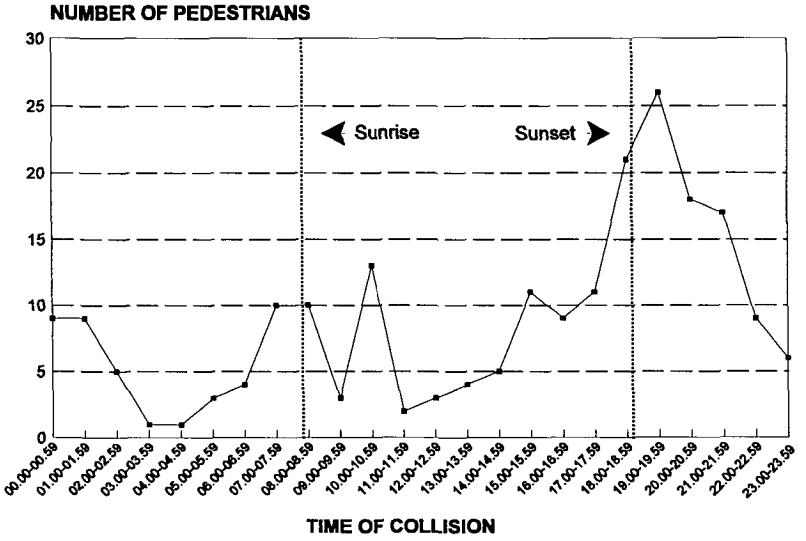
Table 3 : Pedestrian actions involved in traffic trauma in Cape Town (1991-1993)

ACTION	1991	1992	1993
Crossing street			
At ordinary intersections	232	228	252
At dedicated pedestrian crossing	84	84	85
Elsewhere (impromptu crossing)	1538	1338	1145
Walking in roadway			
Facing traffic	230	214	285
Back to traffic	116	155	179
Stand/play in roadway	129	160	170
Stand/play on sidewalk	172	167	208
Unknown	154	312	457
TOTAL	**2 655**	**2 658**	**2 781**

Furthermore, almost a quarter of pedestrian collisions have been found to occur within 30 metres of a designated pedestrian crossing (Ribbens, 1989) and a relatively large proportion (14%) occur while pedestrians are attempting to cross major highways (Peden, 1997). As indicated previously, the number of pedestrians who are struck by vehicles in informal settlements is a major concern.

Most pedestrians (65.5%) are injured between sunset and sunrise (Figure 2) and the classic transient increase in collisions an hour after sunset is also apparent (Peden, 1997). Also, pedestrians injured at this time are invariable dressed in dark clothing, confirming that pedestrian conspicuity is a critical risk factor.

Figure 2 : Time of collision for pedestrians



ALCOHOL USE AND ABUSE AMONG INJURED PEDESTRIANS

No national data are available on the role of alcohol in pedestrian collisions but regional data indicate a strong relatedness. According to the Cape Town City Traffic Department (1993), 181 pedestrians were killed in the Cape Town municipal area in 1993; 114 of these were aged 16 years or older and had died within 6 hours of injury, all of whom had Blood Alcohol Concentration (BAC) analyses performed. Seventy percent of cases had non-zero BACs and 61.4% had levels at or above 0.08 g/100ml (the legal driving limit in SA at present).

An in-depth study conducted on 227 injured pedestrians (both fatal and non-fatal) revealed that 141 patients (62.1%) were BAC positive. Only 2.6% had BAC levels of less than 0.08 g/100ml, while 59.5% were at or above the legal limit for drivers. Forty-one percent of these pedestrians had BAC levels at least twice the legal limit for drivers (Figure 3) (Peden et al, 1996).

The mean BAC for all 227 pedestrians tested was 0.12 g/100ml (±0.11), with a range of 0 - 0.39 g/100ml. For BAC positive pedestrians only, the mean BAC was 0.19 g/100ml (±0.08), with a range of 0.03 - 0.39 g/100ml.

The above results cannot be causally linked to pedestrian collisions. However, as is evident from Figure 4, there is a distinct trend between injury severity and alcohol-relatedness, particularly when compared to randomly sampled pedestrians on the streets, i.e. unselected by traffic collision or injury (as indicated in the lowest slice of the pyramid).

Figure 3 : BAC levels for 227 injured pedestrians

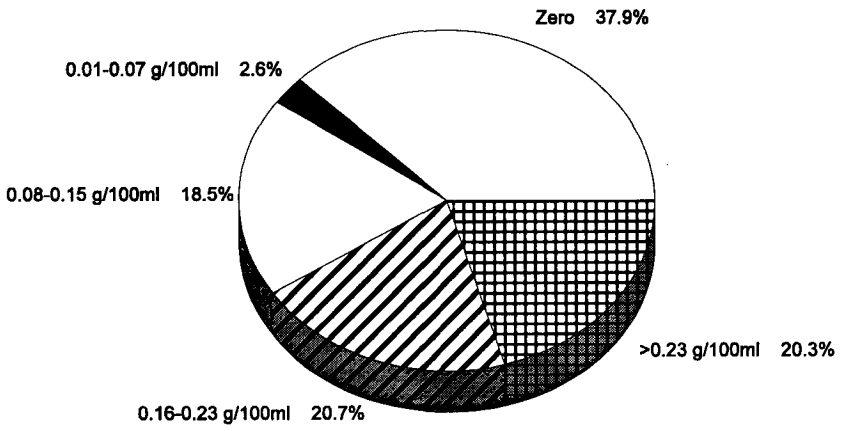
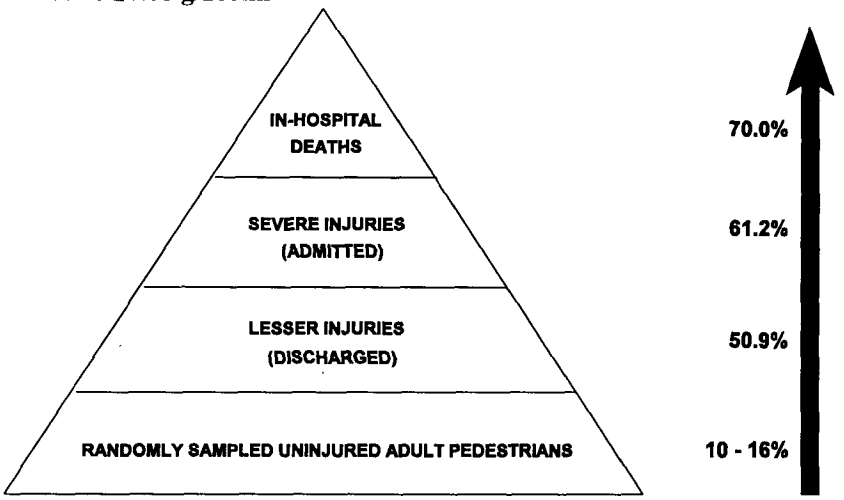


Figure 4: Pyramid indicating the proportion of pedestrians who had BAC levels ≥0.08 g/100ml



DRUG USE AMONG INJURED PEDESTRIANS

In 1994 a study was conducted on all traffic trauma patients presenting to a Durban hospital. This study found that 51.7% of the patients had BAC levels ≥0.08 g/100ml, 35.1% had traces of cannabis in their urine and 18.5% were positive for both substances. For pedestrians only, these proportions were: 42.9% for alcohol only, 36.0% for cannabis only and 21.1% for the combination of alcohol and cannabis (Hedden and Wannenberg, 1994).

In 1996 Foster conducted a study on 60 fatally injured pedestrians and 104 homicide cases. She found that three-quarters of the pedestrians had BAC levels ≥0.08 g/100ml. However, a third of those with BAC levels ≥0.08 g/100ml had also consumed an illicit drug (cannabis or methaqualone) (Table IV). None of the pedestrians were found to be positive for the combination of cannabis and methaqualone - this combination was found exclusively among the homicide group.

Table 4 : Substances found in fatally injured pedestrians

	BAC 0 - 0.08 g/100ml (n = 15)	**BAC ≥0.08 g/100ml (n = 45)**
Neither drug found	13 (86.7%	30 (66.7%)
Drugs found		
Cannabis	1 (6.7%)	6 (13.3%)
Methaqualone	1 (6.7%)	9 (20.0%)
Methaqualone + Cannabis	0 (0.0%)	0 (0.0%)

The Trauma and Drugs (TAD) Study

This study was conducted at the Level I trauma unit at Groote Schuur Hospital (Cape Town) in 1997. Data collection occurred over a 3 month period - July to September. All patients presenting for treatment as a result of physical trauma were included. Because of the volume of patients seen at this facility, the concept of an idealised fortnight was used, i.e. a continuous 24 hour period was captured twice for each day of the week over the data collection period. Patients gave written consent for the study. Every effort was made to get a relative's consent if a patient was unable to consent for him/herself. In some severely injured patients, alcohol and drug results were requested by the attending doctor as an adjunct to clinical assessment.

Alcohol levels were determined with a Lion Alcolmeter S-D2. This breathalyser had been used previously by the author and found to correlate well with BAC levels ($r = 0.998$). Patients were also interviewed with regard to their alcohol and drug consumption on the day of injury and the day before. The CAGE questionnaire was used to assess chronic alcohol consumption.

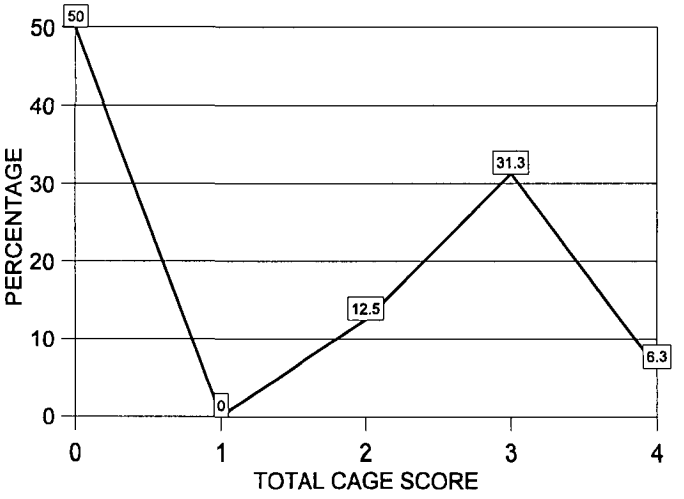
A cannabis *Drugwipe* (Suretec, Germany), which utilises sweat, was used to screen all patients. Urine and blood samples were taken from all patients. Abbott Laboratories Diagnostic Division Fluorescence Polarisation Immunoassay kits were used to analyse the urine for cannabis (THC [delta-9-tetrahydrocannabinol]), cocaine (benzoylecgonine) and opiate metabolites. Blood samples were analysed for methaqualone using a solid phase extraction technique and High Performance Liquid Chromatography (developed by the Department of Pharmacology, University of Cape Town).

Provisional Results

A total of 254 patients were included in the study. Of these 61 had been injured in a traffic-related collision - 43.1% of whom were pedestrians.

With regard to their alcohol usage before the collision, pedestrians were very forthcoming and sometimes even volunteered information. Results similar to other studies conducted in SA were obtained, viz. 70% were found to be alcohol positive with a mean breath alcohol of 0.15 (±0.1) g/100ml. However, it was interesting to note that 50% of injured pedestrians scored 2 or more on the CAGE questionnaire indicating chronic alcohol use (Figure 5). On average these patient had consumed 6 drinks (range 1 - 15) before their collision while those who scored less than 2 on the CAGE had consumed an average of 4 drinks. The majority of pedestrians had been drinking beer or wine.

Figure 5 : Total CAGE scores in injured pedestrians



Only 5.7% of injured pedestrians acknowledged use of an illegal substance prior to their injury but 71% said that they smoke an average of 8 cigarettes per day.

Nearly 20% of injured pedestrians tested positive for cannabis on the sweat test (*Drugwipe*). All cannabis smokers were also found to be alcohol positive but there was only one pedestrian who acknowledged use of both cannabis and methaqualone but this was not confirmed on the urine/blood tests. The "white pipe" combination was therefore once again found almost exclusively in the violence subgroup (Table V).

Table 5 : Substance use among injured pedestrians, drivers and interpersonal violence patients

	PEDESTRIANS (n=31)	**DRIVERS (n=16)**	**VIOLENCE (n=138)**
Acute Alcohol intoxication			
% BrAC positive	71.0%	40.0%	70.0%
Mean BrAC	0.15 g/100ml	0.10 g/100ml	0.12 g/100ml
Chronic Alcohol use			
% CAGE 2+	50.0%	12.5%	30.0%
Substance abuse			
% cigarette smokers	71.0%	55.6%	75.0%
% cannabis positive	19.2%	28.6%	35.3%
% cocaine positive	0	0	3.4%
% opiate positive	15.4%	14.3%	12.5%
% "White pipe*" positive	0#	0	7.9%

* White pipe = cannabis + methaqualone # one patient acknowledge use

There were no cocaine users among the pedestrians. 15.4% of injured pedestrians tested positive for opiates but it is possible that these results were due to the therapeutic intravenous administration of morphine in the prehospital phase or immediately on arrival in the trauma unit.

DISCUSSION

A number of studies in South Africa have now shown that there is a particularly high alcohol-relatedness in both fatally and non-fatally injured pedestrians and that exceptionally high alcohol levels are the rule rather than the exception. In fact, the alcohol levels found are considerably higher than those found in developed countries such as the USA (Kliger and Sporty, 1993; Rivara et al., 1989; Soderstrom et al, 1988) and the UK (Atkins, 1988; Bradbury, 1991; Irwin et al., 1983) but are thought to be similar to those found in other African countries although reliable comparative data is scarce (Zwi et al., 1996).

Provisional results from the TAD study seem to indicate that alcohol remains the most abused substance in Cape Town, but that a relatively large proportion of pedestrians had also consumed cannabis prior to their collision. Other street drugs such as cocaine and opiates do not appear to be a problem in this cohort of patients probably because of the cost of these drugs. The "white pipe", i.e. combination of cannabis and methaqualone, although smoked by a number of pedestrians, appears to be more of a problem among patients admitted as a result of interpersonal violence (Foster et al., unpublished). However, it was interesting to note was that there were a number of patients who had consumed methaqualone on its own. This is not common practice in South Africa but appears to be an emerging problem.

The South African studies reviewed appear to validate research done in a number of other countries which suggest that there is an increased risk of injury and death in cannabis smokers (Hadorn, 1997; Sidney et al., 1997) although this may be because cannabis use is strongly associated with alcohol use which is known to be a major risk factor for traumatic death (Cimbura et al., 1990; Soderstrom et al., 1988; Rivara et al., 1989).

According to Rostenberg (1995) the presence of alcohol in injured patients should be a 'red flag' for the presence of other drugs and further investigations should be undertaken. But there are a number of difficulties in trying to detect drug intoxication.

Firstly, the clinical manifestations of alcohol and drug intoxication are very similar. Secondly, there is no single set of test procedures that constitutes a standard drug screen and sophisticated and costly equipment is required. Also, positive results of urine drug screening may not necessarily indicate use or impairment at the time of the injury because drug metabolites may be excreted for days and even weeks after use (Rostenberg, 1995). And lastly, the extent of impairment attributable to drugs is uncertain because of the complex relationship between performance and drug concentrations. Furthermore, the psychological and behavioural effects of drugs such as cannabis often only manifest once the blood concentration of the principal psychoactive constituent has peaked and is returning to normal.

The Drugwipes used in the TAD study were found to correlate reasonably well with more conventional methods of testing for cannabis usage. Using a Drugwipe on all injured patients could therefore at least overcome the first two obstacles mentioned above since they are quick, cheap and easy to use, do not require clinical experience and the sweat results may be more indicative of recent usage (and therefore possible injury causation) than urine assays. In a country where cost containment is a priority, but drug trends are essential, these kits may provide a valid alternative to doing expensive toxicology screening on all injured patients.

Of less importance, but disturbing, was the high proportion of injured pedestrians who were habitual cigarette smokers. Although this habit may not in itself be a risk factor for pedestrian collisions, it may indicate a "risk-taking" personality and therefore every effort should be made to discourage the youth of our country from taking up the habit.

The SA studies reviewed show that substance abuse and pedestrian collisions go "hand-in-hand". Therefore aggressive efforts which address the alcohol and drug abuse problem in target populations in South Africa could do much to reduce the incidence of pedestrian collisions in our country. Efforts aimed at eliminating environments which foster substance abuse and educating communities with regard to risk-taking behaviours are whole-heartedly supported. Also, drug screening of patients seen in Accident and Emergency units as well as routine toxicology screening on all cases requiring medico-legal autopsies is called for. These routine surveillance methods could assist in monitoring the longitudinal trends of substance abuse and pedestrian collisions as well as the impact of prevention programmes.

CONCLUSION

These data confirm that there is a very high proportion of pedestrians who have consumed alcohol prior to their collision and that the majority of these pedestrians also have high BAC levels. It furthermore shows that there are significant numbers of pedestrians who have taken an illicit drug, usually cannabis and/or methaqualone, prior to their collision. Since the hallmark of South Africa's disturbingly high traffic injury rate is the high pedestrian component, the present focus on the motorist (drunken driving) and the road (engineering measures) will do little to solve our overall problem. Concerted efforts to address risk factors relating to the pedestrian him/herself are strongly called for.

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CHAPTER 3

SUCCESSFUL LEGISLATIVE AND MOTIVATIONAL INTERVENTIONS

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The papers in this chapter present methods with some evidence of success in reducing risky behavior.

Allan Williams, in "Graduated Licensing and Other Approaches to Controlling Young Driver Risk Taking," discusses measures to reduce risk taking by beginning teenage drivers. He reviews the origins of risky driving in teenagers' developmental and lifestyle characteristics. He discusses how graduated licensing systems phase in driving through controlled exposure to progressively more difficult driving situations. He summarizes the provisions of graduated licensing systems in different jurisdictions and presents evidence of their effectiveness. Wang Zheng-guo's discussion describes how drivers are licensed in China.

Edward Ogden's "Safer Because We Chose to Be: Engineering Perceptions of Risk and Safety in Victoria, Australia" describes the state of Victoria's comprehensive program for changing driver behavior. The program includes strong legislation such as substantial penalties for drink driving and speeding; aggressive enforcement using techniques such as random breath testing and speed cameras; and targeted, clearly-researched, well-funded, and hard-hitting advertising campaigns. The system reduced annual traffic fatalities from 777 in 1989 to fewer than 400 by 1992. Michael Henderson's discussion notes that the adjoining Australian state of New South Wales experienced a similar traffic fatality reduction over the same time period while employing a deliberately different approach to driver behavior management than Victoria.

David Shinar's "Aggression and Frustration in Driving: Stiuational Variables and Individual Differences" postulates that aggressive driving behavior results when drivers are frustrated -- when congestion, red traffic signals, discourteous drivers, and other factors prevent the smooth, quick trip that drivers expect. He presents evidence to support these views from three studies of driver behavior at traffic lights. He concludes that the best way to reduce aggressive driving is to reduce driver frustration by improving the road environment rather than attempting to change driver behavior directly through driver education and media campaigns.

Lauren Marchetti, in "Developing Public Information Programs to Reduce Young Adult Drivers' Risky Behaviors," discusses how to communicate highway safety messages to youth. She

provides overall guidance on effective public information roles -- what it can and cannot do -- and rules -- how to do it. She discusses how effective safety belt and drinking and driving campaigns for young drivers were developed and implemented in North Carolina and gives evidence of their success in reaching their target audience and in raising safety belt use.

GRADUATED LICENSING AND OTHER APPROACHES TO CONTROLLING YOUNG DRIVER RISK TAKING

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ABSTRACT Adolescents are more likely than older people to engage in risky driving practices, and some young people are particularly prone to risky driving. Young beginners combine risky driving practices with driving inexperience, greatly heightening crash risk. The young driver problem is acute in the United States because licensure is allowed at very young ages, and the path to full driving privileges is quick and easy.

Risky driving is tied to developmental and lifestyle factors and is difficult to change. The traditional approaches of driver education and penalty-based licensing systems have not worked adequately. Graduated licensing systems now are being considered by many states and have been adopted by some. These systems do not address risk factors directly but are structured to provide beginners the opportunity to gain initial on-road experience outside of situations that have more driving difficulty and therefore more risk and/or that encourage risk taking. Graduates are older and on their way to maturing out of risky driving tendencies, and they will have accumulated important driving experience under protected conditions.

The initial graduated systems adopted in the United States vary substantially in their features. It will be important to evaluate the effect of these systems in reducing young driver crashes and to determine which set of provisions is optimal in terms of both acceptability and effectiveness.

INTRODUCTION

The overinvolvement of young drivers in motor vehicle crashes has been recognized for decades as a major health problem. Crash rates for teenage drivers are particularly elevated. Illustrative data on police-reported crashes in the United States are presented in Table 1. Teenagers as a group have higher crash rates than any other age group whether rates are based on mileage, licensed drivers, or total population of that age. However, there are wide differences within the 16-19-year-old age group, and 16 year-olds stand out.

Table 1.
Driver Crash Involvement*
by Driver Age

Age	Per Million Miles 1990**	Per 1,000 License Holders 1995	Per 1,000 Population 1995
16	43	213	92
17	30	163	101
18	16	152	110
19	14	128	96
16-19	20	158	100
20-24	10	103	89
25-29	6	75	75
30-34	5	65	60
35-39	4	60	56
40-44	4	54	51
45-49	4	50	48
50-54	4	46	43
55-59	4	40	37
60-64	4	37	33
65-69	7	33	28
70+	10	34	24
All ages	6	63	55

*Based on the General Estimates System, a probability sample of police reported crashes in the United States.

**Mileage data are from the Nationwide Personal Transportation Survey. The most recent available
data are for 1990.

In terms of crashes per mile driven -- the best available measure of crash risk -- 16 year-olds have the highest rate, followed by 17 year-olds. Sixteen year-olds also have the highest crash rate per licensed driver, even though the average annual miles driven by 16 year-olds (4,405 in 1990) was slightly less than that of 17 year-olds (5,383) and substantially less than miles driven by 18 (9,033) and 19 year-olds (9,016). On a per capita basis, 18 year-olds have the highest crash rate and 16 year-olds have the lowest, primarily because fewer than half are licensed. Despite this lower licensure rate of 16 year-olds and their lower average annual miles driven relative to older drivers, the crash rate per 16-year-old population is extremely high.

The young driver problem is common to all industrialized countries, not just the United States. However, the problem is exaggerated in the United States primarily because the driving process begins earlier than in many other countries. Sixteen year-olds, and in some cases 15 year-olds, typically are allowed access to licenses.

RISKY DRIVING PRACTICES

One central feature of young drivers' elevated crash involvement is a driving style that heightens the likelihood of a motor vehicle crash. Risky driving, along with driving inexperience, are considered the

two major contributors to the overinvolvement of young drivers in crashes. On average, young drivers are more likely than older drivers to drive too fast, follow too closely, overtake in a risky manner, allow too little time to merge, violate traffic controls, and fail to yield to pedestrians (Bergeron, 1991; Romanowicz and Gebers, 1990; Jonah, 1986; Saibel et al., 1995). The crashes of young drivers are more likely than those of older drivers to be speed related and involve driving errors often associated with risk behavior (Williams et al., 1996).

ORIGINS OF RISKY DRIVING

Risky driving practices among youth are related to adolescent development. In Jessor's (1987) problem behavior theory, risky driving and other behaviors such as excessive alcohol use are viewed as aspects of a larger adolescent lifestyle. The trend during this period is away from parental authority and toward independence. From this perspective, risky driving can be a way of achieving goals that are functional and purposeful, for example, expressing opposition to societal values, establishing a sense of personal identity, affirming independence from parents, and gaining status among peers.

Other normative developmental features of adolescence contributing to behavior such as risky driving include sensation seeking and adolescent egocentrism (see Arnett, 1992). Sensation seeking is an aspect of personality involving thrill and adventure seeking, disinhibition, aversion to repetition and routine, and pursuit of a nonconforming way of life (Zuckerman, 1979). Sensation seeking and risky or reckless behavior of various kinds, including risky driving, are strongly related (McClelland et al. 1972; Beirness and Simpson, 1988; Wilson, 1991; McMillen et al., 1989). The highest scores on the Zuckerman (1978) sensation seeking scale are achieved by 16 year-olds, and there is a steady decline with age.

Adolescent egocentrism, a concept formulated by Elkind (1968, 1985), is a cognitive stage that includes the belief by young people that there is something unique and unparalleled about their lives. This belief can lead to the view that they are invulnerable to consequences of risky driving; others may suffer negative consequences, but they themselves are exempt. This phenomenon is illustrated by a study in which young drivers were found to estimate their likelihood of being in crashes as lower than that of their peers and of older drivers, whereas older drivers thought their crash risk was comparable with that of their peers (Finn and Bragg, 1986). This belief in personal uniqueness supports risky driving.

PROBLEM BEHAVIOR THEORY

Jessor's (1987) problem behavior theory has spawned several studies of risky driving among adolescents (e.g., Wilson and Jonah, 1988; Beirness and Simpson, 1988; Jonah, 1990). Most are cross-sectional studies of adolescent populations, indicating that variables from three systems of psychosocial influence -- personality, perceived environment, and behavior -- relate to risky driving. Variables from these systems produce a psychosocial proneness away from conventionality and toward problem behavior including an inclination to engage in risky driving behavior. For example, self-reported risky driving practices are associated with higher value on independence, lower value on achievement, greater alienation, and less religiosity (personality system). In the environmental sector, risky driving is associated with lower parental support and controls, greater influence of friends relative to parents, and more friends as models for problem behavior. Risky driving also is associated with other problem behaviors such as smoking, marijuana use, excess alcohol use, and delinquent acts. As Jessor notes, the correlation of risky driving with other problem behaviors "suggests that it is part of a larger syndrome of problem behavior, that is, part of a more general lifestyle that transcends the specificity of the driving situation" (p.10).

Although there is a subgroup of adolescents most likely to display risky driving and other problem behaviors, attitudes and motivations related to these behaviors are prevalent among adolescents in general. Risky behavior can serve a variety of functions central to adolescent development. The behaviors are "problem" behaviors in that they depart from legal or social norms and can be health compromising. However, as Jessor (1987) notes, "In considering this variety of adolescent problem behaviors, it is important to re-emphasize that they are functional, meaningful, purposeful, and instrumental, rather than being arbitrary, pathological, or merely perverse" (p.4). Arnett (1992) describes reckless behavior as "virtually a normative characteristic of adolescent development," and its prevalence during this life stage "calls into question the common assumption that it necessarily arises from pathological personal characteristics or from pathogenic socialization practices or that reckless behavior is always deviant behavior for adolescents. Because reckless behavior is so pervasive among adolescents, other explanations are called for that explain it in terms of factors that are features of adolescence as a developmental stage" (p.344).

THE MATURATION PROCESS

The decline in risky driving practices that comes with age is one of the main factors contributing to the steep reduction in crash involvement rates that occurs over a span of just a few years. Young people "mature out" of risky driving, and conditions that promote and support risky driving lessen with increasing age. As Jessor (1997) notes, there is "a developmental process that involves the adoption of more conventional attitudes, values, beliefs, and behaviors with the approach to and entry into young adulthood" (p.14). As young people get married and take jobs, there are more restrictions and responsibilities. The decline in sensation seeking is in part biologically based, and there is an age - associated increase in cognitive maturity that decreases notions of personal invulnerability. Reasons for the decline in risky driving are not fully understood, but these are contributing factors.

THE ROLE OF EXPERIENCE

Inexperience is the other main factor contributing to the high crash rate of young drivers. Research studies have indicated that inexperience and factors related to youthful age contribute about equally to the young driver problem (Mayhew and Simpson, 1990). However, inexperience may be more of a factor among young drivers when licensing is not allowed until age 17 or 18, as in Europe. For example, in an international review of research literature on age and experience, Gregersen and Bjurulf (1996) note the importance of both factors but conclude "experience is of greater importance than age, at least from 17 years of age. The studies showing that age is more important are often American and include drivers of younger ages" (p.23).

Inexperience renders young drivers less able than more experienced ones to cope with hazardous situations. Inexperienced drivers have less developed search and scan abilities, are less able to detect imminent hazards, and are more likely to perceive hazardous situations as less dangerous than they really are (Matthews and Moran, 1986; Quimby and Watts, 1981; Groeger and Brown, 1989; Brown and Groeger, 1988). It is more difficult for inexperienced drivers to monitor their driving environment and take appropriate actions; yet young beginners also overestimate their capabilities. Inexperience and risk taking interact: Risky driving can get young drivers into crash-threatening situations, while inexperience hinders their ability to cope with these situations.

Driving inexperience can contribute directly to risky driving practices. That is, driving behavior that is objectively risky is not necessarily motivated by thrill seeking or deliberate risk taking. Rather, drivers may be unaware or unappreciative of the potential consequences of their actions. Some have argued that

what appears to be risk taking is primarily a reflection of inexperience in terms of car placement, speed adjustment, etc. According to MacDonald (1994), "it needs to be recognized that behavior such as excessive speeding or following too closely, which are objectively risky, might be due at least in part to a failure to identify all the potential hazards and associated risks of such behavior. From this point of view, the behavior might be due not so much to deliberate risk taking or risk acceptance, as to lack of skill in hazard perception and cognition" (p. 26). McKnight (1997) has argued that for young beginning drivers, the primary source of the problem is not risk taking motivated by thrill seeking but failure to perceive and respond appropriately to the degree of risk presented by the environment.

Although risk taking as thrill seeking behavior clearly is a factor in many young driver crashes (see Williams et al., 1997), not all risky driving by young people occurs because of their desire for risk or thrills. It is also important to note that many crashes said to be caused by risky driving -- whatever its motivation -- would not have happened if the drivers had been more experienced (e.g., going too fast around a curve and then overcorrecting).

MODIFYING RISKY DRIVING

What can be done to curb risky driving behavior? In considering this question, it should be recognized that both developmental and lifestyle factors produce and shape this behavior. And risky driving serves important functions for young people, who are rewarded through feelings of power, esteem and independence, peer recognition, and the satisfaction that comes from mastering risk (Simpson, 1996).

Since developmental and lifestyle factors clearly influence how young people choose to drive, attempts to alter risky driving behavior logically should address these factors rather than focus solely on the risky behavior itself. Noting the dramatic decline in crash risk occurring as drivers move into their 20s, Simpson (1996) points out, "The challenge is to identify what the key psychological factors are that give rise to the lower risk and attempt to instill them earlier ... If the appropriate developmental factors that lead to a diminution in risk can be identified, there might be ways to build these in to accelerate the process" (p.8).

However, modifying lifestyle and developmental factors to reduce risk behaviors is not an easy task. Lifestyle variables are shaped by many social forces including parental and peer influences, and they are not easy to affect through interventions, especially those involving contacts of brief duration. As Beirness (1996) notes, "given that lifestyle choices made up to the point of licensing will undoubtedly continue to influence the way young people drive, attempts to superimpose 'safe driving' behavior on a well-established pattern of behavior that is dominated by a more pervasive high-risk lifestyle may have limited impact" (p.76).

Because risky driving is strongly associated with other behaviors that put young people at risk, it is instructive to examine how modification of these other behaviors has been approached. Some sophisticated programs in high schools have addressed non-driving risk behaviors based on social learning and communication theory principles, but the results have been disappointing overall. Programs using techniques such as social skills/peer pressure resistance, refusal assertion training, decision making training, etc., typically have had little success in reducing the use of tobacco, alcohol, or drugs other than alcohol. Occasional successes have been short-term, dissipating after a few months (e.g., Ellickson et al., 1993; Dielman et al., 1989; Hansen et al., 1988; Baer et al., 1997).

Programs enjoying greater success typically have been multifaceted ones of longer duration (see Shope, 1996). For example, a recent three-year program for young adolescents consisting of social-behavior curricula in schools, peer leadership, parental involvement/education, and community-wide task force

activities was found to be associated with lower self-reported alcohol use (Perry et al., 1996). However, the program did not work for one key target group -- those who had used alcohol before the program. It is a problem for intervention programs in the health area that the people most likely to display the risk behavior -- the group one most wants to influence -- have traits, values, and peer associations that make them a very difficult group to reach.

THE ROLE OF DRIVER EDUCATION

In the motor vehicle area, driver education programs have had the dual role of teaching people how to drive and teaching them to apply safe driving practices (i.e., be a careful, risk-averse driver). These goals are addressed through a combination of classroom instruction and on-road training. There is evidence that formal driver education can be a superior way to learn how to drive, but the goal of reduced crash involvement through driver education has not been met. A recent comprehensive review of driver education evaluations concluded, "Studies in the United States, Sweden and Australia suggest that driver education produces no beneficial advantage in reducing collisions compared to informal training" (Mayhew and Simpson, 1996, p.ix).

Many contemporary driver education courses include minimal on-road training. However, an enhanced program involving more extensive driving practice (the DeKalb study) was found to improve driving skills. Students who participated in the "safe performance curriculum" performed better on the Southern California on-road performance test than those in a control group or a minimum-training group (Stock et al., 1983), although this did not translate to reduced crash involvement.

The goal of reducing the crashes of young, beginning drivers via traditional driver education programs is laudable but not very realistic. The courses are of short duration, and safety messages taught can readily be overwhelmed by ongoing parental, peer, and other social influences. Moreover, in the time typically available, it is only possible to teach beginners basic vehicle handling skills; there is less opportunity to try to teach safe driving skills (National Highway Traffic Safety Administration, 1994). The audience for high school driver education courses also may be relatively unmotivated regarding safety; the primary motivation may simply be learning enough to get a driver's license.

Probably the biggest impediment to driver education effectiveness involves the inherent difficulties in affecting lifestyle and developmental factors: the attitudes, motivations, peer influences, and cognitive and decision making skills that are so influential in shaping driving styles and crash involvement. In this context, it is of interest that males in the DeKalb study who had the highest scores on the driving test were most likely to be in subsequent crashes (Stock et al., 1983).

There are other instances where young drivers with superior skills have higher crash rates. Among young males, courses that teach skid control, off-road recovery, and other emergency maneuvers have produced drivers with higher crash rates than among comparable drivers not taking these courses (Glad, 1988; Jones, 1993; Katila et al., 1995). It is not clear why this happens -- whether the courses produce overconfidence and/or whether young people create extra opportunities to try out the advanced maneuvers. However, it is a case where skills have been learned through driver education but have interacted with developmental and lifestyle factors typical of young people (e.g., sensation seeking, invulnerability feelings, desire to impress peers) to produce unintended results.

TRADITIONAL U.S. LICENSING PRACTICES

The young driver problem is exacerbated in the United States not only because of the relatively young

licensing ages that prevail but because in many states licenses can be obtained easily and quickly. For example, prior to 1996 most states made learner's permits available, but only 30 states actually required them. Of the states requiring permits, only 11 had mandatory minimum holding periods, and these were generally of short duration, ranging from 14 to 90 days (Williams et al., 1996). Newly licensed young drivers in most states have had full privileges in terms of where, when, and with whom they may drive. Thus, there has been a tradition of allowing full driving privileges to very young and inexperienced people, with consequently high crash involvement.

GRADUATED LICENSING

States now are turning to a system called graduated licensing. In traditional U.S. licensing systems, the control of risk taking has been attempted largely through penalty systems. That is, prior to age 18 -- the legal age of adulthood in the United States -- drivers may be subject to penalties applied on the basis of fewer violations than would be the case for adults, and the penalties may be more severe. In some cases, this applies only for alcohol or other drug violations; in other cases, for all traffic violations. These probationary systems are designed to provide early identification of problem drivers (i.e., to control those whose unsafe actions associated with risky driving come to the attention of the police). Evaluations of probationary systems have found them to have modest positive effects (Mayhew and Simpson, 1990).

Aggressive penalty-based licensing systems are one way to try to control risky driving among adolescents. However, the trend now is toward systems that phase in driving privileges over time. These systems attempt to control exposure to risky driving circumstances as both experience and maturity are gained. That is, risky driving actions themselves are not targeted. Rather, the attempt is to minimize driving by young beginners under conditions that foster risky driving practices or that are more difficult and therefore involve more risk.

Graduated systems directly address the experience issue, phasing in full-privilege driving by controlling exposure to progressively more difficult driving experiences. This allows for the accumulation of lower risk, on-road driving experience. The maturity issue also is addressed indirectly because lengthening the licensing process increases the age at which young people obtain full-privilege licenses, so they are on their way to maturing out of risky driving tendencies.

PROVISIONS OF GRADUATED SYSTEMS

Graduated systems include two stages prior to full privilege licensure. There is a required learner's period, typically 6-12 months, with driving allowed under adult supervision. Upon passing a driving test, there is an initial intermediate license period of 1-2 years with driving restrictions. Late-night driving typically is prohibited except under adult supervision or for essential driving such as to and from work. Other restrictions have prohibited driving on high-speed roads, banned other teenagers without an adult in the vehicle, and banned any driving after drinking (zero blood alcohol concentration threshold). It is not clear that driving on high-speed roads, compared with other roads, heightens crash risk for young beginners. However, about two-thirds of the fatal crash involvements of 15-year-old learners driving under supervision on U.S. roads take place on high-speed roads (Williams et al., 1997). Banning travel on high-speed roads while drivers are learning vehicle handling skills would provide protection from serious injuries.

Nighttime driving and travel with other teenagers are major risk factors for young drivers (Williams and Preusser, *in press*; Preusser et al., 1997). The driving task is more difficult when it is dark, and high-risk driving incidents, whether or not associated with alcohol use, are most likely to occur late at night

(Farrow, 1987). Transporting other teenagers is a risk factor both daytime and nighttime (Preusser et al., 1997). Other teenagers in the vehicle may distract the driver or induce risk taking, and drivers may want to show off for their friends.

Alcohol is a risk factor for all drivers, more so for young people who are beginners at driving, drinking, and combining these two activities (Zador, 1991). A zero blood alcohol concentration is not a licensing system element, but it is an important feature of a program to control the risks of young drivers.

Graduation to full-privilege driving typically is contingent on remaining violation-free during the first two stages, which can provide important motivation to curb risky driving practices.

A few states have had elements of graduated systems such as night driving curfews for many years. Curfews have been established as extremely effective in reducing crashes (Williams and Preusser, in press). However, prior to 1995, no state had a bona fide graduated licensing system, although some states had systems with features making them more effective than others in controlling young driver crashes (see Williams, in press).

THE EMERGENCE OF GRADUATED LICENSING

The concept of graduated licensing originated in the United States in the early 1970s, and a model system was developed by the National Highway Traffic Safety Administration in the mid-70s (Teknekron, 1977). Two states -- Maryland and California -- subsequently adopted systems with some of the exposure control features of graduated licensing, and these systems were successful in reducing crashes (McKnight et al., 1983; Hagge and Marsh, 1988). However, the trend to full-fledged multistage graduated systems began in New Zealand in 1987, followed by Victoria, Australia in 1990, and the Canadian provinces of Ontario and Nova Scotia in 1994. In 1996, six U.S. states enacted learner's permit holding periods of six months duration. Two of these states added the second stage of a graduated system, instituting night curfews for initial license holders. In 1997, six additional states have enacted multistage systems. Selected features of the eight states that enacted multistage licensing systems in 1996 and 1997 are shown in Table 2. Although all of these systems have the two stages of a graduated system, they vary substantially in ways that may relate to their effectiveness, and some have additional features to supplement the limits on high-risk driving. It will be important to evaluate the effectiveness of these initial systems in reducing crashes and to determine which set of provisions is optimal in terms of both acceptability and effectiveness.

Table 2

Selected Characteristics of U.S. Graduated Licensing Systems

	Learner's Phase		Intermediate License		Full License	Eff.
State	Min. Age	Criteria	Min. Age	Criteria	(min. age)	Date
California	15, 6 mo.	Practice at least 6 mo. Parents must certify 50 hours training	16	Midnight–5 a.m. curfew Minimum period 12 mo. For the first 6 mo., no passengers younger than age 20 unless family members	17	7/98
Florida	15	Practice at least 6 mo.	16	11 p.m.–6 a.m. curfew for 16 year-olds; 1 a.m.–5 a.m. curfew for 17 year-olds	18	7/96
Georgia	15	Practice at least 12 mo.	16	1 a.m.–5 a.m. curfew Minimum period 12 mo. No more than 3 passengers younger than age 21 unless family members	18	1/98
Illinois	15	Practice at least 3 mo.	16	11 p.m.–6 a.m. curfew M–Th; Midnight–6 a.m. curfew F–Su No minimum period (must hold until age 17)	17	1/98
Louisiana	15	Practice 3 mo.	16	11 p.m.–5 a.m. curfew Minimum period 12 mo.	17	1/98
Michigan	14, 9 mo.	Practice at least 6 mo. Must have completed segment one driver education to enter learner's phase Parents must certify 50 hours training	16	Midnight–5 a.m. curfew Minimum period 6 mo. Must have completed segment two driver education to obtain intermediate license	17	4/97
New Hampshire	16	Practice at least 3 mo.	16, 3 mo.	1 a.m.–5. a.m. curfew No minimum period (must hold until age 18)	18	1/98
North Carolina	15	Practice at least 12 mo.	16	9 p.m.–5 a.m. curfew Minimum period 6 mo.	16½	12/97

The starting ages in the six U.S. systems vary from 14 years and 9 months to 16 years. Minimum time periods for the learner's stage range from 3 to 12 months. All the systems have night driving curfews, but the starting times vary from 9 p.m. to 1 a.m. Two systems (California and Georgia) include restrictions on

transporting teenage friends. Some of the systems allow graduation to full-privilege driving prior to age 18 (Michigan, North Carolina, Louisiana, Illinois); the others keep people in the system until age 18.

Graduated licensing systems outside the United States apply to beginners of older ages (all beginners in Canada, up to age 25 in New Zealand), whereas U.S. license applicants age 18 or older do not have to go through the graduated system. Beginners who have started but not yet completed graduated licensing by age 18 are immediately exempt from further requirements. From a public health standpoint this is not optimal. However, this still allows coverage of the highest risk ages 16 and 17, and it is important that U.S. systems be structured so that graduation prior to age 18 cannot be accomplished (Williams, 1996).

The differences in age requirements in U.S. systems can have an important effect on the motivation of young people to curb risky driving. Under graduated systems, the accumulation of traffic violations typically results in the lengthening of restricted periods. In Nova Scotia, for example, violations incurred in the two-year intermediate license stage start the clock over so that such drivers who entered the system at age 16 could remain under the 10 p.m. curfew restriction well beyond age 18. This can provide strong motivation for low-risk driving.

In the United States, systems that allow graduation prior to age 18 are not preferred but they do motivate beginners to be free of the restrictions without delay as in North Carolina, for example, where it is possible to get a full- privilege license at age 16-1/2 unless moving violations or seat belt infractions are incurred. However, where night curfew restrictions apply to all 16 and 17 year-olds (Florida) or apply until age 18 (e.g., New Hampshire), there are no system-based incentives to curb risky driving so that the night curfew restriction no longer applies; the restriction automatically expires at age 18. It should be noted, however, that other motivations for low-risk driving still exist because traffic violations can result in significant penalties such as license suspension.

EFFECTIVENESS OF GRADUATED SYSTEMS

There is limited information about the effectiveness of graduating licensing in reducing crashes. New Zealand's system is the only one that has existed long enough to be fully assessed. There have been some technical difficulties in evaluating this system, but the reduction in injuries among 15-19 year olds is thought to be at least 7 percent (Langley et al., 1996). New Zealand's system has a 10 p.m. curfew and restrictions on transporting teenage passengers, although a full license can be obtained as early as the 16th birthday. This system is under review, and proposed changes to strengthen it are being considered (Land Transport Safety Authority, 1997).

Preliminary results from Ontario indicate a sharp drop in the number of 16 year-olds in collisions, from an average of 5,916 in 1992-93 to 2,015 in 1995, the first full year of the graduated system (Ontario Road Safety Annual Report, 1997). Prior to this system, 16 year-olds could obtain full licenses. Under graduated licensing, only learner's permits can be obtained at age 16 and must be held for 12 months or 8 months with driver education. A more complete report on the Ontario system is expected in late 1997.

The established effectiveness of night driving curfews suggests graduated systems with this element will reduce crashes. It can reasonably be expected that graduated systems will be effective by both reducing and altering driving exposure among 16-17 year olds. However, it will be important that young people do a substantial amount of driving under protected conditions during both the learner and intermediate license stages to build their experience. Something that should help in this regard are requirements in California and Michigan that parents certify that their children have completed 50 hours of on-road driving practice before they may obtain initial licenses.

It is also important that the prohibitions on high-risk driving be observed. Survey evidence from Nova Scotia, New Zealand, and U.S. curfew states indicates stated compliance is quite high (Mayhew et al., in press; Opinion Research Corporation, 1985; Frith and Perkins, 1992). In regard to night driving curfews, many young people say they do or did drive during restricted hours but not often.

DRIVER EDUCATION AND GRADUATED LICENSING

It is likely that graduated licensing will be effective with or without driver education, but the legitimate question has been raised as to whether driver education might take advantage of the features of a graduated system and add to its effectiveness. For example, Michigan has adopted a version of the two-stage system recommended by the National Highway Traffic Safety Administration (1994): an initial program to teach basic vehicle handling skills and rules of the road, and a later program to teach safe driving procedures, including perceptual and decision making skills. The rationale for this approach is that traditional driver education courses, which necessarily concentrate on basic driving skills, have little time available to try to instill safe driving skills and attitudes. Thus, it makes sense to separate these programs and concentrate on safety issues in the second stage of graduated licensing. However, Michigan's second stage course will be substantially less than originally contemplated, consisting of six hours of classroom instruction.

There are many possible paths to take in trying to strengthen driver education offerings, tying them in with graduated licensing systems. For example, Mayhew and Simpson (1996) suggest various changes to the content and delivery of driver education and ways in which graduated systems might be structured to provide motivation to practice the safe driving skills taught in driver education programs (e.g., by requiring more frequent and demanding tests prior to graduation). It is important, however, that driver education not be integrated with graduated licensing in ways not beneficial to the system. For example, graduated systems outside the United States have given time discounts for those taking driving education, which enable them to graduate to full licensure more quickly. From a safety standpoint, this practice has potential negative effects.

In trying to teach safe driving, most U.S. driver education programs have concentrated on the unwanted driving behaviors themselves and largely disregarded lifestyle and developmental influences that promote and reward risk-taking practices. Some programs outside the United States do address lifestyle factors. For example, New Zealand's "Star Driver" program, developed for secondary schools, attempts to instill responsible driving behaviors by combining practical driving skills training with self-management training based on social learning theory (Kirkwood, n.d.). This program also includes instruction in how to resist social pressures to perform damaging behaviors. It uses the commentary driving technique to assist students in developing the perceptual skills needed to recognize and respond to hazards. In addition, "Star Driver" uses a modification of a judgment training program, based on critical incident analysis, developed for light aircraft pilots. The program focuses on a key set of dangerous attitudes -- thrill seeking, impulsiveness, etc. -- and teaches students self-monitoring techniques for dealing with such attitudes. It also teaches stress management techniques.

This is a sophisticated program based on modern social influence techniques, but the experience of similar programs in other health promotion areas has been mixed. However, driver education will be a part of many graduated licensing systems, and besides being a way to guarantee that some driving experience is gained, there is opportunity to try new programs that integrate with graduated systems.

CONCLUSION

Graduated licensing is not a panacea. It is, however, a sensible and effective approach to dealing with the risk taking tendencies and driving inexperience of young beginners, protecting them and others they encounter on the roads as they gain experience and maturity.

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REQUIREMENTS FOR DRIVERS IN CHINA

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Abstract In China each person who applies for a motor vehicle driving license must have completed at least junior high school. In addition, he or she must be healthy and must be within specified age limits. For some license types, applicants must pass psychological or occupational aptitude tests to determine if they are prone to make disturbances.

AGE AND FITNESS REQUIREMENTS

1. Age

The Chinese traffic administration authorities have established the following age requirements for motor vehicle driving license applicants.

Bus and trolley bus drivers: 20-40 years old
Motor car drivers: 16-55 years old
Other motor vehicle drivers: 18-50 years old

Licenses of both professional and non-professional motor vehicle drivers must be checked each year. Originally, a driver's license would be revoked if the driver was over 60 years old. Some professional drivers could work until age 61 with the approval of the traffic administration authorities. Since 1996, drivers may work until age 70.

These age limitations avoid many diseases, especially gerontological diseases.

2. Fitness

2.1 Height Bus drivers must be taller than 155 cm and other motor vehicle drivers must be taller than 150 cm. If shorter persons were to drive, it would be easy for them to lose control of their vehicles and cause accidents.

2.2 Eyesight The eyesight of both eyes should be more than 0.7 in the International Visual Chart after any correction with eyeglasses and more than 0.4 before correction. As everybody knows, eyesight is most important for a driver, because 90% of signals or other environmental conditions are perceived through the driver's eyes. If the driver's eyesight is not qualified, the driver will not be able to discern external signals correctly which may lead to wrong judgments and traffic accidents.

2.3 Color discrimination People with red and green monochromallism (color blindness) or color weakness are definitely not permitted to obtain a driver's license because they cannot discern traffic lights, traffic signs, and colored brake lights, which may easily lead to traffic accidents. In particular, people with color weakness cannot correctly discern traffic lights against a background of different colored lights at night.

2.4 Hearing The orientation of a sound from a tuning fork must be discerned at a distance of 50 cm from both ears.

2.5 Heart, lungs, blood pressure All should be normal. The applicant will be considered to be suffering from hypertension if his or her systolic pressure is over 21.3 kPa (160 mm Hg) and the diastolic pressure is over 12.7 kPa (95 mm Hg). When the systolic pressure ranges from 18.7 kPa to 21.3 kPa (140-160 mm Hg), and the diastolic pressure varies from 12.0 kPa to 12.7 kPa (90-95 mm Hg), it will be called critical hypertension. People suffering from either hypertension or critical hypertension are not eligible to drive.

2.6 Other factors Applicants should have no physiological defects or other diseases hindering them from driving. The main physiological defects are disablement of the body, general hypoplasia, deformity, and severance of arms, legs, thumbs, or forefingers. The main diseases affecting driving are mental diseases and a history of those diseases, cerebro-spinal diseases, and chronic nervous diseases.

Some of the fitness to drive criteria mentioned above are not very definite or concrete. In practice, a basic principle is followed: all applicants without any potential or apparent physiologic defects or diseases which hinder driving are considered "healthy".

3. Psychological tests

The traffic administration has not stipulated psychological tests for driver license applicants as a routine. However, some units, such as transportation companies, have begun to try out psychological tests on applicants for jobs involving driving. Stability of attention and action, coordination ability, and judgment of speed and distance are typical of these tests.

People who are liable to cause disturbances often possess the following characteristics: frequent mistakes in receiving signals, amnesia, habitual behavior, and lack of patience and self-control. Based on foreign and domestic studies, Jin et al (1994) put forward six normal values of physiological and psychological parameters for driver license applicants and professional drivers as a testing reference (Table 1).

Table 1. The normal values of six physiological and psychological parameters of applicants and professional drivers

	Driver applicants	Professional drivers	
Items		under 40 years old	over 40 years old
1. Judgment on speed (ms)	1400-2500	1400-2600	1400-2600
2. Complex response time (ms) (No. of mis-responses)	< 1100	< 1100	< 1150
3. Operation function (No. of mis-operations)	< 4	< 4	< 4
4. Night vision (time for dark adaptation)	< 115	< 110	< 115
5. Depth perception	< 30	< 30	< 30
6. Dynamic vision	> 0.3	> 0.3	> 0.3

According to these tests about 0.1 - 1.0% of professional drivers and 8-10% of nonprofessional driver applicants should not be licensed.

In the Chinese Army, a criterion for judging the fitness of motor vehicle drivers has been tried out. It is suitable for appraising the fitness of driver license applicants between the ages of 18 and 30.

DISCUSSION

The Chinese traffic administration authorities have required each motor vehicle driver's license applicant to pass the medical examination. If an applicant has a physiological defect or a disease that would hinder driving, or a history of epilepsy or psychosis, he or she will not be licensed. In addition, applicants are required to be between 18 and 60 years old. Generally speaking, when a driver reaches age 60 his or her driver's license will be revoked. This will prevent many persons with diseases, especially some gerontological diseases, from being licensed. However, investigations from the Traffic Administration Office and Institute of Forensic Medicine have found few motor vehicle drivers caused traffic accidents because of bad health. In Chongqing city in the past several years there was only one driver who suffered from a sudden coma and was bent over the steering wheel when the car was involved in an accident. The diagnosis was acute cerebrovascular accident. Another driver caused an accident in which a passenger was killed. After careful inquire and examination it was found that this driver suffered from color weakness. Obviously an irregular medical examination was at fault. In general, emotional instability, excessive drinking, and fatigue were the more common causes of accidents.

Fitness to drive is one of the most important things for safe driving. Generally speaking, fitness to drive has been paid attention to by the Chinese traffic administration authorities. Nevertheless, some criteria for fitness to drive should be more concrete and should be applied more strictly. The

occupational aptitude tests are recommended to be tested for driver license applicants. In this way, I am sure, traffic safety will improve and traffic accidents will be reduced.

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SAFER BY CHOICE: ENGINEERING PERCEPTIONS OF RISK AND SAFETY IN VICTORIA, AUSTRALIA

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ABSTRACT Victoria, Australia has achieved remarkable results in road safety by the deliberate engineering of community awareness and attitudes. The resultant reduction of risk has been sustained through cooperation between government agencies and the community.

Thirty years ago Victoria had one of the highest rates of road fatality in the western world. A coordinated approach by all the groups involved in traffic safety has led to the state's roads becoming amongst the safest in the world. The initial programs were built on the intuition of professionals involved in road safety and enforcement, but decades of evaluation have led to the development of a carefully targeted, and measured approach. Sustained improvement has been achieved by continuing cooperation between the legislature, the police, the licencing authority, the personal injury insurer and the community. This paper describes part of the complex whole that makes up "Road Safety in Victoria".

BACKGROUND

4.5 million people live in Victoria, a small state in the south-eastern corner of Australia. With 3½ million registered vehicles and 3 million registered drivers, Victoria has one of the highest rates of vehicle ownership in the world. Widely separated communities and sprawling cities make Victorians very dependent on motor vehicles.

The first coordinated campaign for road safety was conducted by the Trauma Committee of the Royal Australian College of Surgeons in the 1960's. They forced the public to consider the human costs of transport and question why the community was so complacent about road trauma. The surgeons argued that adopting simple measures like wearing seat belts and avoiding drink-driving could save countless lives. They made road safety a political priority.

Successive Victorian Parliaments pragmatically legislated for safety:

- blood alcohol concentration 0.05%, 1965
- compulsory seat belts, 1970
- blood for alcohol from all persons over 15 years taken to hospital, 1974

- speed limit 100 kilometres per hour, 1974
- Random Breath Testing 1975

and were greeted with early success. For the next 18 years annual fatalities fell.

But in 1988, the road toll had started to rise again. Road Safety became a political priority once more. Road trauma was costing the Victorian community $Aus 1.5 billion per year. Even the most complacent people could see that expenditure on road safety would be a sound community investment.

Government formed a *State Road Safety Coordinating Council* which brought senior officers of the key agencies together. The Council was charged with responsibility for coordinating policy across all agencies, evaluating existing road safety measures, and engineering any social change necessary to achieve road safety. The initial goal was to reduce road fatalities from 777 in 1989 to 500 fatalities per year by the year 2000.

This target was achieved in just two years. Driver behaviour responded to the initiatives. The Council wanted to see permanent changes.

State Road Safety Coordinating Council Partnerships between Agencies		
Agency	Principal focus	Joint responsibilities
VicRoads (State Road Authority)	• roads • vehicles • traffic engineering • driver licences • regulation	**Information** • crashes • injuries • fatalities • trends **Research & Evaluation** • program evaluation • research priorities • program priorities **Education** • coordination • schools • public
Transport Accident Commission (Third Party Insurer)	• road user attitudes • road user behaviour	
Victoria Police	• enforcement (detection) • investigation • crash reporting	
Department of Justice	• enforcement (penalties) • protection of individual rights	

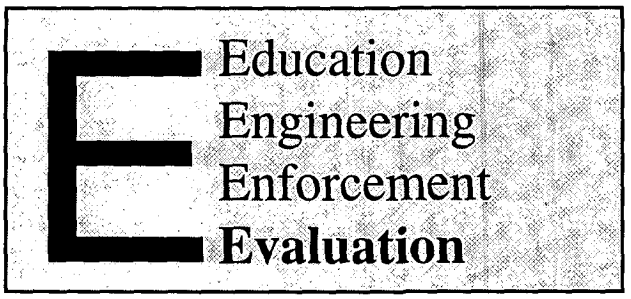
CHANGING DRIVER BEHAVIOUR

Deliberately altering the behaviour of drivers poses quite a challenge. Human behaviour on the road is a very complex phenomenon. Individual driver behaviour results from a series of conscious and unconscious judgements which reflect personal perception of risk and innate sense of responsibility. So, the quality of driving judgements is influenced both by attitudes to road safety and the value that the driver places upon it.

For many years the three pillars to improving road safety have been the "E's" - Education, Engineering and Enforcement. This traditional approach has often meant policy development based on intuition. When the community questions policy change the response has often been an authoritarian "It's for your own good!".

The community is more likely to accept change if the resultant benefits are readily apparent. Policy development based on measured outcomes allows the community to understand and own the process and analyse the costs and benefits.

It is unlikely that any Australian community would tolerate high profile enforcement using tools such as speed cameras, and random breath testing if the resultant improvements in safety were not obvious. Evaluation and feedback are integral to the process.



STRONG LEGISLATION

Strong legislation signals to the community that the matter in question is serious and is meant to be taken seriously. Weak legislation indicates that any problem that exists is not worthy of greater attention. Legislative change can send powerful messages to the community.

Successive Victorian Governments have been serious about traffic safety. Strong legislation and targeted enforcement have demonstrated this commitment. The resultant programs have often led the world in attempts to regulate for safer driving.

ENFORCEMENT

Legislation that is not enforced is useless at best, and may actually be counter productive. It may actually encourage risk taking. The police are active participants in the road safety strategy. Police are involved at all levels from the *Road Safety Coordinating Council*, through community road safety groups, development of materials for schools, to maintenance of a web site on road safety.

(Visit the Victoria Police web site at www.vicnet.net.au/vicnet/traffic.html).

Random Breath Testing

By 1965 the legislature had been convinced of the need to control drink driving. The introduction of evidential breath analysis was intended to lead to increased conviction of drinking drivers and act as an effective general deterrent.

The first evidential breath analysis instrument was the Smith and Wesson *Breathalyser 900.* Screening tests were done with *Draeger Alcotest* bags. Random testing was allowed, but was time consuming, costly, and only performed on a small scale. The aim of this program was detection and prosecution of offenders.

In 1976 the aim of Random Breath Testing (RBT) was

> "to identify and prosecute as many alcohol affected drivers as possible with a view to removing them from our roadways".

This concentration on detection showed a traditional enforcement perspective: but, it proved to be the wrong approach. National evaluation of RBT programs in 1988 revealed that the primary benefit of RBT was not the detection of the few drink drivers but the **generalised deterrent effect** on the many in wider community. RBT could create the perception "I might be caught - It could happen to me".

The 1988 study recognised that the potential of breath testing to prevent drink driving would only be realised if the program is

- highly visible;
- rigorously enforced;
- sustained; and
- well publicised.

Fuel cell technology made breath testing cheaper and quicker. The achievement of high-profile, random testing became a realistic possibility. The Victoria Police were given the mandate and resources to conduct a program that met these criteria. For example, in 1997 over 1 million random breath tests will be conducted in highly visible campaigns that include country towns, and roads of all sizes, even metropolitan freeways. The earlier "detect and punish" approach, gave way to a strategic, preventative and educational approach. The aim of breath testing shifted from traditional enforcement to general deterrence.

By 1989 the policy has become "Drink driving is socially unacceptable ..." requiring a change in police attitudes. The aim was deterrence not detection. Success was no longer shown by high conviction rates but was indicated by **low** rates of arrest. High rates of detection indicate a failure of prevention.

The 1997 Road Safety Strategy lists **drink driving** as a **principal issue** and states the objective is to **"maintain [drink driving] as socially unacceptable behaviour"**.

The Victoria Police Traffic Alcohol Section is dedicated to the task of reducing drink-driving by random testing, prosecution and education. The Section has 13 "Booze Buses" fitted out as mobile police stations that can be located anywhere, anytime. The associated advertising campaign has the slogan

"If you drink and drive, you're a bloody idiot!".

Blood Testing

Blood testing of injured drivers is an example of community cooperation on traffic safety.

The legislation was amended in 1974 so that every person aged of 15 years or older who attended for medical treatment as the result of a motor vehicle accident, was required to furnish a sample of

blood for alcohol testing. The law places an onus on the individual to provide a sample: refusal to do so carries an automatic two year cancellation of licence (which is the same penalty as driving with a blood alcohol concentration of 0.20%). At its peak, there were about 25,000 blood tests done each year, collected by emergency room doctors.

The doctors groups argued that taking blood from known passengers was pointless and time consuming. A voluntary code was negotiated to target drivers exclusively. If the doctor was satisfied (by ambulance or police personnel) that the individual they were treating was not a driver, no blood was taken, even though this was not strict compliance with the law, the police agreed. The number of tests dropped to less than half, but the number of prosecutions remained unaltered, showing that drinking drivers could be effectively identified without blanket testing. It was a significant demonstration of commitment to road safety by the health professionals. In 1995 the legislation was amended to reflect practice.

Drink Driving Penalties

A system of minimum licence disqualifications for drink driving is set out in a the act leaving reduced discretion for the courts.

If a licence is cancelled for a reading over 0.15% or for a repeat offence, the driver has to apply to the court for permission to regain a licence and demonstrate improved attitudes and drinking behaviour. Attendance at an approved drink driving education is often required.

Speed Control

Excessive speed is a risk-behaviour that is amenable to social control. When the maximum permissible highway speed was reduced in 1974 from "unrestricted" to 100 kilometres per hour (63 mph), there was an immediate reduction in fatalities and serious injuries. Monitoring of road speeds showed that a significant number of drivers (23% in 1989) ignored restrictions.

Speeding is the primary cause of 20% of fatal collisions and contributes to many others. Regardless of cause, degree of injury is directly related to speed on impact. So, in 1990 the police began the **Speed Camera Program.**

MINIMUM DISQUALIFICATION PERIODS
Road Safety Act 1986 Schedule 1

Concentration of alcohol in blood in grams Column 1 per 100 millilitres of blood	*Column 2 First offence*	*Column 3 Subsequent offence*
less than .07	6 months	12 months
.07 or more but less than .08	6 months	14 months
.08 or more but less than .09	6 months	16 months
.09 or more but less than .10	6 months	18 months
.10 or more but less than .11	10 months	20 months
.11 or more but less than .12	11 months	22 months
.12 or more but less than .13	12 months	24 months
.13 or more but less than .14	13 months	26 months
.14 or more but less than .15	14 months	28 months

MINIMUM DISQUALIFICATION PERIODS (continued)

Road Safety Act 1986 Schedule 1

Concentration of alcohol in blood in grams Column 1 per 100 millilitres of blood	*Column 2 First offence*	*Column 3 Subsequent offence*
.15 or more but less than .16	15 months	30 months
.16 or more but less than .17	16 months	32 months
.17 or more but less than .18	17 months	34 months
.18 or more but less than .19	18 months	36 months
.19 or more but less than .20	19 months	38 months
.20 or more but less than .21	20 months	40 months
.21 or more but less than .22	21 months	42 months
.22 or more but less than .23	22 months	44 months
.23 or more but less than .24	23 months	46 months
.24 or more	24 months	48 months

Speed cameras have the objective of immediately altering perception. The program had the objective of reducing the:

- absolute rate of speeding,
- mean travel speeds, and
- speed differential.

2.4 million speed checks are made each month per month. With 3 million vehicles in the state, every vehicle could be checked for speed in any six week period.

Highways and arterial roads that used to have 15 to 30% of vehicles over the speed limit now have 1 or 2 % over the limit. "Black spots", where speed-related collisions have occurred, are identified and targeted in consultation with Community Road Safety Councils.

Radio stations often broadcast the sites of speed cameras as a service to their listeners. Every time they do, they are reinforcing the deterrent message with free advertising. As all speed cameras are mobile, the broadcast is often about the previous location of the camera. This creates the perception that there are many more cameras in the community than actually exist.

The billboard campaign says "**You can speed but you can't hide".**

Current policy demands 4000 hours of speed camera operation each month. Each camera can capture up to two violations per second. Processing the film and the resultant infringements posed a significant challenge. The Victoria Police developed TIMS© - the Traffic Infringement Management System - which is capable of processing 100,000 infringements per month.

The speed camera program has brought the reality of speed violation home to all drivers. In the first eighteen months of operation, 1 million infringement notices were issued. Every Victorian driver has either had a speeding fine, or knows several people who have. Drivers with a tendency to speed have had multiple infringement notices and periods of suspension.

Automatic license suspension is linked to excessive speeds (see table) and a demerit point system operates.

MINIMUM SUSPENSION FOR EXCESSIVE SPEED
Road Safety Act 1986 Schedule 5

	Column 1 *Speed of Vehicle*	*Column 2* *Minimum Period*
1.	30 kilometres per hour or more, but not less than 40 kilometres per hour, in excess of that permitted	1 month
2.	40 kilometres per hour or more, but not less than 50 kilometres per hour, in excess of that permitted	4 months
3.	50 kilometres per hour or more in excess of that permitted.	6 months
4.	Any speed over 130 kilometres per hour or more that is not covered by items 1,2 or 3.	1 month

THE TRANSPORT ACCIDENT COMMISSION

The Transport Accident Commission (TAC) was established in 1987 to administer compulsory, universal, "no-fault" personal-injury insurance. Every car registration includes a compulsory premium (around $AUS 270 per annum) for third party injury insurance.

TAC derives the greatest direct, financial benefit from improvements in road safety. Consequently, TAC has invested heavily in accident prevention including financing the infrastructure for enforcement initiatives and associated communication and public education.

The media campaign has been unashamedly provocative in order to force a fundamental change in thinking about attitudes to drinking/driving, speed and concentration on the driving task. The aim has been to market road safety as a desirable consumer product and provoke lasting changes in attitude and behaviour.

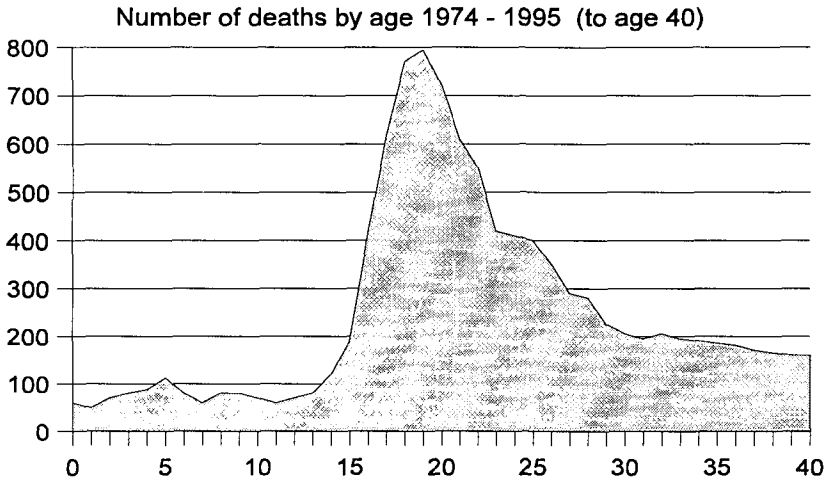
To better understand who is involved in crashes and hence accurately target prevention programs, TAC has been actively involved in research including sponsorship of the Monash University Accident Research Centre, commissioning independent projects and monitoring injury claims for significant trends.

Selling Road Safety

TAC developed advertising and public education campaigns, each aimed at specific groups or problem behaviours as identified by research. The objectives are:

- place road safety on the public agenda,
- deter unsafe behaviours,
- highlight consequences, and
- support enforcement programs.

For example, young drivers are over-represented in road trauma statistics. In their first year of driving, young Victorians are four times more likely to be involved in a fatal or serious injury crash than more experienced drivers.



A specific strategy for young people learning to drive - ***Learn and Live Youth Strategy*** - was developed. This aims of his strategy are reduction in high risk behaviours, increase in supervised driving experience before licencing and research into attitudes of young people.

Classroom materials have been developed for 12 to 16 year-olds as part of the compulsory English studies program. Advertising has been directed at parental attitudes to supervising driving experience for their kids. The television commercials use the slogan

"Your Kids Need Experience, Not Excuses".

Information reinforcing this message is sent to all learner drivers and their parents when they obtain a learner's permit.

Other advertising campaigns have had slogans like:

If you drink and drive - you're a bloody idiot!
Don't fool yourself - speed kills!
Buckle up in the back seat!
Buckle up and live!
Drive to survive!

TAC has invested more than $AUS 160 million over the past seven years. The direct actuarial saving to the insurer is calculated at more than $AUS 600 million in claims foregone. It is estimated that the community has saved a staggering $AUS 1.8 billion.

COMMUNITY PROGRAMS

There are twenty Community Road Safety Councils throughout Victoria supported with grants and research assistance by VicRoads (the licencing and traffic authority).

The Community Councils bring together local government, police, ambulance, teachers, schools, service clubs, business associations, the media and other interested groups to develop local road safety programs. These have been remarkably successful at identifying local issues and exploiting local resources to identify solutions.

Examples of successful community initiatives are:

- fitting of child restraints in taxis
- training taxi drivers in the proper restraint of children
- designated driver programs with free soft drinks at participating venues
- free checking of child restraints
- "Drinksafe" promoting light beer to regular hotel patrons
- cyclist visibility programs.

CONCLUSION

Victoria has pioneered initiatives to reduce the road toll. The underlying drive has been the unwillingness of the community to accept road fatalities as an inevitable cost of transportation. This paper has traced just some of the highlights of a campaign that has brought government agencies and community groups together in a spirit of cooperation.

Victoria's approach has been pragmatic, targeted and sustained. No longer prepared to accept deaths and injuries on the road, the community has taken messages about road safety and risk taking behaviour to every household in the state.

The end result has been a real and sustained reduction in road trauma. No single person or agency can claim credit. The community has accepted tighter enforcement, stricter penalties, and changed their risk taking behaviours, because together they chose to reduce the toll.

With commitment, any community can follow this lead.

DISCUSSION OF "SAFER BECAUSE WE CHOSE TO BE" BY DR EDWARD OGDEN

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Dr Edward Ogden has done an excellent job in describing so well the many traffic safety initiatives that have been initiated and applied in Victoria. We all recognise that in this state of Australia there has been a clear determination to innovate and strongly promote a wide variety of behavioural measures irrespective of criticism and concern. The improvements over the last 25 years in the road safety situation in Victoria have become a matter for world-wide attention and commendation.

In the case of perhaps the most important measure of all, the mandatory use of safety belts, the state pioneered this initiative in late 1970, following recommendations from the state's road safety parliamentary committee and the support of professional medical and engineering associations. Similar laws were quickly picked up in other states, and mandatory belt-use laws were Australia-wide by the end of 1972. Within five years about 20 jurisdictions worldwide had followed suit, and in 1984 the first such laws were introduced in New York State.

As Dr Ogden described, the state of Victoria has taken a similarly robust approach to the control of drinking and driving. Best known and, in the end, the most effective of these was the introduction of truly "random" breath testing for alcohol. As Dr Ogden says, the initial 1976 efforts in Victoria were disappointing, but Victoria and all other states now apply these laws in a determined manner and they now have successful application nationwide. The principles of general deterrence that they espouse have been shown to work well, and these principles are being followed in many jurisdictions outside Australia.

As Chairman of the Australian Advisory Committee on Road Trauma (AACRT), a statutory committee which advises the federal transport and health administrations, my own perspective is a national one. My task today is to put the energetic and often groundbreaking efforts of the administration in Victoria into some kind of national perspective.

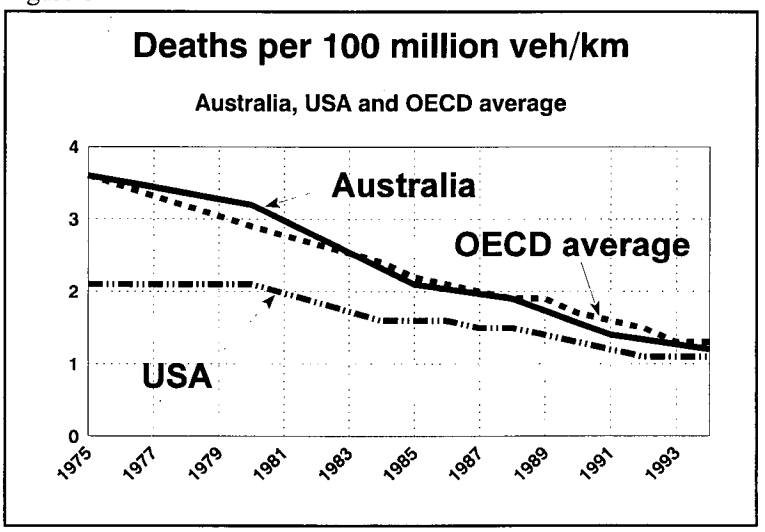
Australia has a national road safety strategy (Federal Office of Road Safety, 1992). This was developed by nearly 50 government, non-government, industry and community organisations and endorsed by all states and territories in April 1992 as a coordinated approach to reduce road trauma into the next century. From the framework presented by the strategy grew a series of national action plans (Federal Office of Road Safety, 1994a, 1996a, and 1997). Following a national conference, an associated action plan specifically directed at rural road safety was also developed (Federal Office of Road Safety, 1996b). Most components of the action plans have been implemented by most states, with activities reviewed every few months by the work of the national Road Safety Strategy Panel.

Recently, several components of the action plan have been identified for special emphasis. They include enhancement of random breath testing operations, the promotion of server intervention programs and alcohol interlock trials, strengthening of deterrent measures directed at aberrant speed and the non-use of occupant restraints, and a renewal of efforts directed at the correction of black spots and rural road and roadside safety.

Clearly, among the many components of these plans there have always been several directed at risk-taking behaviour. A recent study by the Federal Office of Road Safety has shown that throughout Australia, road safety measures have had the greatest effect on driver fatalities associated with high-risk road use (such as alcohol use, speeding and non-use of seat belts), and that the effect has been greatest among younger drivers (Wylie, 1996).

Figure 1 shows that improvements in the road death rate in Australia have approximately followed the OECD median over two decades (Federal Office of Road Safety, 1994b and 1996c). However, the OECD median is heavily influenced by the USA, and many industrialised countries - including France, Germany and Japan - have 1994 fatality rates of 1.7 to 1.9 deaths/100 million veh/km. Australia's record over the period has been good by world standards.

Figure 1



Initiatives at the national level in Australia have always placed a strong emphasis on community involvement and ownership, against a backdrop of intersectoral cooperation and local government involvement (Australian Road Research Board, 1994). Such themes have been followed with enthusiasm by all the states and territories which have also produced and are implementing their own targets, strategies and plans for action. These community initiatives have understandably placed special emphasis on unique local problems, such as high levels of alcohol use among remote and indigenous communities (Crundall, 1993).

What has made the state of Victoria unique over the last ten years or so has been its special emphasis on the social and behavioural "engineering" of which Dr Ogden has spoken. The level of funding for such programs has well exceeded that in other states and territories (Hakkert and McGann, 1996). In many other ways these programs have gone beyond what has been attempted in other administrations

in Australia. One example is that no other administration has placed such heavy emphasis, not to say resources, on highly dramatic and graphic advertising campaigns with striking emotional impact. Another example is that other administrations have taken a "softer" approach to speed control, not lowering the top speed limit from 110 km/h (68 miles per hour) to 100 km/h (62 miles per hour) as Victoria has done. No administration has so far deployed anywhere the near the numbers of speed cameras (photo radar) used in Victoria, which as Dr Ogden says result in the processing of 100,000 speed infringements per month (at a minimum penalty of over AUD$100). Victoria processes 15.7 speed offences per million vehicle kilometres travelled, compared with 8.8/MKVT in New South Wales (Hakkert and McGann, 1996).

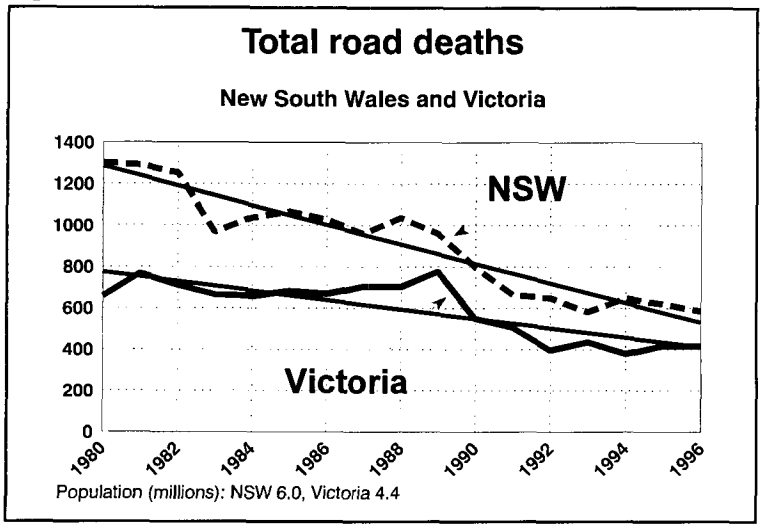
The opportunity therefore arises to attempt some basic comparisons within Australia, and to examine whether the trends in Victoria over recent years have been significantly different from those in other states. While it is inevitably difficult to separate out individual factors, it should be possible to discern some differences in trends if the measures described by Dr Ogden have had the powerful effect on driver behaviour - especially during the period 1989-1991 - that he suggests. Demographically, the state with the most similarity to Victoria is the adjoining state of New South Wales (NSW). The other state adjoining Victoria, South Australia, is too small to put much significance into trends, and the other eastern state - Queensland - has several demographic differences including substantial population changes over recent years. The population along the Victoria-NSW border is very small compared to the population of the whole of NSW, and any bleeding over of Victorian measures would not measurably affect state trends.

Figure 2 confirms that the 1989-1992 period showed a considerable drop in annual road deaths in Victoria. However, as is also shown, the drop in deaths from 1988 to 1991 in New South Wales was of the same order of magnitude, although the general approach to behaviour management was deliberately different than Victoria.

A simple examination of the annual figures shows that the drop in road deaths over the 1989-1992 period in Victoria was preceded by a figure for 1989 that was high to an aberrant degree, and could thus be just as well attributed to regression to the mean as to measures implemented that year. Further, that high 1989 figure was a reflection of an increase from 1988 in *non-occupant* deaths; annual vehicle occupant deaths, to reduce the rate of which was the prime target of the dramatic advertising, did not fall nearly so quickly in the 1989-1992 period.

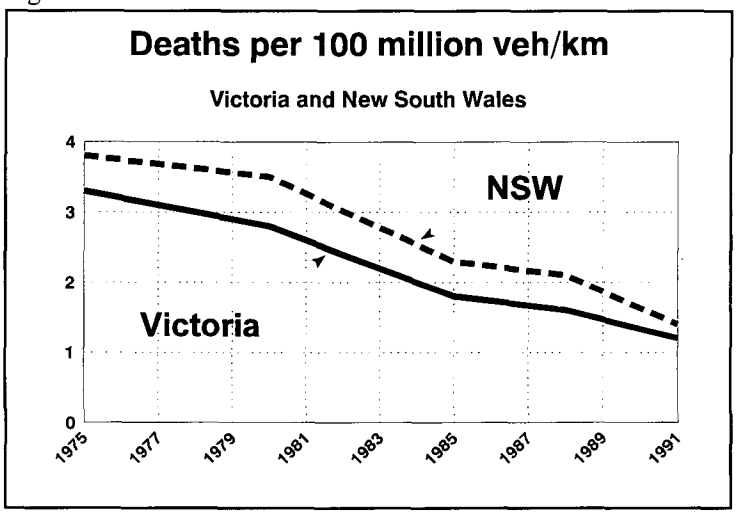
The rapid decline in deaths in the 1989-1991 period was seen in every state in Australia, and just over one-third of that decline was attributed to the effects of the recession during that time (Pettit, Haynes and Low Choy, 1992). A study in Victoria also placed emphasis on the effects of the recession, although giving it rather less weight, with reduced economic activity showing up in increased unemployment rates and lower alcohol sales (with an assumed effect on traffic deaths) (Newstead, Cameron, Gantzer and Vulcan, 1995).

Figure 2



Deaths per 100 million vehicle/kilometres, a rate that reflects exposure, shows a bigger drop in the rate for New South Wales than for Victoria through the 1988-91 period (see Figure 3).

Figure 3



Overall, both Victoria and New South Wales have shown trends over the short and long terms that are in general accord with the average progress shown throughout the OECD nations, although at a lower level than many. Traffic death rates in Victoria have *always* (since measurements were first taken, as well as now) been slightly lower than in NSW and the other Australian states. This is almost certainly for demographic reasons, primarily related to the mix of urban and rural environments, with a large concentration of the population of Victoria living in its capital city, Melbourne. Two-thirds of Australia's road deaths occur on country roads and in country towns.

There is therefore room for doubt that the unique initiatives Dr Ogden has highlighted would have general application outside Victoria, or that the aggressive approach to social engineering in that state has been significantly more successful than rather different approaches in other similar states in Australia or, indeed, generally in the OECD nations.

None of the above is to suggest that the package of behavioural countermeasures introduced in Victoria in 1988 has been ineffective. This is manifestly not so, and studies in that state have attempted to disaggregate the different measures in order to apportion what part of the continuing reduction in annual deaths can be attributed to each.[10] However, given interstate comparison, it may be a mistake to over-estimate the short-term benefits of some specific and widely publicised behavioural measures. It may also be a mistake to under-estimate the longer-term effects of the systematic, nationwide application of a national strategy and action plan that comprises a balanced mix of measures directed at human behaviour (including driver risk-taking) as well as the human/environmental interface.

Finally, I thank Dr Ogden for his stimulating paper, which has prompted us to think analytically about the successes and failures of all kinds of attempts to reduce risk-taking behaviour and the trauma it causes.

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AGGRESSION AND FRUSTRATION IN DRIVING: SITUATIONAL VARIABLES AND INDIVIDUAL DIFFERENCES

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Abstract Aggressive driving is defined in terms of the frustration-aggression model. In that context aggressive driving is a syndrome of frustration-driven behaviors that infringe on other road users' rights such as inconsideration and annoyance of other drivers, saving time at the expense of others, and unsafe behaviors purposefully directed at other drivers. While these behaviors may be reflective of individual differences in aggression, it is argued that the focus on the characteristics of the aggressive drivers and how to control them is short-sighted. Instead, this paper focuses on the contribution of situational variables that cause driver frustration. It is shown that variables like duration of the signal lights, congestion, and purpose of travel all affect behaviors such as driving through red lights and honking at drivers blocking the travel lane. Implications for the reduction of aggressive driving are discussed.

INTRODUCTION

In a study published nearly half a century ago, two Canadian psychiatrists, Tillman and Hobbs (1949), compared the non-driving background of high-crash rate drivers to that of crash-free taxi cab drivers. They found that crash involved drivers exhibited a high degree of socio-pathology as evidenced in a much greater involvement with social agencies, courts, police, jail, collection agencies, etc than crash-free drivers; and they concluded that "man drives as he lives". Although not stated in these terms, this study was a precursor to our current focus on aggressive driving and the aggressive driver. Who is he/she? Why does he/she behave that way? And what can be done about it? Thus, although "aggressive driving" is a current buzz word, the problem has been around for a long time. Its importance was already highlighted in a book "Aggression on the Road" published nearly three decades ago (Parry, 1968), and in the claim made by Whitlock in 1971 that 85 percent of all crashes in Great Britain may be due to aggression.

The term "aggressive driving" is used rather loosely by different people, and in some cases it is used synonymously with "road rage". The National Highway Traffic Safety Administration presently defines aggressive driving as "driving behavior that endangers or is likely to endanger people or property" (Martinez, 1997). The problem with such a definition is that it is too general and somewhat tautological. It is general in the sense that it encompasses just about any crash-producing

[1]I would like to thank Richard Compton, Marvin Levy, and Stanley Feldman for their comments on earlier drafts of this paper.

driver action or inaction: driving too fast or driving too slowly, falling asleep at the wheel as well as driving under the influence of a stimulant. It is also tautological because it defines the behavior (aggression) by its consequence (crash damage). For both of these reasons, it is very unlikely to lead to solutions of the problem, though it may make it easier for an officer to cite a driver.

The definition I am using here as a starting point is the one originally offered by Dollard, Doob, Mowrer, Miller, and Sears (1939) in their classic book "Frustration and Aggression". They defined aggression as a "sequence of behavior, the goal-response to which is the injury of the person toward whom it is directed" (p. 9), and postulated (and demonstrated very convincingly) that "aggression is always a consequence of frustration" (p .2). Brown and Herrnstein (1975) proposed that an element that is common to all of the aggression models (including the frustration-aggression model), is that it is instigated by "illegitimate (behavior that results in) disappointment of legitimate expectations" (p. 274). In this definition 'legitimate' is synonymous with 'fair' or 'appropriate'. This definition implies that we have norms about what is 'fair' or 'legitimate' and 'appropriate' vs what is not. Aggression is directed towards another person only when his/her behavior is considered illegitimate: unfair, contrary to the norm, or contrary to the expected behavior. Thus we may be frustrated by a forced wait at a red light, but aggression toward the driver ahead of us in the queue will result only if he or she does not move when the light turns green. Furthermore, if we are made to realize that the car ahead is in some sort of trouble, then we will consider his/her behavior legitimate and we will most likely not behave in an aggressive manner toward that driver. However, since we are still frustrated (relative to our goal to move), we may show some displaced aggression towards other drivers by passing the car ahead and running the light after it has turned red.

Already in 1939, to illustrate the frustration-aggression model, Dollard et al. used as an example the aggressive driving behaviors of a hypothetical college student who is stopped and berated by a police officer (the frustration source) in front of his girlfriend. Once he drove away, according to Dollard et al., "he grated the gears frequently in shifting, refused to let other cars pass him, and made insulting comments about every policeman who came in sight" (p. 12). The link of aggression to frustration is very important, since it implies that all aggressive behaviors are instigated by a frustrating situation, behavior or event.

In the context of highway safety, I believe that the greatest benefit of embracing the frustration-aggression model is that it can direct the search for a solution not only towards the personality of the aggressive person, but also towards the environment that breeds aggression, and consequently highlight some direction for its reduction.

For the present purpose I distinguish aggressive driving from road rage. I restrict road rage to a specific type of aggression on the part of one driver that is directed at psychological assault (e.g., rude gesture) or physical assault (e.g., shooting) of another driver or pedestrian on the road. Road rage is certainly a type of aggressive behavior as defined by Dollard et al. Fortunately it is quite rare. However, the more typical 'aggressive' behavior that we witness on the road are the frustration-driven behind-the-wheel mobility-oriented behaviors, that may endanger self and others. Unlike Dollard's et al's definition, these behaviors are not necessarily directed at assaulting the other drivers, as much as they ignore their rights. The frustrated goal that generates these behaviors is to

move quickly at a 'justifiable' or 'reasonable' speed, and the purpose of the behaviors is to make up for lost mobility/time (whether that loss is real or not). The resulting aggression toward the other drivers may be 'appropriate' (when they are the ones purposefully blocking the path) or may be essentially displaced aggression (when they are not to blame).

In summary, aggressive driving is a syndrome of frustration-driven behaviors which are manifested in (1) inconsiderateness towards or annoyance of other drivers (tailgating, flashing lights, and honking at other drivers), (2) deliberate dangerous driving to save time at the expense of others (running red lights and stop signs), and (3) unsafe driving behaviors that are purposefully directed at other drivers (obstructing path of others, weaving).

According to the above definition neither falling asleep a the wheel, nor speeding through a dangerous curve or weaving at excessive speed in the absence of traffic are manifestations of aggressive driving. The first example is obvious, but the latter is less obvious. Although the behavior is dangerous and purposeful, it is not caused by any impediments or frustrations to movement. It is most likely a reflection of a personal tendency (risk taking? Thrill seeking?). The aggressive behavior used in one of the studies reported below - driving through red lights - may also reflect habitual tendencies. This is probably the best explanation for Retting and Williams (1996) finding that red light violators are three times as likely to have previous multiple violations in comparison to non-violators. In this case, both the causes and the treatment are different than those of aggressive driving as defined here.

The scientific concern with aggressive driving is very topical and the public concern with it is much greater than ever before. In a survey conducted in England in 1995, 62 percent of the drivers queried felt that the behavior of motorists has changed for the worse "in recent years", and 88 percent stated that they had experienced at least one of the listed manifestations of road aggression (being subjected to aggressive tailgating, flashing lights, rude gestures, deliberately obstructed, verbal abuse, physical assault, and unspecified others) (Connell and Joint, 1997). In a 1996 survey conducted in the U.S., Washington D.C. area, drivers said they felt more threatened by aggressive drivers (40%) than by drunk drivers (33%) (AAA Foundation for Traffic Safety, 1997).

Summarizing the situation before a special meeting of the U.S. House of Representatives, Committee on Transportation and Infrastructure, Williams (1997) suggested that what may have worsened over the past five decades are the "conditions that encourage this behavior." Consequently, I believe that one key to the solution of aggressive driving - and the one that I want to focus on here - is to study the conditions that cause aggressive driving.

I think it is rather unfortunate that the focus of the aggressive driving issue has been almost exclusively on who are the aggressive drivers and what aggressive behaviors they display, rather than on why drivers in general are more aggressive now than before and what can be done (not necessarily to the drivers) to ameliorate the situation. In accordance with the frustration-aggression model, the driver's goal is to achieve mobility with minimum disruptions (and possibly with some pleasure). The negative feelings of frustration and aggressive behaviors that are generated when the path to this goal are blocked are most likely to be directed toward the perceived illegitimate source of the frustration, but may be generalized to other drivers.

This model of aggressive behavior does not negate the existence of individual differences in aggression, but it does highlight the contribution of the environment (in frustrating the drivers' goals) to aggressive behavior. Overt behavior is always the end product of individual tendencies in the presence of environmental catalysts. Taken together, people with a greater tendency toward aggressive behaviors (as those in Tillman and Hobbs' study) are generally more likely to exhibit aggressive driving. And when the driving environment becomes increasingly frustrating relative to mobility, and when the cultural norms seem to tolerate it, we are likely to observe aggressive driving in more and more people as their threshold of self-restraint is exceeded.

Given this approach, to reduce or eliminate aggressive driving - especially when driver surveys suggest that it characterizes the majority of the driving population - we must first identify the source of the frustration. I assume that the frustrated goals in driving are efficient mobility and pleasure. Automobile manufacturers and highway designers certainly believe these are relevant goals since they are promoted in advertisements, in the cars people buy, and in the routes people choose to drive. Yet, with more registered vehicles than licensed drivers (1.11 vehicles per drivers in the U.S.A.), and when most drivers want to use the roads at similar times, we observe how both goals are frustrated. The situational sources of the frustration are the same factors that cause congestion: blocked path of travel by other cars, red signal lights, insufficient number of lanes for the volume, and discourteous drivers.

In this paper I describe three studies that evaluated the effects of three potential situational sources of frustration in modern driving - all related to time pressure: (1) the durations of the green and red phases of traffic lights, (2) traffic congestion, and (3) hour-of-day and day-of-week as they relate to rush vs non-rush hours.

The aggressive behaviors that we studied were running red lights and horn honking at stopped vehicles that obstruct the traffic movement at signalized intersections during the green phase.

Because we know that aggressive behavior and crash-involvement varies with age and sex - men in general being more aggressive than women and younger persons being more aggressive than older persons (Dollard et al. 1939) - we also looked at the effects of age and sex of the frustrated drivers.

Gender differences in aggression and violent behavior have been studied ad-nausea. In a meta-analysis of 143 studies that examined gender differences in aggressive behavior, Hyde (1984) found that while none of the studies showed that women were more aggressive than men, and many studies showed that men are more aggressive, the gender differences explained only 5 percent of the variance, once other individual characteristics were taken into account. The discrepancy between these studies and the over-involvement of males in violent crimes is due to the fact that in most psychological studies, the situation is rigged and the aggressive behavior that is measured is rather mild. This suggests that women are less likely to exhibit extreme aggression, but possibly just as likely to exhibit more subtle aggression, and exhibit aggression in more subtle ways (e.g., the expression shoot!). In driving, aggressive behaviors span a wide range from muttering, through yelling and making obscene gestures, and all the way to violent actions with the car. Thus, it is prudent to specify the gender role in terms of concrete specific behaviors.

Hauber (1980) studied the aggressive reactions (including horn honking) of drivers to pedestrians who stepped of the curb to cross the street in non-signalized locations, and found no differences

between male and female drivers. Doob and Gross (1968) found that male drivers were quicker than female drivers to honk at vehicles stopped at the green light, but did not report differences in the likelihood of honking. Daux (1971) in his attempt to replicate Doob and Gross' findings, obtained no gender differences in the likelihood of honking at a stopped car, though drivers of both genders honked more at stopped female drivers than male drivers. Interestingly, Hauber obtained an opposite result: both male and female drivers were more aggressive towards crossing male pedestrians than towards female pedestrians. Retting and Williams (1996) did not find any differences between males and females in the likelihood of driving through red light, but Lawson (1991) reported that crash-involved red light running drivers were more likely to be males than the non-violating drivers in these collisions. In conclusion, the driving aggression studies are not conclusive with respect to the effect of gender.

The relationship between age and aggressive driving seems to be more consistent. Retting and Williams (1996) found that driving through the red light is more common among young drivers. Lawson (1991) in his analysis of red light running crashes, found that the red light violators were more likely to be under 35 years old than the non-violators. Hauber (1980) reported that younger drivers are more likely than older drivers to honk at pedestrians.

Despite the prominence of the aggressive driving issue in the media, there are still very few empirical studies that directly assessed variables that may effect aggressive driving. I will review here only the ones using the two behaviors that I studied; namely driving through red lights, and horn honking at drivers blocking traffic at signalized intersections.

A recent study on driving through red lights by Retting and Williams (1996) compared the characteristics of 462 drivers who violated the red light signal with over 900 drivers who did not violate the red light at the same intersection. They found that drivers who drove through the red light were younger, were less likely to use seat belts, and had worse driving records than the drivers who did not drive through the red light. These results are consistent with the numerous studies of crash analysis that find that young male drivers are over-involved in crashes relative to women and older men (e.g. Cerrelli, 1995; NHTSA, 1996).

Horn-honking was first used as an observable dependent measure of aggressive driving behavior in a field study published by Doob and Gross almost thirty years ago (1968). In their experimental paradigm the experimenter's car was stopped at a signalized intersection, and remained stopped when the light changed to green. They then studied the horn-honking behaviors of the drivers stopped behind the experimenter's car. They rationalized that this is a realistic situation for observing frustration-aggression, since it provides a "clearly identifiable frustrator and a fairly typical response for the blocked driver" (p. 213). Also they noted that horn-honking has both an instrumental value (since it may quicken the movement of the blocking car) and an emotional tension-reducing value (since it is an unpleasant stimulus to the driver of the blocking car).

The effects of several independent variables on horn honking have been studied by different researchers. In all of these studies the experimenter's car was stopped at a red signal. When the light changed to green a timer was started and it was stopped when either the driver behind honked the horn or 12 seconds had elapsed. Special care was taken in these studies to conduct all trials during non-rush hours. In the first study of the kind, Doobs and Gross (1968) showed that drivers more readily honked at a low-status car (old Rambler sedan) than at a high-status car (new Chrysler

Imperial). In light Sunday traffic the mean delay (for male drivers) was 6.8 seconds for the former and 8.5 seconds for the latter. Also males were quicker to honk than women by 1-2 seconds. Deaux (1971) partially replicated Doobs and Gross' findings and also showed that drivers more readily honked at female drivers than at male drivers, supporting - what they termed - the "damn female driver" stereotype. Turner, Layton, and Simons (1976), measured honking behavior on Saturdays and found a greater likelihood of honking at a blocking pickup truck when the curtain behind the driver was drawn than when it was removed, suggesting that drivers (all males) are more likely to honk when their anonymity is assured than when it is not. Finally, in the most recent study using this measure, Ellison, Govern, Petri, and Figler (1995) observed honking tendencies by drivers of convertible cars and 4X4 vehicles with the top up (providing anonymity) and with the top down (with no anonymity). They found that the time to honk was significantly shorter when the driver behind the stopped car was with the top up (6.3-6.5 seconds) than when he/she were in an open top (9.0-9.6 seconds). They did not find any differences between men and women.

In all of the above studies, care was taken to conduct the research in non-rush hours. Thus, the very common situation of congestion and (possibly) time pressure was not a factor. The effects of congestion, rush-hours, or crowding on driving behavior, to the best of my knowledge, have not been studied empirically. However there is ample evidence from social psychology and urban anthropology that crowding and congestion lead to increase in violence. The urban plight of most large cities is a testimonial to that. A related issue, that to the best of my knowledge also has not been tested directly, is that people drive more aggressively when under pressure than when they are not under pressure (though in a related study, McMurray (1971) found that people just prior to divorce have a higher crash rate than either much before or after it). In the traffic scene, time pressure, congestion, and alienation (or anonymity) are often confounded; occurring at the same times and in the same places. Thus we are probably more likely to observe some aggressive driving in crowded cities during the rush hours than in small towns during the weekends. Some direct evidence for this was obtained by Hennessy and Weisenthal (1997). In their study, drivers were queried about their mood and behaviors through cellular phones in congested and non-congested traffic. Using structured questionnaires, they found that 'state' stress (as distinguished from 'trait' stress) was much higher in high congestion than in low congestion, and aggressive behaviors (including 'swearing', 'purposeful tailgating', and 'horn-honking') were twice as frequent in the high congestion than in the low congestion.

THREE EMPIRICAL STUDIES

The purpose of the studies reported here was to investigate the behavioral effects of some common situational frustrations on aggressive driving, and determine if the effects of these situations are more pronounced on high risk drivers (young males) than low risk drivers. The first two studies were smaller in scope than the last and should be viewed as pilot studies.

Experiment I: Driving through red lights

This study used running through red lights as a measure of aggressive behavior, and tested the hypothesis that the longer the expected delay from waiting for the light to change, the more likely drivers will be to drive through the red light. Thus, it was expected that for drivers approaching the intersection as the light changes to red, the duration of the red phase will be directly related to the

drivers' likelihood of driving through the red light. In a converse manner, the longer the green phase, the less likely the driver will be to run through the red light.

Method

Subjects and locations. The subjects in the study were a convenience sample of drivers who drove through the pre-selected intersections. No data were collected on any vehicle or driver characteristics. Ten intersections in metropolitan Tel-Aviv were chosen. The speed limit in all locations was 50 km/hr The green phase durations in the 10 intersections varied from 10 seconds to 50 seconds, and the red phase durations varied from 30 to 70 seconds (in Israel, the green phase is typically protected for all turns, meaning that each leg has its own dedicated green phase. Thus in a standard four-legged intersection, with equal time for all directions, the duration of the red phase is three times as long as the green phase). Total cycle time varied from 60 to 100 seconds, and the Pearson correlation between the green and red phase was r=-0.74. All measurements were made between the rush hours of 7:00-9:00 am and 2:30-4:30 pm. This insured, that on all trials, there were cars in the cue when the traffic light changed from green, to yellow, and to red. Observations were limited to the straight-through lanes only. One hundred cycles were observed at each of the 10 intersections.

Design. The independent measures were the duration of the green and red phase and the dependent measure was the number of cars running through the red light per lane of traffic per 100 signal light cycles. For example, in a two lane intersections in 100 trials 154 cars ran through the red light. Therefore there was an average of 77 cars per lane, over 100 observations of light changes. Thus the probability of running the red light in that intersection was noted as p=0.77.

Results and Discussion

The results showed a moderate inverse monotonic relationship (Pearson r=-.41, p<.001) between the likelihood of running the red light and the duration of the green phase, and a slightly weaker direct relationship (r=.35, p<.001) between the likelihood of running the red light and the duration of the red phase. Figures 1 and 2 illustrate these relationships. These patterns suggest that when people anticipate a brief 'window of opportunity' to move ahead, they are more likely to be aggressive in order to exploit it, to the point where they feel justified in driving through the red phase. In a like manner, the idea of waiting a long time for the red light phase to end, is also sufficiently frustrating to induce many drivers to violate it. Whether the duration of the green phase is a more powerful influence than the duration of the red phase remains to be studied with more signalized intersections and more trials. It is interesting to also note the very high actual frequency of the red light violations. In their studies in multiple lane roads in suburban Washington, D.C., Retting, Williams, and Greene (1996) recorded an average of 5.6 such violations per hour!

Figure 1

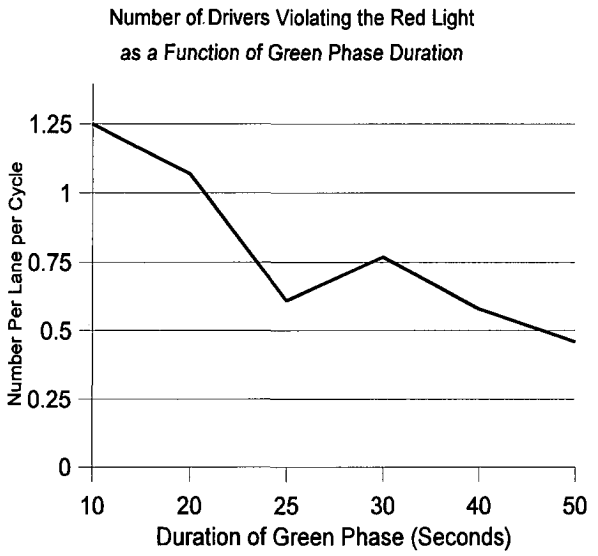
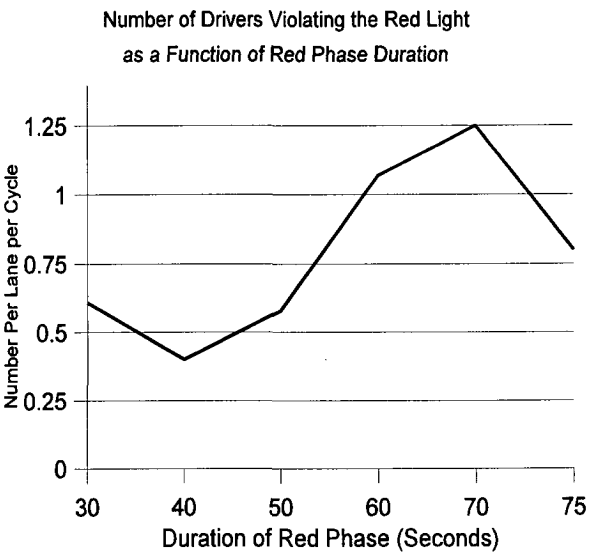


Figure 2



Experiment II: Horn honking at stopped cars at signalized intersections - a pilot.

The purpose of this study was to evaluate the effect of both situational variables (traffic signal duration, and time pressure) and individual differences (age and sex of drivers) on aggressive behavior (horn honking) when waiting behind a car that does not begin to move when the traffic signal light changes to green. The duration of the traffic signal green and red phases are directly related to the expected time delays, and were shown in the first study to affect aggressive behavior. Therefore signal duration was included as a situational variable that effects frustration level. 'Time pressure' was manipulated by the day/time of travel, assuming that driving in weekday rush-hour traffic would be more stressful and generate more aggression than weekend driving (as would be suggested by Hennessy and Wiesenthal's , 1997, findings).

Method

Procedure. The study was conducted at two signalized intersections. One with a long green phase (35.2 seconds) and one with a short green phase (9.6 seconds). The male experimenter positioned himself in the traffic stream so as to be the first car stopped at the red traffic signal, and turned his head to the right as if distracted by something on the front passenger seat. Each trial began when the signal changed to green and terminated when the driver behind the experimenter honked his/her horn. Driver horn reaction time (RT) was measured by an inconspicuous assistant who was standing on the curb, partially obscured from the sight of the following driver. The RT consisted of the lag between the onset of the green light and the onset of the horn. As soon as the driver honked, the trial ended, and the experimenter drove around the block to return to the same site. In addition to the reaction time, the assistant also noted the sex and apparent age of the honking driver. Two different compact cars were used by the experimenters, one at each site. Neither car had any bumper stickers, commercial logos, or any other messages printed on them that might have affected the attitudes of the drivers behind them.

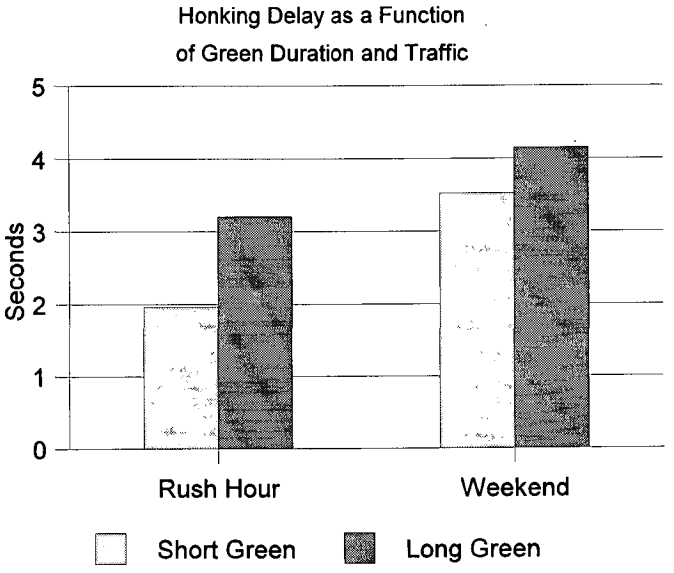
Design. Two situational independent variables were manipulated in this study:
1. Time pressure - half the data were collected on weekdays during rush hour traffic and half on Saturday traffic (in Israel Saturday is the day of rest, there is no public transportation, and with exception of places of entertainment, all businesses are closed).
2. Signal duration - short green phase (9.6 seconds) vs long green phase (35.2 seconds). With 18 observations at each Time pressure X Signal Duration combination there were a total of 72 trials. In addition to the two situational variables, the effects of age (as estimated by the assistant on the curb) and sex were also analyzed.

Results and Discussion

None of the drivers - in all 72 trials - waited for the green phase to end before honking. Consequently there was no need to provide an artificial time limit for drivers who failed to honk (as was done in the U.S. studies). An Analysis of Variance conducted on the honking delay data showed that mean honking delay was shorter at the short signal duration than at the long one [$F(1,68)=5.32$, $p<.01$], and during the weekday rush hours than on the weekend [$F(1,68)=9.44$, $p<.01$]. Yet even during the weekend hours, the honking delay times were approximately half as long as the ones obtained in the U.S. studies. This probably reflects a cultural difference. The interaction between these variables was not significant. The average honking delay times for the four conditions are presented in Figure 3.

The analysis of the individual differences showed that males were more impatient to honk than females (with an average delay of 2.89 vs 3.94 seconds, $F(1,70)=5.86$, $p<.01$), and there was a positive correlation ($r=0.25$, $p=.03$) between honking delay and age: older drivers being slightly more patient than younger drivers.

Figure 3



Experiment III: Multiple Factors that influence Honking at Intersections

Although the pattern of results from the pilot study was consistent with the hypothesis and previous research, the actual horn honking delays were much shorter than those observed in the U.S. studies. Therefore, the purpose of this study was to validate the results obtained in Experiment II on a broad range of different intersections and to extend the findings to additional variables.

Method

Procedure. The procedure was similar to that of Study II. The experimenter positioned himself in the traffic stream so as to be the first car stopped at a traffic signal. Each trial began when the signal changed to green and terminated when the driver behind the experimenter honked his/her horn. Driver horn honking time was measured by the assistant sitting next to the driver, and consisted of the lag between the onset of the green light and the onset of the horn honking. As soon as the driver honked the trial ended. However, unlike Experiment II, in this study each trial was conducted at a different intersection, and the progression from one trial to the next consisted of driving to the next signal light in the predetermined route, consisting of 15 short signals and 15 long signals. In addition to the horn honking time, the assistant also noted the sex and apparent age of the honking driver. (Because there were four different experimenter+assistant teams in the study, an adjustment for individual differences in the RT was made by measuring each assistant's simple RT on 10 trials and then adjusting each one's RT measures relative to the difference between his mean and the group mean). All four experimenter cars were compact passenger cars without any bumper stickers (that might have affected the attitudes of the drivers behind them; c.f., Turner et al., 1976).

Design. Four situational independent variables were manipulated in this study:
1. Congestion - based on measures made during work hours traffic (07:00 - 17:00 on weekdays) vs Saturday (09:00 - 18:00) traffic (in Israel, Saturday is the day of rest, there is no public transportation, and with exception of some places of entertainment, all businesses are closed).
2. Road type - rural roads vs urban downtown streets.
3. Signal duration - short green phase (10 seconds or less) vs long green phase (30 seconds or longer)
4. Distraction - the experimenter appeared distracted (looking towards and conversing with his assistant) vs not distracted (looking straight ahead).

These four dichotomous variables, constituted an experimental design of 16 combinations. Fifteen trials were conducted on each combination for a total of 240 trials.
In addition to these four variables, the effects of estimated age and sex were also analyzed.

Results and Discussion

On all 240 trials, the blocked drivers honked before the green phase ended. Across all conditions, the average reaction time to honk the horn was 3.3 seconds. Thus there was no need to measure incidence of honking as a dependent measure, and - unlike in the case in the U.S. studies - there was no need to make assumptions about honking delays, when the drivers did not honk.

An analysis of variance of the 4 independent variables yielded a significant main effect of signal duration [$F(1,224)=5.94$, $p=.008$], congestion [$F(1,224)=3.20$, $p=.038$], and distraction

[F(1,224)=5.94, p=.008], congestion [F(1,224)=3.20, p=.038], and distraction [F(1,224)=6.61, p=.006]. Also significant were the two way interactions road type x congestion [F(1,224)=7.09, p=.004], and signal duration x distraction [F(1,224)=3.08, p=.040], and the three way interaction of road type x congestion x distraction [F(1,224)=11.75, p<.001].These significant effects and interactions are represented in Figures 4 and 5.

As can be seen from these figures drivers are more impatient and are quicker to honk when the green phase is short than when it is long: 3.0 s vs 3.7. Honking delays are also shorter in congested weekday hours than on the uncongested weekend hours (3.1 vs 3.6 seconds) and when the driver appears distracted than when he is not: (3.0 vs 3.7 seconds). The significant interactions further reveal that the effect of congestion is limited to city driving where during the weekend drivers are willing to wait nearly 50% longer before they honk their horns relative to their wait during the weekday rush-hours. The interaction of signal duration with distraction indicates that when the driver ahead appears distracted (and therefore assumed to be unaware of the light change) the honking is almost immediate, regardless of the signal duration (2.9 vs 3.0 seconds), but when the driver ahead is not given that benefit of the doubt (does not appear to be distracted), then the honking RT is nearly 50 % longer for long green phases than for short ones.

Figure 4

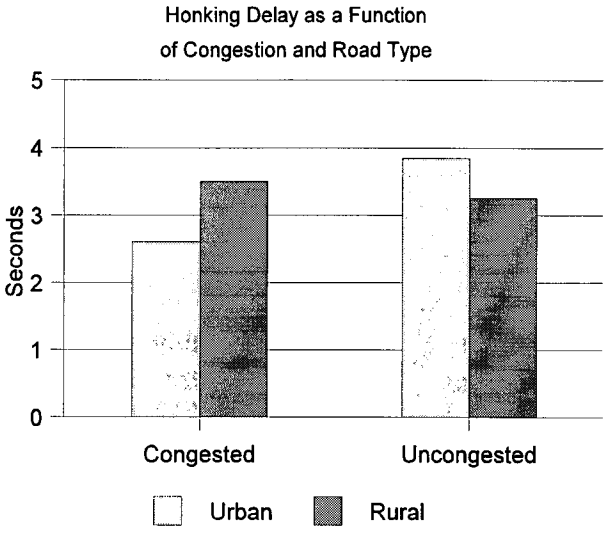
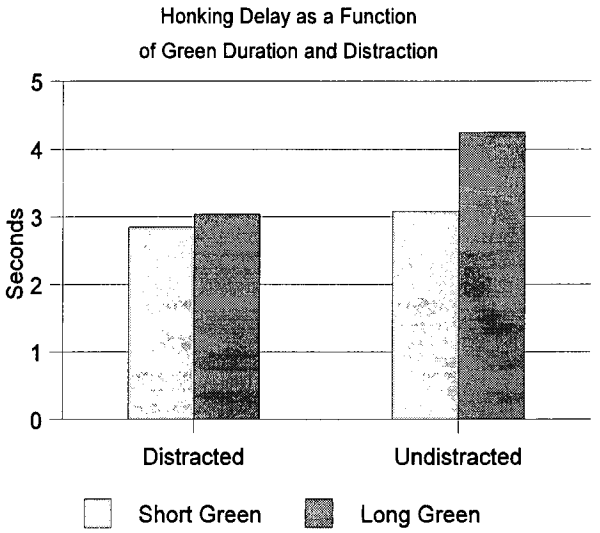


Figure 5



With respect to individual differences, the perceived driver age ranged from 18 to 70, with a median of 38, and the majority of the drivers (80%) were males. Analysis revealed that young drivers (appearing to be 30 years old or less) honked significantly faster than older drivers (50 or older): 3.04 vs 4.5 seconds. On the average, men and women did not differ significantly in their horn honking delays [t(238)=0.60, ns]. The correlation between perceived age and honking delays was low but positive and significant (r=0.17, p=.007)., and when the correlation between age and honking delays was calculated separately for men and women, it was essentially zero for women (r=-.03), but positive and significant (r=0.21, p=.004) for men, indicating that the age effect is relevant for men only. In short, young males are more impatient than older ones. Finally, drivers of commercial vehicles (trucks, buses, and taxicabs - constituting 10% of the vehicles) and drivers of vans, pickups, and 4-wheelers (constituting an additional 24%) did not differ significantly from drivers of passenger cars.

GENERAL DISCUSSION

The three studies described above are consistent in reflecting the role of situational variables in two manifestations of aggressive driving: running red lights and horn honking. In all three studies, situational variables that can be frustrating - by blocking the path to the desired goal of moving - were shown to generate the measured aggressive response: increasing likelihood of driving through the red light the shorter the green phase was; and quickening the horn-honking response to a driver blocking the path when the green phase is short, when congestion is high (during the rush hours), and in urban (vs rural) driving. The potential for reducing such behaviors through the manipulation of the environment can be appreciated from Retting and Greene's (1995) study, where red light violations were reduced by increasing the clearance intervals (also known as the inter-green interval).

It is possible that the situations manipulated to reflect varying levels of frustration are typical of the driving environment and culture in motorized countries at the end of this century. If this is so, then it may explain why such behaviors are either more common today than in yesteryear, and why we focus on them more than before. The pressured urban lifestyle of the late 90s, (coupled with the spreading instantaneous communications that act to compress time), is such that we are under constant pressure to perform under an ever-increasing time and work pressure. In this environment, weekday driving is one of the last blocks of perceived 'wasted' time (and we try to eliminate that by working behind the wheel as much as possible - with cellular phones and dictating machines). Thus, it is likely that the increased value of lost time, is causing us to be much more aggressive on the road then ever before: especially during the working days in work-related travel.

Some of the situational variables studied here cannot be that easily manipulated to reduce stress: time of day and location of the road. But others, can be controlled at a high cost (congestion) or even a low cost (signal phase durations). What this study highlights, is the importance of these factors - that are usually ignored - as over-riding issues in the desire to reduce road aggression.

The actual values of the behaviors observed in this study are also interesting. I was unable to find studies that would allow comparisons of the likelihood of driving through red lights. However, the horn honking delay times are interesting in the sense that they are (a) much shorter than those obtained in the U.S., and (b) in no case did the blocked driver fail to honk before the light changed. In the U.S., where all measures were made in non-rush hours, in approximately one third or more of the observations, the blocked drivers did not honk within the typical 12 second period allowed by the experiments (before the blocking driver started to move). In our studies, even in the weekend the drivers were much more impatient. This difference may reflect the stereotypical perception (by those who have been there and here in the U.S.) that life in Israel in general is much more intense and stressful than it is in the U.S. If horn honking reflects this cultural difference, it would be interesting to conduct similar studies in other countries and use this as a potential standard measure.

Our results concerning individual differences did not shed light on this issue. In the first study on driving through red lights, no data were collected on age and sex. In the second two studies we obtained conflicting results. The pilot study did find that men were quicker to use the horn than women, but the more extensive study failed to replicate this finding. This may be due to the fact that

in neither study, was there an attempt to control age and sex, and consequently there were many more men then women in the study samples, and the two groups were not evenly distributed across all conditions. Both studies did however show an effect of age: older people tending to wait longer than younger people before honking. This is not an artifact of longer reaction times of older people since the values here are much longer than those needed to simply respond to a stimulus target. Instead it is likely that older people may be both more considerate (i.e., less aggressive) and less in a hurry ('in a hurry' being a subjective feeling of time pressure).

Finally, it is important to realize - as was realized by Turner et al. (1976) - that horn honking serves more than just a means of expressing aggression. It is also a means of effective on-the-road communication. This motive to simply communicate was probably more prevalent in the case of the apparently distracted driver. And indeed, the shortest horn honking delays were obtained when the blocking driver appeared distracted, suggesting that in this case the lead driver does not wait for frustration to build up.

CONCLUSIONS AND IMPLICATIONS

The primary conclusions that can be drawn from the existing theory and data, and from the three studies described above on aggressive driving are that:

1. The frustration-aggression model can be useful to understand and predict aggression on the road, by evaluating variables that can be theoretically linked to the frustration of the driving goals.

2. From the perspective of the frustration-aggression model, a short green light and a car blocking traffic are illegitimate behaviors that result in disappointment of legitimate expectations, and therefore lead to aggressive behaviors such as driving through the red light and honking at the blocking vehicle, respectively.

3. As long as the value of time increases (in a culture where 'time is money'), obstacles to mobility will generate frustration, and to the extent that they are perceived as illegitimate, they will generate aggression. In this case, containment of aggression through enforcement and education and public information campaign may have some limited value, but will be psychologically useless, since the pent-up aggression will eventually surface elsewhere.

4. The effects of individual differences in age and sex on aggressive driving are less clear from the results of these studies, though it is likely that overt manifestations of aggressive driving decreases with age, and is possibly less common for women than for men. Gender effects, in particular, may be very subtle since it appears that women are just as likely as men to resort to mild aggressive behaviors, and the behaviors studied here - unlike those that I consider 'road rage' - are definitely mild. The effects of other factors such as trait- and state-stress is a different issue that remains to be investigated.

5. There are probably cultural differences in aggressive driving, and the driving behaviors studied

here are consistent with some stereotypes, and may in fact contribute to the stimuli that generate these stereotypes. However, this needs to be studied further.

6. There is a need to provide more exact definitions of aggressive driving behaviors than we currently have. Even the specific behaviors used in the empirical studies above are probably not specific enough. In our study of driving through the red light, we only encountered and measured vehicles that ran through the first seconds of the red light phase. Obviously driving through a red light long after it commenced is a totally different behavior. Also, in our studies we did not distinguish between different kinds of honking. In studies we are conducting now we are also measuring the number of honks and their durations.

The practical and research implications of the results of these and the previous studies are that:

1. We can reduce a significant amount of aggressive driving by careful user-friendly ergonomically oriented design of the driving environment.

2. From an effective public health perspective the way to reduce road aggression is to control the situations that give rise to it, rather than focus on driver education and mass media campaigns.

3. There are very little data on the relationship between the environmental stimuli, individual differences, and aggressive driving. Much more research is needed, before action oriented large-scale programs are embraced.

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DEVELOPING PUBLIC INFORMATION PROGRAMS TO REDUCE YOUNG ADULT DRIVERS' RISKY BEHAVIORS

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INTRODUCTION

In recent years there has been a rise in the importance of health issues on the public and media agendas. Smoking, AIDS, alcohol, poor diet and physical inactivity are among the topics that have been given much exposure. All of these issues deal with the reduction of risky behaviors, which is a particularly difficult objective to achieve. The public is being asked to take action now—stop smoking, practice abstinence or safe sex, avoid abusing alcohol, not eat foods they like, work up a sweat—because something unwanted—lung cancer, AIDS, liver disease, or premature death because of poor health—might happen sometime in the future.

Those of us in the highway safety field urge the public to use safety belts and avoid drinking and driving, speeding and other aggressive driving behaviors to prevent crashes and thereby the associated injuries and deaths. For our messages to have an impact, they must convince the public that the reasons for changing behaviors outweigh the reasons why the behaviors exist. The public must believe that they are vulnerable to being in crashes, that seat belts work, that drinking and driving and speeding kills or that enforcement of laws exist and there is a good chance of getting caught and receiving the negative consequences.

Reaching youth about these issues is particularly important and difficult. Young adults have the most problems with driving. In North Carolina, one in four 16-year-olds is in a motor-vehicle crash during that first year of driving. The rate for 17-year-olds remains high at one in five. In nearly forty percent of these crashes, someone is killed or injured (NCDOT, 1995). As both drivers and passengers, teenagers are disproportionately involved in crashes compared with other ages. Young drivers are more likely to have speed-related crashes than any other age group. In North Carolina, only seven percent of the licensed drivers are aged 16 to 20, yet this age group accounts for 17 percent of all crash involvements and 27 percent of speed-related involvements (Stewart et al., 1997). Young drivers are more likely to crash at lower alcohol impairment levels than other age groups (Phelps, 1990). North Carolina high school students have observed belt use rates that are about 10 percentage points lower than drivers in general (Marchetti et al., 1993).

While young adults are at a greater risk of crash-involvement than any other age group, this age group has the least recognition of the risks associated with driving. Young males in particular appear to believe they are at less crash risk than older males (Matthews and Moran, 1989), rate themselves

as less cautious yet perceive less danger than older drivers (Jonah and Dawson, 1987), and rate situations as less risky than older males (Trankle et al., 1990). Research has suggested three possible explanations for high risk-taking among youth: young drivers have a lower perception of risk than older drivers; young drivers may assign a higher *utility* to a hazardous behavior than older drivers; and young and older drivers may weigh utility and risk equally, but older drivers *choose* lower risk levels (Hodgson et al., 1981; McKnight and Resnick, 1993).

Developing programs and messages to change risky behaviors is a difficult task. Understanding the environment, motivations and attitudes of the audience all are critical in the design of potentially successful programs. This paper looks at messages and strategies young people have said might work in getting them to reduce drinking and impaired driving or to increase seat belt use and explores whether this information might be helpful in developing messages for other risk-reduction efforts such as reducing speeding. Although this paper focuses on reaching the young adult audience, the principles are the same for any group.

THE ROLE OF PUBLIC INFORMATION

There are several ways in which public awareness programs can help to change the risk-taking behaviors of young adults:

1. Create awareness among youth of the risks that they take and the consequences of those risks in terms to which young adults can relate. The negative consequences of risky driver behavior range from getting stopped and receiving a ticket to causing a crash in which someone is killed. Focus groups of high school students, 18 to 20-year olds and 21 to 24 year olds all informed us that they could not relate to deaths and injuries well, especially not their own (Marchetti et al., 1997; Wiliszowski et al., 1997). For young adults of all ages, the greatest concern expressed was that of hurting or killing someone else, especially a friend. They could relate to having to deal with the parents, the shared friends, or the siblings of someone who was killed because of their driving.

2. Make the behavior socially unacceptable. While the previous message is directed toward the person who is likely to engage in the risky behavior, creating social unacceptableness begins with getting young people to understand how their peers' risky behaviors affect them. Everyone is a stakeholder in reducing risky driving behaviors. MADD has done an excellent job of putting a face on innocent victims of drinking drivers. Seat belt laws have won support, in part, through promotion of the fact that we all pay for the health care and other societal costs for people who do not wear seat belts. More work needs to be done to determine what makes others' risky behaviors unacceptable to youth.

3. Establish norms, dispel perceived norms that are wrong. A survey of students at five North Carolina high schools showed that among both males and females, across all grades, consumption of alcohol was overestimated (Marchetti et al., 1997). Students thought they knew that most of their peers were drinking; however, the normative belief far exceeded reported drinking. Getting out the fact that not as many peers drink as they think could help change what is perceived as normal and affect some drinking decisions. When 18 to 24 year olds were asked what the norm is for drinking

and driving, the vast majority stated that drinking and driving is *never OK*, but even so, it is still done.(Wiliszowski et al., 1997). Public information had reached them in terms of understanding the problem, but it had not changed the behavior.

4. Offer alternatives. Alternatives are especially needed when dealing with drinking and driving issues. As long as people drink to excess, we will have to face the fact that an impaired person is not necessarily able to make a smart decision. The dilemma was aptly described by one youth who simply stated "We know all that stuff when we're sober, but that's not what we're thinking about when we're drunk." When the choice is made to drive or not after drinking, the consequence of leaving the car in a bad place, the inconvenience of having to pick it up the next day, the embarrassment of admitting they could not drive, or allowing someone else to drive their cars seemed like a more real consequence than the abstract possibility of having a crash, or hurting themselves or someone else. Young adults suggested that messages be developed to enhance the value of a friend who intervenes and to enhance the status of an impaired friend that allows a sober friend to intervene. They gave high marks to messages such as *Be there for your friends. Let your friends be there for you* (Wiliszowski et al., 1997; Stewart et al., 1995).

5. Function as part of a larger program. Public information should not stand alone. It works best in support of a larger program. Alone it stands little chance of creating measurable change, but it is a vital component of any program to change behavior.

UNDERSTANDING TODAY'S YOUTH

The first rule for developing messages is to never assume you know your audience. And, when it comes to younger generations, it is safe to assume that whatever an adult thinks a teenager might like, probably won't hit the intended audience.

An important part of marketing anything is knowing the customer. Values, preferences and marketplace behaviors are based on three elements: life stage, current social and economic conditions and formative cohort experience. An example of life stage differences is the fact that youth often express that they can not relate to their own deaths in crashes. As we get older, the possibility of dying seems more real. Social and economic factors were at play when a group of 21 to 24 year-olds indicated that they believe that they drank more when they were younger, that as they got older the responsibility of getting good grades to graduate, of holding down a job, of being married with kids made it harder to drink as much. The cohort experience forms the values and life skills. Whether friends wear seat belts, drink or drink and drive affect behavior.

Today's young adults are not merely a younger version of the groups that preceded them. Yankelovich Partners, a marketing research company, has done intensive survey research on consumers sixteen years of age and older over a 25 year period. They have found that pop culture, economic conditions, world events, natural disasters, heroes, villains, politics and technology create bonds that tie members of a generation together into *cohorts*. They grouped consumers into three age groups, those born before 1945; those born between 1946 and 1964, and those born 1965 or after. Survey questions gauged their confidence in themselves, the economy, the control they feel they have over their lives and the direction in which they feel they are going.

The world of people born since 1965 is defined by divorce, AIDS, crack cocaine, MTV, game boy and personal computers. This generation knows that risks are everywhere and surprises are often bad. HIV, date rape, computer viruses, a drunk driver, random acts of violence are facts of life. Live for today, but designate a driver and buckle up.

They are pragmatic. They have lower expectations. They expect Social security will be long gone by the time they are ready to retire. They accept they will be moving, changing jobs, staying flexible and living at home with parents longer. They believe they will succeed because they will have two jobs. Over two-thirds of today's young people agree that *I have to take whatever I can get in this world because no one is going to give me anything* (Smith and Clurman, 1996).

The Yankelovich data indicate that this group is the most diverse generation to date. When developing messages for a generation so diverse, it is particularly important to recognize that all males, all females, all of a race or ethnic group does not form a common group. A male college student recently explained that if he were shown two copies of the same ad with two different male characters of different races, he would relate to the one that dressed like him, appeared to act like him and whose body indicated the same concern for physical fitness.

Marketing to youth

Research conducted by Saatchi and Saatchi Advertising (Kim, 1993) found that although teens come from diverse backgrounds, they all go through the same developmental themes: autonomy versus belonging, rebellion versus conformity, idealism versus pragmatism and narcissism versus intimacy. But today's teens also must cope with the responsibilities that come with being the children of dual-income or single parent families. This contributes to their pragmatism.

They are sophisticated about advertising, but skeptical. Media-saturated and marketing-jaded, this generation wants honesty and irreverence. Messages need to talk at their level or above. They like attitude and they want to have fun. Get a life. Lighten up. Today's young people are more committed to fun as a life value than previous cohorts ever were.

They are not smarter but they are exposed to a lot more. They are committed to making up their own minds. On merchandiser capitalized on this information by launching a promotion that offered a grand prize of a trip anywhere in the world to see any band. It would have been foolish to try to come up with a trip that would have appealed to the majority of this target population.

Friends are very important. Younger generations are always more peer-focused, but survey data indicate that this generation is more so than those that preceded them (Smith and Clurman, 1996). They look toward friends for advice and what to believe. They use friends and peers to fill emotional holes. Friends have tremendous value for safety messages. Friends are the ones young adults indicate that they do not want their own behaviors to harm. Friends are the ones who can deliver messages and have the best chance of intervening in risky behaviors.

They get information by *surfing*. Information is linked by serendipity, like a web search. The speed and convenience of information is different. It is accessible on all news, all day channels. They are bombarded with great variety of information They are the most enthusiastic embracers of technology but also the most skeptical. A visual generation, they are the least likely to read or look at a

newspaper. Today's youth can be reached through cable TV, MTV, radio, niche magazines, Channel One (in-school television channel), comic books, screen vision (advertising that precedes movies), and the Internet (Kim, 1993).

Students are savvy about marketing by age eleven. A 1992 study found that a negative attitude toward advertising is already developed by adolescence. The study examined how children interpret beer commercials and found that focus groups of fifth and sixth graders were skeptical about the promises that beer commercials made and were aware of the health consequences of drinking and driving (Ringold, 1996). Savvy, however, does not necessarily translate into avoiding the behavior. During a 1997 focus group session held for an HSRC project, eighth grade boys were asked what came to mind when drinking (specifically drinking in high school) was mentioned. Their responses were variations on how drinking is a dumb thing to do, how it makes you sick and it has bad consequences (get killed, wreck your car). Ironically though, when the question was followed with, *Well, do you plan to drink in high school*, most responded with an enthusiastic *yes*.

Only by understanding how the young adult audience is different, can we increase the chances that we will avoid producing messages and materials that young adults will ignore, laugh at, or be insulted by the waste of money.

DEVELOPING HIGHWAY SAFETY MESSAGES FOR YOUTH: AN EXAMPLE PROGRAM

The UNC Highway Safety Research Center developed a program in 1993 to help high schools across North Carolina design and carry out programs to increase seat belt use and awareness of alcohol issues among teenage motorists. This was done by providing grants (up to $500 per school) to conduct peer-led programs at the high schools. Schools were required to conduct belt use surveys as part of their applications and periodically during the programs.

Over the four years of the project, programs were conducted at 256 high schools in 76 of the state's 100 counties. Special emphasis was placed on recruiting schools within counties with higher-than-average teen crash rates. Training workshops were held at colleges across the state. The process was designed to treat the students as creative, bright, young adults. This approach aimed to provide students with skills to develop and implement program ideas, set up research methodology (collect seat belt data) and evaluate the effectiveness of their programs. They were given ideas and facts, but were told to use their own creativity to design programs to change the negative behaviors of their peers.

A series of seat belt and alcohol messages using the campaign slogan *Get a Grip. Buckle up. Drive Sober.* were produced by HSRC for use by the programs. The methodology for the development of the messages is described.

Get a grip. Buckle up.

Crash statistics and observational seat belt surveys were used to help determine what the message should be. Discussions with high school students determined what the messages should look like, who should deliver them, and how they should be delivered.

Seat belt observational surveys found that youth buckled up less often than older drivers, that males buckled up less often than females and that drivers of cars more often than those in pickup trucks and utility vehicles.

Belt use data were collected at 48 high schools and belt-wearing characteristics of 10,938 students were observed prior to any program exposure. Belt use rates for high school students were around 55 percent, approximately 10 percentage points lower than the rate observed for the general driving public through statewide surveys (Marchetti et al., 1993). Occupants of cars and mini vans buckled up more frequently than drivers of pickup trucks, full sized vans and utility vehicles (56 percent versus 42 percent respectively). The belt-wearing rate for females (60 percent) was 11 percentage points higher than that for males (49 percent). Drivers were more likely to buckle up than passengers (58 versus 49 percent, respectively).

This data provided valuable information for the development of both materials and strategies for high school programs. Programs needed to include strategies specifically for males, drivers of pickup trucks and utility vehicles, and passengers as well as drivers.

Focus group sessions were conducted with school leaders and students identified by their principals as risk-takers and as likely non-users of seat belts. The student leaders are an important group. They are the ones who will implement programs and distribute materials. But talking to the group at risk is important, too. They have a different perspective than the peer leaders, and they are the ones whose behavior we want to change. We tried to use focus groups creatively. We presented the facts and what we were trying to accomplish. Half the time was spent discussing attitudes toward seat belts and how negative attitudes could be changed. During the second half of the session, the participants were drafted into being part of the creative team.

At each session, similar comments were expressed. The students suggested that seat belt messages intended for young drivers needed to be powerful but not preachy. Messages also should be slick but not fake. The students stressed that credibility of even the details was important.

Most students believed that wearing seat belts was a good idea, but felt belts were uncomfortable or a hassle to use. Even students who said they usually buckled up admitted that in certain situations, like going on dates or partying, they did not wear their belts. Other reasons given for not buckling up included a fear of being trapped in a vehicle should it catch fire, just forgetting, and following the example of law enforcement officers whom they had seen not wearing their belts. The most often repeated reason for non-use was comfort. Males were more likely than females to indicate that they felt it was better to be thrown free of the vehicle. Females, though they buckled up more often than males, agreed that they were less likely to wear belts if they were dressed up and did not want to wrinkle their outfits.

Bringing home to the focus group members the reality of their own mortality was hard. They could not relate to either their own deaths or permanent injury. One student expressed shock that a friend had been in a crash and the paramedics had cut off his brand new leather jacket. This rescue operation disturbed the other students in the focus group as well.

Clothes became the visuals for our messages. Each message shows a single piece of expensive clothing that teenagers regularly wear. Two of the three messages speak to males because young

men fail to fasten their belts more often than young women. The clothing is damaged as it might be damaged in a wreck or by paramedics attending to an injured person. We followed the advise of the students to be credible down to the details by using paramedics to cut the clothes.

One poster, shown in Figure 1, addressed females' reluctance to buckle up when they are dressed up. The poster features a party dress that is cut down the middle and stained with blood. The headline reads *Not Wearing a Seat Belt Can Be Murder on Your Clothes.* In this scenario a broken windshield and paramedics' scissors, rather than a unused seat belt, ruined the dress.

Another poster in the series, shown in Figure 2, addressed the idea that it was better to be thrown free of the vehicle. It shows a scuffed leather jacket lying on a black asphalt highway. The simple headline, *Road Kill,* implied that being unbelted means a person is more likely to be ejected during a crash and more likely to die.

In an effort to make the materials part of a larger program, the posters and the rationale for them were part of the training workshops for applying for mini-grants. Students were encouraged to use the materials as talking pieces for presentations to peers and middle school students. One school used mannequins dressed similarly to the posters as hallway displays.

Figure 1. Seat belt poster for high school females

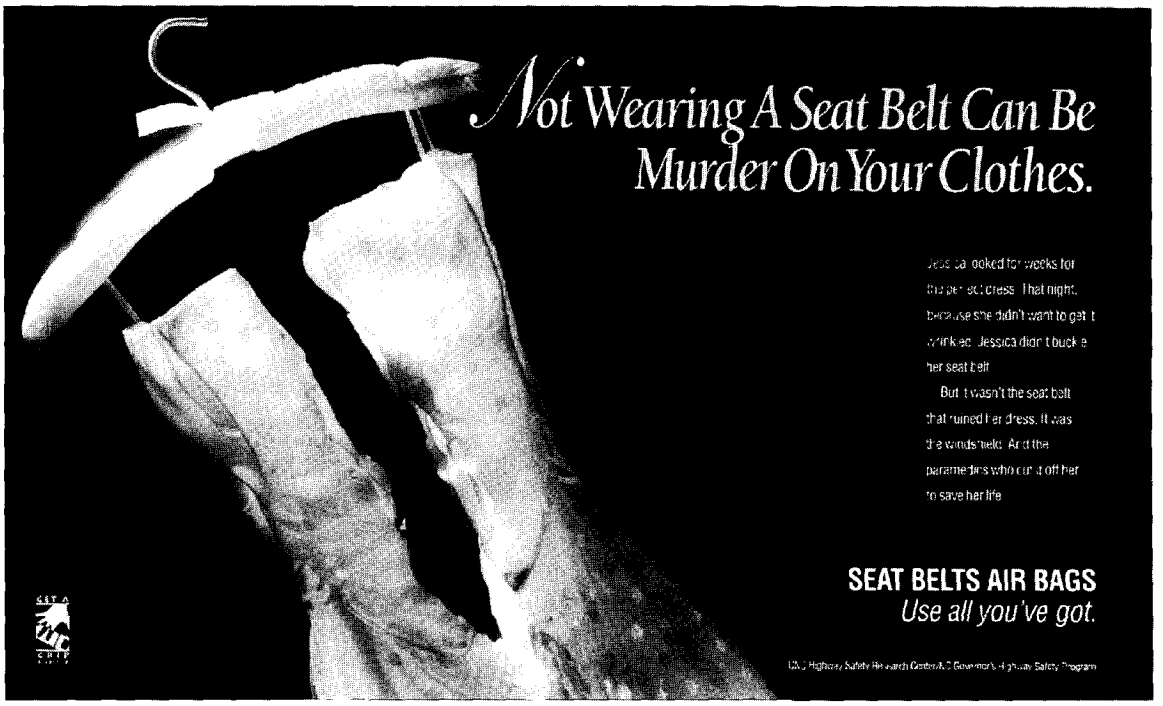
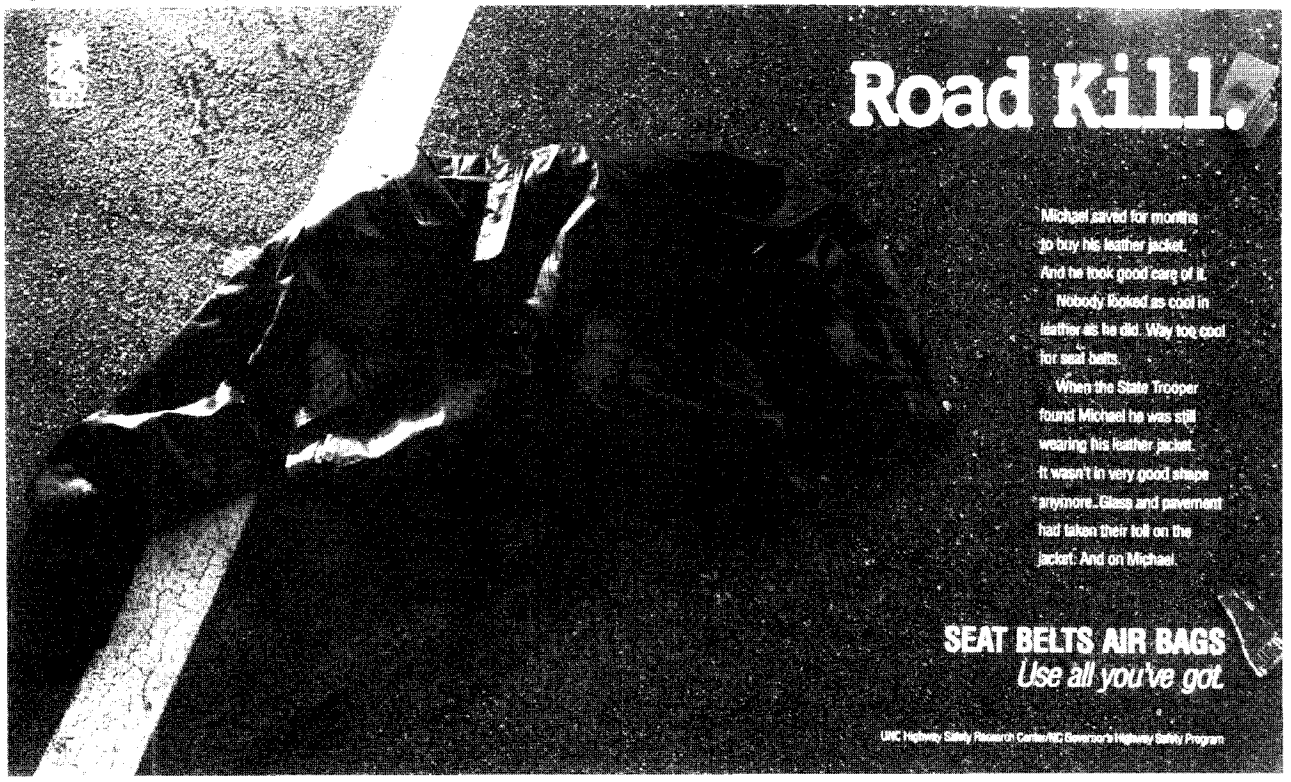


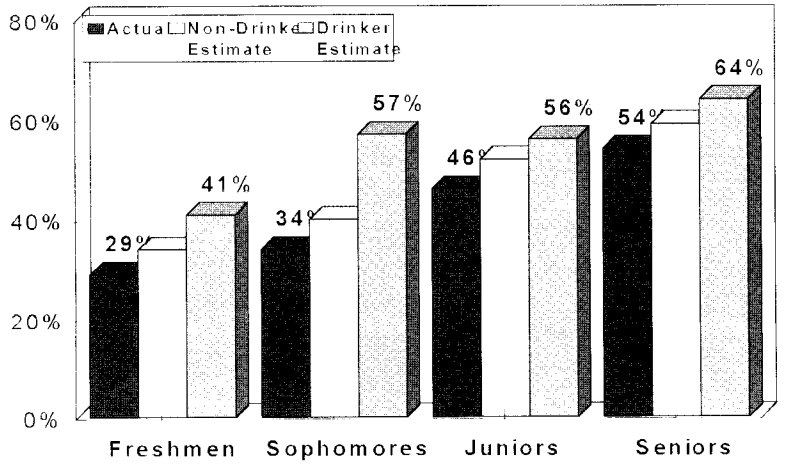
Figure 2. Seat belt poster for high school males



Get a Grip. Drive Sober

The popularity of the seat belt program and materials led to the development of an alcohol component for the program and a similar series of messages focused on alcohol. Data on high school alcohol use and attitudes were obtained from a written survey of 544 freshmen, 480 sophomores, 568 juniors, and 401 seniors at five North Carolina high schools. Fifty percent of the respondents were male.

Figure 3. Self-reports and estimates of drinking by class and drinking status: males

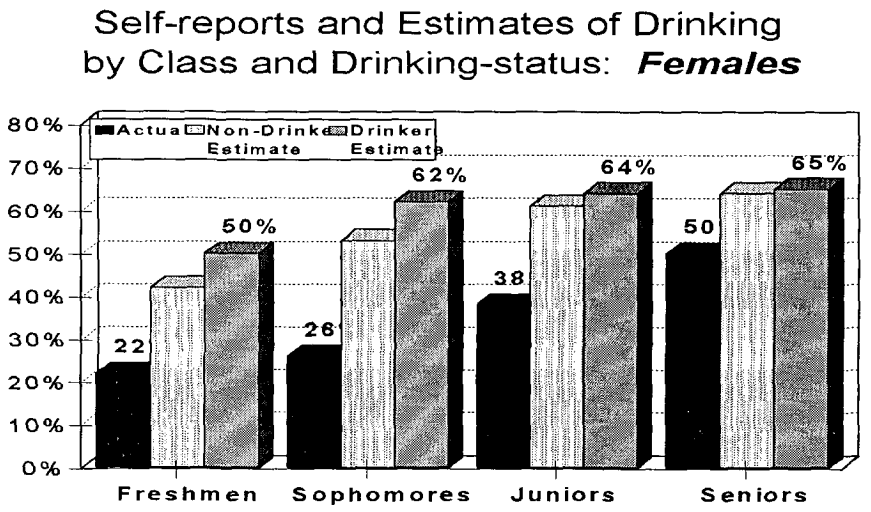


Students were asked if they drank and to estimate the percent of their peers who drank. Overall, 38 percent of the students surveyed said they drink alcohol. All student groups overestimated the amount of drinking by peers. Figures 3 and 4 show the estimated percentage of peers who drink for males/females and drinkers/non-drinkers by grade and the actual number of self-reported drinkers for each category.

Although the results showed that 29 percent of freshman males drank, freshman male drinkers who were surveyed estimated that 41 percent of the population drank, and freshman male non-drinkers estimated that 34 percent drank.

Females also over-estimated the amount of drinking by peers. The survey showed that 22 percent of freshman females drank. Freshman female drinkers who were polled, however, estimated the figure to be 50 percent of the population and freshman female non-drinkers thought that 42 percent of the student population drank.

Figure 4. Self-reports and estimates of drinking by class and drinking status: females



Perhaps the most disturbing finding in these data was that many drinkers said they drink specifically to get drunk. Thirty percent of the males who drank said the reason they drank was to get drunk while 24 percent of the females said that was their motivation. Students who drank were asked what it would take to get them to stop drinking. Table 1 shows that 88 percent of the females said they would stop if they got pregnant and 52 percent of the males said they would stop if they caused a pregnancy. There is no way to know if the high response from females is related to awareness of the dangers of drinking during pregnancy.

Table 1. Reasons high school students would quit drinking by sex

Would you stop drinking if you:	Males	Females
Were arrested for drinking	41%	55%
Were punished by your parents for drinking	15%	17%
Got pregnant/caused a pregnancy while drinking	52%	88%
Had a close call in a car	55%	69%
Lost a friend to drunken driving	68%	81%
Got very sick or blacked out	26%	30%

Eighty-one percent of the females also responded that they would stop if they lost a friend to drunken driving, while 68 percent of the males responded that way. Although this is what students said would motivate them to quit drinking, we do not know whether these situations actually would translate into reduced drinking. However, the concern for friends is consistent with marketing data for this age group and with what focus groups have told us.

Virtually everyone polled—drinkers and non-drinkers—agreed that students change after drinking. About two-thirds said drinkers become more violent and aggressive, more casual about sex, and more reckless behind the wheel. Non-drinkers appeared less likely to have trouble and more likely to have fun, good grades, and self-respect. Both drinkers and non-drinkers agreed on one issue: that non- drinkers have more self-respect. If this is truly the way many students feel, then we should be able to develop strategies to enhance the status of non-drinkers in high schools.

Focus group sessions

A series of focus groups with students from three North Carolina high schools was conducted to discuss youth alcohol issues. Since youth are such avid users of the Internet, we found a web site for a young adult Alcoholics Anonymous support group and asked if we could share in their discussions and seek their suggestions about strategies that might be beneficial. The poster message that has received the most favorable response came, in part, from these Internet contacts.

The focus group participants had very specific suggestions that were quite similar to those of the focus groups who discussed seat belt messages. The teenagers in the focus groups counseled us to avoid patronizing messages, not to preach, and to use real examples of real people. They said to show what can happen, to show how drinking and driving can affect their future. The students told us that they felt that it was important to cover both the issue of teen-age drinking and the issue of drinking and driving.

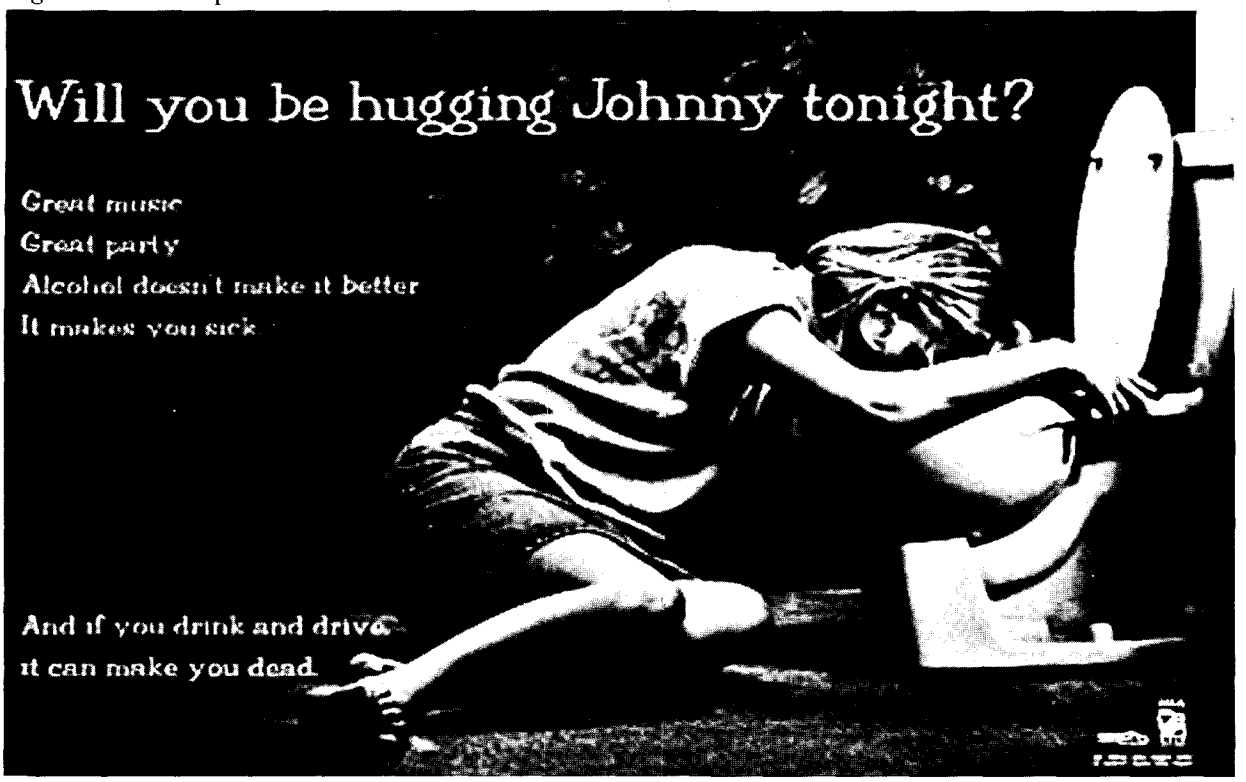
Figure 5. Poster about the consequences of drinking and driving.

Three messages were developed. The first concept deals with the fear expressed by youth of killing someone else, especially a friend. *I bought the beer. But my best friend paid for it*, shown in Figure 5, features a despondent-looking teenager, leg in cast and leaning on crutches, viewing a funeral from a distance.

This poster has had the most universal appeal of any message we created. It has been favored by eighth graders, high school students, and the 18 to 24 year-old age group. Perhaps this is because it combines much of what young people have told us. *I bought the beer* puts the delivery of the message in the hands of the young person. It deals with consequences, short and to the point, and hits hard on the importance this age group places on friends. As with the other messages, it has some attitude. The Alcoholics Anonymous support group provided the text for the poster which lists the escalating costs of alcohol as someone becomes addicted. They reasoned that for some high school students alcohol is already a serious problem. Listing the levels of paying for it provides an opportunity to reach some youth who may recognize themselves as sacrificing their futures to alcohol.

The second concept deals with the alarming information regarding the number of females who are drinking to get drunk and addresses tangible consequences. The poster shown in Figure 6 features a teenager with her head bowed over a porcelain toilet in a dark bathroom. *Will you be hugging Johnny tonight?* reads the headline. In smaller letters underneath, it says: *Great music. Great party. Alcohol doesn't make it better: It makes you sick. And if you drink and drive, it can make you dead.* This message provided a talking piece for young women to use for discussions with their peers and middle school students. It aims to deal with the expectancy that alcohol makes parties better.

Figure 6. Alcohol poster for females



A third poster dealt with the suggestion by students that we explain how drinking and driving can affect their futures. The poster shows a graduating class dressed in white robes with one student in a prison-orange gown. The text reads that the student in the orange gown had earned two things that would affect his future—a diploma and a DWI conviction. The poster explains that college and job applications ask about both.

RESULTS

Since 1993, more than 200,000 North Carolina high school students have received information about the importance of seat belt use and the dangers of drinking and driving through the high school programs established through the HSRC project. The student-led programs conducted various activities including staged events such as crashes, DWI arrests and trials; testimonials from various perspectives such as belted survivors, DWI victims/families and drinking drivers; distribution of seat belt incentives; programs for in-school television broadcast; activities with middle school students; and community events.

All participating schools conducted alcohol awareness activities. The effects of alcohol programs on individual behavior are difficult to monitor and such an evaluation was beyond the scope of the project. The evaluation of alcohol strategies was limited to documentation of what occurred and how many students were exposed to the messages.

The evaluation of this project, in terms of behavioral change, was based on seat belt use which was easy to collect and provided a reasonably accurate measure of change. During the four years of the

program, average seat belt use rates at participating schools increased 22 points in 1993 (43 high schools); 14 points in 1994 (57 high schools) and 1995 (62 high schools) and 9 points in 1996 (78 schools). Although data from comparison sites were not available, the increases in seat belt use were compared to belt use changes among motorists under age twenty-five during that time period.

Between the first and second years of the programs, North Carolina began a statewide campaign of seat belt public information and enforcement blitzes called *"Click It or Ticket"* and statewide 72-site observational seat belt data were collected. Belt use for this age group immediately after the initial blitz increased 19 percentage points in November 1993. The campaign and belt use increase occurred after all 1993 program activities and data collection were completed. Baseline data collection for the 1994 programs occurred after November 1993 and reflected any effect of campaign in its pre-program data. During May, 1994; August, 1994; August, 1995; and December, 1995 additional statewide seat belt data were collected. Belt use for this age group showed only modest change during that time: up 1.7 percent; down 0.6 percent; up 2.9 percent; and down 2.7 percent, respectively (Reinfurt, 1996).

Comparisons of pre- and post-program observational seat belt surveys indicated that approximately 34,000 teenagers who once did not buckle up began to do so during these programs. If these young adults continue to buckle up, this increase in belt use would ultimately reduce approximately 143 serious or fatal car crash injuries among teens to less serious injuries and save an estimated 30 lives.

DISCUSSION

The only conclusion we can draw about the messages discussed is that the materials in combination with peer-led and designed programs were able to increase seat belt use at many North Carolina high schools. There is no way to know what contribution, if any, these messages made. What can be said is that the messages were accepted by the target audience, the student program leaders wanted to use them (we could not keep them in stock) and they were integrated into larger efforts that included an evaluation component. They also won awards for their creative design, however, too often materials are judged to be effective based on the awards they have won. Although this type of recognition indicates that the materials were appealing, design awards have little, if anything, to do with whether the intended audience got anything out of the message.

It is difficult to declare public awareness programs and materials to be effective, yet we should not be too quick to judge them to be ineffective. It usually takes a critical mass of programs, campaigns, strategies to create a measurable change in human behavior on a widespread basis. Most behavioral change start slowly and only once enough activity has occurred does acceptance take off. It took many seemingly unsuccessful anti-smoking campaigns to create conditions for the momentum these campaigns have today.

The information gained about messages for increasing seat belt use and alcohol awareness can be transferred to other risky behaviors by youth. Youth have made it clear that they value their friends tremendously. They do not want to harm their friends. Messages like *I bought the beer but my friend paid for it* or *drinking and driving turns friends into killers* could be used equally well to emphasize that speeding and other risky driving behaviors kill friends as well. As youth are encouraged to intervene with friends about to drink and drive, perhaps the climate can be set for

interventions to apply for speeding or other generally risky driving behaviors as well. There is an important truth to tell. Youth are over-involved in crashes and in speed-related crashes. The consequences are the same as for drinking and driving. People are hurt and die.

We also need to expand our goals when it comes to alcohol. Drinking and driving is a problem that is only part of a larger alcohol problem. Alcohol is a factor in all the leading causes of death for young people. As we focus on the highway safety mission to reduce drinking and driving, we may inadvertently convey another message. Sometimes it appears that we have been so effectiveness in creating awareness of the dangers of drinking and driving that the message has been taken to mean if you have a designated driver or if you are not going to drive, then you are safe no matter how much you drink.

Much of what's happening today is the result of a combination of environmental factors and personal choice. The alcohol industry wants drinking to be the norm. High school drinkers, likewise, want their behavior to be what is normal. Drinkers are more likely to brag about drinking than non-drinkers are to brag about refraining. Even parents who, with the best of intentions, decide to have parties in which they take the keys and make everyone spend the night are missing the mark. The assumption is that they are being responsible by preventing the possibility for drinking and driving. However, this is also sending the message that these parents think everyone is doing it, or that drinking by youth is okay as long as they do not drive.

Survey results show that 1) both high school students who drink and those who do not believe that high school drinkers have less self-respect than non-drinkers; and 2) the normative belief that the majority of teenagers drink far exceeds the actual percent of teenage drinkers. Now is an excellent time to for efforts to change the norm among this age group.

We need to take some risks in order to find ways to change youth's risky behaviors. Youth-led and designed programs appear to be an effective way to create positive change among teenagers. Those of us who design programs must be willing to let go of some control, be open to different approaches and find more ways to meaningfully involve youth in solutions.

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CHAPTER 4

INNOVATIONS WITH HIGH POTENTIAL

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The papers in this final chapter explore several promising strategies for affecting driver behavior.

Ralph Hingson's "Legislative Strategies to Reduce Alcohol Impaired Driving" reviews several laws designed to reduce drinking and driving. The laws define the offense (*per se* laws at a specified blood alcohol concentration), set penalties (administrative license revocation, vehicle actions, jail), and control alcohol availability (minimum drinking age, dram shop laws, and alcohol taxes). Many of these laws have been proven effective through several well-designed studies; for others the evidence is less conclusive. Richard Malott's discussion provided a psychologist's perspective on the key features of effective drinking and driving laws. Unfortunately, Malott's computer graphics could not be captured in print for this book.

Nils Petter Gregersen, in "Road Safety Measures for Professional Drivers: A Comparison of Four Different Safety Measures," discusses how a Swedish telephone company reduced traffic accidents among its professional drivers. In a controlled study, the company used four different methods. Two were effective in reducing accidents: driver training in risk awareness and risk avoidance (not in driving skills) and group traffic safety discussions. Two were not effective: information campaigns with seasonally appropriate information and cash bonuses for avoiding accidents.

Graham Grayson and Geoff Maycock's "What Do Drivers Learn Through Experiences - and Can It Be Taught?" discuss whether hazard perception (or risk awareness) is a skill that can be identified, whether it can be taught to beginning drivers, and whether this instruction reduces accidents. They discuss two hazard perception tests that have been developed as research tools and two that have been used in driver licensing in Victoria, Australia, and in the United Kingdom. The latter two tests are objective and reliable, related to driving experience, and can be taught. However, the evidence on whether they reduce accidents is mixed.

Fred Goldberg, in "The Electronic Driving License Saves Lives," presents a technological method for controlling risky behavior. He has developed an electronic driver license similar to a credit card that serves as a vehicle's ignition key. Each driver's licence would contain personal information, including license status and any restrictions; each vehicle's computerized ignition system would accept only specified drivers. The system could prevent unlicensed drivers or thieves from driving, enforce alcohol interlock requirements, and assure that commercial drivers obey hours-of-service rules. The system has been installed on several vehicles in Europe and the United States.

Legislative Strategies to Reduce Alcohol Impaired Driving

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Objectives: This paper examines several legislative initiatives introduced during past fifteen years to reduce alcohol related traffic crashes.
Methods: Quasi experimental studies have compared states adopting new laws with states that did not. Interrupted time series analysis have assessed law effects in single jurisdiction studies.
Results: Since the early 1980's legislation including the minimum legal drinking age of 21, administrative license revocation, criminal per se laws and lower legal blood alcohol concentrations for youth and adults have significantly reduced alcohol related traffic fatalities. These general deterrence laws attempt to dissuade the general public from driving while intoxicated. Specific deterrence laws that prevent persons convicted of driving under the influence from repeating their offenses include mandatory license actions and treatment, vehicle and license plate impoundment and jail sentences. Alcohol tax policies can also influence alcohol related traffic fatality rates. Education, enforcement and comprehensive community programs can enhance the beneficial effects of these state level laws. Regulatory action at the community level such as alcohol server training, enforcement of alcohol service laws and zoning restrictions on hours of sale and alcohol outlet density may further help reduce alcohol impaired driving.
Conclusions: Alcohol related traffic deaths have declined by nearly one-third since 1982. However, in the last three years, the annual number of deaths has remained relatively constant. Renewed efforts are needed to ensure that all states adopt administrative license revocation, zero tolerance laws for youth and .08 percent laws for adults. Further, these laws will have the greatest benefits if they are actively publicized and enforced at the community level through comprehensive community programs that involve multiple departments of city government and concerned private citizens and organizations.

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INTRODUCTION

Traffic crashes are the leading cause of death for persons between the ages of 1-24 in the United States (U.S. Department of Health and Human Services 1997) and alcohol is involved in 41% of fatal traffic crashes(National Highway Traffic Safety Administration 1997). In 1996, 17,126 persons died in alcohol related traffic crashes and approximately one million are injured each year (National Highway Traffic Safety Administration 1997). Those deaths and injuries cost the nation over $45 billion in lost economic productivity, hospital and rehabilitation costs (NHTSA 1997b). Each year approximately 1.4 million people are arrested for driving while intoxicated (NHTSA 1996a). This has been the leading category of arrests over the past decade, accounting for nearly 10% of all arrests.

This article reviews the nature and extent of the drinking-driving problem in the United States and discusses legislative initiatives that have been tried in the past 15 years or are being considered to further reduce alcohol impaired driving.

ALCOHOL AND IMPAIRMENT

Even at blood alcohol concentrations as low as .02 percent, alcohol impairs driver performance by reducing reaction time and slowing the decision making process (Moskowitz 1985). At .08 percent, there is reduced peripheral vision, poor recovery from glare, poorer performance on complex visual tracking and reduced divided attention performance (Moskowitz and Burns 1990). Driver simulation and road course studies have revealed poor parking performance, impaired driving performance at slow speed and steering inaccuracies (Mortimer and Sturgis 1975). Roadside observational studies have identified speeding and breaking performance deterioration (Damkot 1975). A national comparison of drivers in single vehicle fatal crashes with drivers not involved in crashes stopped at roadside research surveys indicated that each .02 percent increase in blood alcohol level nearly doubles the risk of fatal crash involvement. For young drivers under 21, the fatal crash risk increases more with each .02% increase in blood alcohol level, in part because young drivers have less driving experience and more often take risks in traffic such as speeding, running red lights, and not wearing safety belts. However, in all age and sex groupings at a blood alcohol level of .05 percent to .09 percent, the fatal crash risk was at least nine times greater than at zero blood alcohol (Zador 1991).

Approximately two in five Americans will be involved in an alcohol related traffic crash at some point in their lives (NHTSA and National Institute on Alcohol Abuse and Alcoholism [NIAAA] 1996). Young people, people previously convicted for driving under the influence (DUI), and males are disproportionately involved in alcohol related traffic deaths. In addition, alcohol impaired driving often has an impact on innocent victims. In 1996, 40 percent of people killed in crashes involving drivers who had been drinking were persons other than the drinking driver (NHSTA 1997a).

RECENT U.S. INCIDENCE DATA

The recent U.S. record in decreasing alcohol-related traffic fatalities is remarkable. In 1982, there were 25,165 alcohol-related traffic fatalities, or 57 percent of traffic deaths, according the NHTSA. In 1996, alcohol was involved in 17,126 crash fatalities, 41 percent of that year's total. Hence, between 1982 and 1996, the number of alcohol-related fatalities dropped by 32 percent, and the proportion of crash fatalities involving alcohol fell by 28 percent (NHTSA 1997a)

Many improvements in traffic safety have occurred since 1982, such as the introduction of air bags in motor vehicles, adoption of laws requiring the use of child restraints in all 50 states and the enactment of legislation mandating the use of seat belts in 49 states. The decline in alcohol-related traffic deaths, however, was independent of these laws. Traffic deaths not involving alcohol increased 32 percent from 18,780 in 1982 to 24,781 in 1996.

The greatest declines in alcohol-related traffic deaths were among youth under 21. Among people age 15-20, alcohol-related traffic deaths declined by 57 percent between 1982 and 1996 from 5380 to 2315. The proportion of fatalities involving alcohol declined from 63 percent to 37 percent, a 42 percent reduction.

Despite this progress, the past two years have raised concern for prevention experts focused on alcohol-impaired driving. In 1994, there were 16,580 alcohol-related traffic fatalities. In 1995, the number of fatalities increased to 17,274, the first rise in nine years, and in 1996, the number stayed approximately the same at 17, 126. Among youth, alcohol-related fatalities increased 5 percent from 2201 in 1995 to 2315 in 1996, the first increase in seven years, and one which exceeded the 2 percent population increase in that age group. It is too soon to know whether this is only a temporary interruption of progress or the beginning of a disturbing new trend. What is clear, however, is that continued research is needed to expand the range of evaluated approaches for reducing alcohol-related traffic fatalities.

GRASS ROOTS ACTION

The establishment in the early 1980's of grass roots organizations such as Mothers Against Drunk Driving (MADD), Students Against Destructive Decisions (SADD), and Remove Intoxicated Drivers (RID) resulted in an unprecedented effort to change laws to reduce alcohol-impaired driving. The largest of these organizations, MADD, has played a crucial role. In addition to offering individual victims support services and widespread educational activities, MADD monitors research findings on alcohol-impaired driving and preventive interventions, and through legislative workshops and its Rating the States National Report Card presents findings from this research and other testimony to state legislators. MADD has been an important force that has contributed to the passage of more than 2000 state laws to reduce alcohol impaired driving since the early 1980's.

RATIONALE FOR LEGAL CHANGES TO REDUCE ALCOHOL IMPAIRED DRIVING

When deciding whether legal changes are needed to alter behaviors that affect health, several factors warrant consideration (Annas 1996). First, the health problem should be important . Second, there should be evidence that the laws are effective in reducing the problem. Third, there should be no equally effective less intrusive way to reduce the behavior. Fourth, if the behavior negatively affects people other than those engaging in the behavior, laws may be appropriate to protect these innocent victims.

Legal efforts to reduce alcohol-impaired driving have emphasized deterrence. Deterrence laws seek to prevent alcohol-involved driving – through swift, certain, and severe penalties if warranted (Ross 1992). Severity of punishment is less important in establishing deterrence than its swiftness and certainty (Ross 1992). Deterrence laws fall into two categories: (1) general deterrence laws, which aim to prevent the general public from ever driving after drinking, and (2) specific deterrence laws, which seek to prevent convicted DUI offenders from repeating their offense. Although convicted DUI offenders are at greater risk than other drivers for subsequent rearrest and crash involvement, most drivers in fatal crashes involving alcohol have never been previously convicted. In 1995, fewer than 13 percent of drivers in alcohol-related fatal crashes with a BAC of .10 percent or higher had a DUI violation on their drivers record during the three years prior to the crash (NHTSA 1996). In fact, two-thirds of persons arrested for DUI have never been arrested before (NHTSA 1995a,b). This underscores the need for laws and programs aimed at both general and specific deterrence.

METHODOLOGICAL PROBLEMS

The evaluation of policies and programs for drunk driving prevention is fraught with methodological difficulties. (DeJong and Hingson, in press).

The optimal research design for evaluating specific laws or programs would be a true experimental design, with large numbers of individual communities or states randomly assigned to either a treatment group that is exposed to the intervention or a control group that is not. With large samples, random assignment would ensure that extraneous variables that might influence the outcome measures are distributed equally across the two groups, meaning that any outcome differences between the groups could be attributed to the intervention itself, rather than to pre-existing differences between the jurisdictions.

Clearly, random assignment of laws to states or communities is politically and financially unrealistic. Therefore, to test the impact of a state or community initiative, researchers have used quasi-experimental designs in which outcomes for treatment communities or states are compared to similar non-treatment ("control") jurisdictions. A challenge for the quasi-experimental studies is to match the intervention and comparison states on relevant variables that might influence study outcomes (Cook and Campbell 1979).

Further, it is not uncommon for several laws or programs and to be initiated within a relatively short time, and to be implemented in the context of national publicity about the problem. This makes it difficult to separate fully the effects of each initiative. Moreover, people who drive after

heavy drinking (defined as five or more drinks consumed on a single occasion) are much more likely to engage in other risky driving behaviors, such as speeding, running red lights, driving after other drug use, and failing to wear seatbelts (Hingson et al. 1990). Therefore, studies need to control for shifts in legislation or law enforcement that might affect these other driving behaviors.

Another research option is the time-series design, which involves the analysis of survey data or other indicators over an extended period of time, both before and after the introduction of the intervention. This design can be used to evaluate national, regional, or local campaigns, subject to the availability of appropriate data. The design is only practical when there is a single event whose occurrence can be precisely defined in time, thus making it possible to make clear before-after comparisons.

Time-series modeling requires that reliable and valid data are available over a lengthy time period. In many cases, the only data available will be broad indicators, such as statistics on alcohol-related traffic fatalities. These data in turn require consistency in testing blood alcohol content of a high percentage of drivers in fatal crashes over time. In the U.S. in 1995, while 68 percent of fatally injured drivers were tested, only 24 percent of surviving drivers in fatal crashes were tested (NHTSA 1996a).

Because most states do not determine the BAC's of all drivers involved in fatal crashes, researchers often rely on proxy measures of alcohol involvement, such as single-vehicle, nighttime fatal crashes, which are three times more likely than other fatal crashes to involve alcohol. Even so, such crashes account for less than one half of all alcohol related fatal traffic crashes, which introduces imprecision in evaluating the effects of legislation or other programs, especially in short-term studies involving small jurisdictions (Heeren et al. 1985).

Imputational methods developed by Klein (1986) have been used by NHTSA to estimate annual alcohol involvement in fatal crashes at the national and state level. These estimates can be used in overall state monthly and annual summaries, but may be problematic when used in smaller subgroups such as cities, on specific age and gender groups, or at different times of day or days of the week.

Despite these methodological difficulties, researchers have been able to draw a number of conclusions about the effects of various legislative and programmatic interventions to reduce alcohol-impaired driving.

GENERAL DETERRENCE LAWS

Minimum Legal Drinking Age

In all states, it is illegal for persons under age 21 to purchase or possess alcohol. Numerous research studies indicate that raising the minimum legal drinking age (MLDA) to 21 reduces alcohol-related fatal crash involvement among youth (General Accounting Office 1987). Of the 29 studies completed since the early 1980's that evaluated increases in the MLDA, 20 showed significant decreases in traffic crashes and crash fatalities. Only three clearly found no change in

traffic crashes involving youth. The remaining six studies had equivocal results (Toomey T, Rosenfeld L, Wagenaar A 1996). States adopting MLDA's of 21 in the early 1980's experienced a 10 to 15 percent decline in alcohol-related traffic deaths among drivers in the targeted ages, compared with states that did not adopt such laws. NHTSA (1996b) estimated that MLDA's of 21 have prevented more than 16,500 traffic deaths since 1976, approximately 700 to 1,000 deaths annually for the past decade. MLDA laws not only have reduced drinking among persons under 21, they also have lowered drinking among people ages 21 to 25 who grew up in states with MLDA's of 21 relative to those who grew up in other states (O'Malley and Wagenaar 1991).

According to the Monitoring the Future annual survey of high school seniors, the proportion of respondents who drank in the previous month declined from 72% in 1980 to 51% in 1996, and the proportion who consumed five or more drinks on at least one occasion in the past two weeks declined from 41% to 30% (Department of Health and Human Services 1997).

Despite laws prohibiting the purchase or possession of alcohol by people under age 21, minors throughout the United States can easily obtain alcohol from many sources. Buyers who appear to be younger than 21 can successfully purchase alcohol from licensed establishments without showing age identification in 50 percent or more of their attempts (Forster et al. 1994, 1995; Preusser and Williams 1992). In addition, although many youth purchase alcohol themselves, most youth indicate that they generally obtain alcohol through social contact with persons over age 21 (Wagenaar et al 1996b). Laws prohibiting the sale and provision of alcohol to minors are not well enforced (Wagenaar and Wolfson 1995). For every 1,000 minors arrested for alcohol possession, only 130 establishments that sell alcohol to them have actions taken against them, and only 88 adults who purchase alcohol for minors face criminal penalties. Wagenaar and Wolfson (1994) estimate that only five of every 100,000 incidents of minors' drinking result in a fine, license revocation, or license suspension of an alcohol establishment. However, enforcement can reduce youth access to alcohol. Preusser and colleagues (1994) found dramatic reductions in alcohol sales to minors (from 59 percent at baseline to 26 percent one year later) following an enforcement campaign involving three "sting operations" in which underage males attempted to purchase alcohol. In this study, store owners were informed about the results of the initial sting, that additional stings would be conducted and potential penalties for selling to minors.

There are other measures to consider that might enhance compliance with the age 21 law: (a) use of distinctive and tamper-proof licenses for drivers under age 21; (b) "use and lose" laws that impose driver's license penalties on minors who purchase or are found in possession of alcohol; (c) keg registration or other limits on large container sales; and (d) increased penalties for illegal service to minors, including dram shop laws to make serving a minor a legal cause of action. Research is needed to establish whether these proposals would significantly reduce alcohol consumption and driving after drinking. (DeJong and Hingson, in press)

Criminal Per Se Laws

Every state except Massachusetts and South Carolina has adopted laws that make it a criminal offense per se to drive with a BAC above the state's legal limit, which is generally either 0.10 percent or 0.08 percent. The per se provision means that prosecutors do not have to introduce evidence other than BAC to demonstrate impairment, making convictions easier to obtain.

Administrative License Revocation

Thirty-nine states have administrative license revocation laws which allow a police officer or other official to immediately confiscate the license of a driver whose BAC exceeds the legal limit. License actions thus occur closer to the time of infraction and, by bypassing the court, are more swift and certain. Although these laws have faced some challenges for allegedly imposing double jeopardy on a driver who subsequently is convicted of DUI and receives additional penalties, no state supreme court has upheld such a challenge. In 1988, the Insurance Institute for Highway Safety conducted a nationwide comparison of administrative revocation laws, criminal per se laws, mandatory jail laws, and community service laws passed between 1978 and 1985 (Zador et al 1989). Administrative license revocation laws were accompanied by a five percent decline in fatal crashes, and a nine percent decline in single vehicle night fatal crashes, compared with a two percent fatal crash decline for other types of laws, such as criminal per se laws. Klein (1989) in a national state level time series analysis of the proportions of fatal crashes that were single vehicle at night examined the relative independent effects of administrative license revocation and criminal per se laws. He reported a median six percent post decline associated with administrative license revocation compared to a median one percent increase associated with criminal per se laws. Administrative license revocation insure more swift and certain license actions than criminal per se laws where license actions does not occur until after a trial if a guilty verdict is reached.

Zero-Tolerance Laws

Forty-five states and the District of Columbia have passed zero-tolerance legislation, laws that make it illegal for drivers under 21 to drive after drinking any alcohol. Laws setting legal BAC limits of 0.00 percent to 0.02 percent are considered zero-tolerance laws. A recent study (Hingson et al. 1994) compared the first 12 states that lowered legal BAC's for drivers under 21 with 12 nearby states that did not. States adopting zero-tolerance laws experienced a 20 percent greater decline in the proportion of single vehicle night fatal crashes among 15 to 20 year old drivers. States lowering BAC limits to 0.04 percent or 0.06 percent did not experience significant declines relative to comparison states in the proportion of single vehicle night fatal crashes among this age group. The study projected that if the remaining states adopted zero-tolerance laws and experienced comparable declines, 375 to 400 fewer fatal crashes would occur each year.

Some states have experienced difficulty in achieving broad awareness of the law. Studies in California and Massachusetts found that 45 to 50 percent of young drivers were unaware of the law. Blomberg (1992), in a quasi-experimental study of an awareness campaign involving public service announcements about Maryland's zero-tolerance law, found a one-third greater decline in alcohol-involved crashes among drivers receiving intensive education than among drivers who received no intensive education.

Of note, nationwide alcohol-related traffic fatalities among 15-20 year olds increased 5 percent in 1996, 2315 compared to 2206 in 1995. Fifty-seven percent of the increase (62/109) occurred in the 14 states that had not implemented zero-tolerance laws by the end of 1996. As a group, states without a zero tolerance law experienced a 9 percent increase compared to a 3 percent increase in states with zero tolerance laws.

An important question that warrants research attention is whether Zero Tolerance laws with criminal per se provisions are more or less effective than those with administrative license revocation only. Also, the effects of different penalty severities warrants study.

The 0.08 Percent Per Se Laws for Drivers Over Age 21

Fifteen states have adopted criminal per se laws lowering the legal BAC 0.10 percent to 0.08 percent. Massachusetts has set the BAC for its administrative license revocation law at 0.08 percent. To reach a blood alcohol level of .08 percent, a 170 pound man would have to consume four drinks in an hour on an empty stomach. A 135 pound woman would need to consume three drinks (NHTSA 1997).

Research on California, the largest state to adopt a 0.08% law indicated a 12 percent post law decline (NHTSA 1991). However, California implemented an administrative license revocation law six months after the 0.08 percent law and one study concluded most of the 0.08 percent law decline in alcohol-related fatal crashes occurred after the administrative license revocation provisions (Rogers 1995).

Johnson and Fell (1995) monitored six different measures of driver alcohol involvement in the first five states to adopt 0.08 percent per se laws and identified several statistically significant pre to post law decreases. However, specific comparison areas with different per se limits were not included; the study therefore could not determine whether post law declines were independent of general regional trends. It did conclude .08% law declines were independent of national trends.

A subsequent analysis (Hingson et al 1996*a*) paired the first five states to adopt a 0.08 percent legal BAC limit with five nearby states that retained the 0.10 percent legal limit. As a group, relative to comparison states, states that adopted the 0.08 percent limit experienced a statistically significant 16 percent post law decline in the proportion of fatal crashes involving fatally injured drivers at 0.08 percent BAC and higher. These results were similar to those in the United Kingdom and France when they first combined 0.08 percent laws with automatic license suspension (Ross 1982). The five U.S. 0.08 percent states also experienced a statistically significant 18 percent post law decline in the proportion of fatal crashes involving fatally injured drivers at 0.15 percent BAC and higher. Four of the five 0.08 percent states experienced greater post law declines than did comparison states. In the three largest of the five 0.08 percent states, the declines were significantly greater than in their respective comparison states. Those three pairs of states accounted for more than 90 percent of the fatal crashes in the study. The only pair of states that did not reveal results in the predicted direction, Vermont/New Hampshire, accounted for only one percent of the nearly 100,000 fatal crashes studied. During the pre and post law period, 88 percent of fatally injured drivers were given blood alcohol tests in 0.08 percent states.

Compared with 0.10 percent states, the 0.08 percent states may have been more concerned about alcohol-impaired driving and more responsive to legislative initiatives to reduce the problem. All five 0.08 percent states had administrative license revocation laws during the study period, three of which were implemented within one year of the 0.08 percent laws. This potential effect restricted the study's ability to separate the effect of 0.08 percent laws from that of administrative license revocation laws. Administrative license revocation laws have been associated with a five

percent decline in fatal crashes and as much as a nine percent decline in alcohol-related fatal crashes. Only in Maine was administrative license revocation in place throughout the pre law analysis period prior to adoption of the reduced BAC limit. Thus, Maine was the only state where it was possible to identify an independent effect of the 0.08 percent law.

The results of this study suggest that 0.08 percent laws combined with administrative license revocation can reduce the proportion both of fatal crashes involving drivers and of fatally injured drivers at 0.08 percent BAC or higher and at 0.15 percent BAC or higher. The study projected that if all states adopted 0.08 percent laws, particularly in combination with administrative license revocation, at least 500 to 600 fewer deaths would occur on the Nation's roadways each year.

In 1994, Massachusetts simultaneously introduced a 0.08 percent BAC and administrative license revocation laws. Statewide randomized telephone surveys in 1993 (i.e., before the 0.08 percent BAC law was implemented) and in 1996 (i.e., after the law was implemented) revealed clear shifts in public perceptions of how much drivers could drink and still drive safely and legally. The proportion of respondents who believed they could consume four or more drinks and drive safely declined from 24 to 15 percent, and the proportion who felt they could drive legally after more than four drinks dropped from 18 to 9 percent. At the same time, the proportion of respondents who believed drunk drivers would have their license suspended before a trial rose from 47 to 71 percent. In addition, the proportion of drivers who reported driving in the past month after consuming four or more drinks declined from 9 to 4 percent (Massachusetts Governor's Highway Safety Bureau 1996). Of note, even among persons who reported consuming 10 drinks on a single occasion at least once during the month preceding the interview there were significant reductions after the .08% law and in the proportion who believed they could drink 4 or more drinks and drive legally. The proportion of those heavy drinkers who reported driving after 4 or more drinks declined significantly after the law.

In 1993-1994, six additional states adopted 0.08 percent criminal per se laws. Those states were paired with six contiguous or very nearby states with the largest population, highest level of testing blood alcohol content of drivers in fatal crashes, and similar pre 0.08 percent trends in alcohol-related fatal crashes. The maximum available equal pre and post 0.08 percent law number of years of fatal crash data were examined in each pair. Kansas adopted a .08% law in July of 1993 and was compared with Oklahoma from July 1990 - June 1996. North Carolina adopted its 0.08% law in October 1993 and was compared with Tennessee from October 1990 - September 1996. Florida, New Mexico and New Hampshire adopted 0.08% laws in January 1994. They were compared respectively with Georgia, Colorado, and Connecticut from January 1991 - December 1996. Virginia adopted its 0.08% law in July 1994 and was compared with Maryland from July 1992 - June 1996.

As a group, the 0.08 percent law states experienced a 16.2 percent post law reduction in the proportion of fatal crashes that involved alcohol (0.10 percent or higher) from .371 (5367/14,475) to .311 (4890/15,710). The comparison states also experienced a 11.3 percent decline from .354 (4203/11,879) to .314 (4049/12,908). The post 0.08% law decline was 1.39 times greater in 0.08 percent law states, $p<.02$. Five of six 0.08% law states experienced greater post 0.08 percent law declines. Results were similar when the proportions of fatal crashes with alcohol at 0.01 percent or higher were examined. (Data available upon request.)

Similarly, the 0.08 percent law states experienced a 20.7 percent post law decline in the proportion of drivers in fatal crashes with positive blood alcohol levels (0.10 percent or higher). The decline was from .213 (4608/21,708) to .169 (4051/23,908). The six comparison states experienced a smaller 13.9 percent decline from .216 (3814/17,641) to .186 (3630/19,486). The post 0.08 percent law decline was 1.49 times greater in 0.08% law states, $p<.01$, and all 0.08 percent law states had greater post law declines than the comparison states. Results also were similar when we examined the proportion of drivers in fatal crashes with BAC's at 0.01 percent or higher. (Data available on request.)

Of note, the non .08 percent law comparison states experienced very similar trends on study outcomes during the pre and post .08 percent law study period as all remaining states in the U.S. without .08 percent laws. There were no significant differences on study outcomes over time during the study period between comparison non .08 percent law states and other non .08 percent law states.

Also of note, four of the 0.08 percent states had administrative license revocation (ALR) laws in place prior to the entire analysis period: Kansas, North Carolina, Florida, and New Mexico. Hence, (ALR) laws in those states could not confound 0.08 percent law study effects. As a group, the four 0.08 percent law states had a 17.2 percent post law decline in the proportion of fatal crashes involving alcohol, at 0.10 percent or higher, .377 (4735/12,564) to .312 (4281/13,700) compared to a 13.2 percent decline in comparison states, .364 (3571/9816) to .316 (3422/10,849). This was a 1.30 times greater decline in those four 0.08 percent law states, $p\approx.07$. Similarly, those four 0.08 percent law states experienced a 21.2 percent post 0.08 percent law decline from .212 (4026/18,968) to .167 (3505/20,970) in the proportion of drivers in fatal crashes at 0.10 percent or higher. Their comparison states experienced a smaller 15.6 percent decline, .223 (3265/14,612) to .189 (3090/16,394). This was a 1.36 times greater decline in .08 percent law states, $p=.01$. Similar significant ($p<.04$) effects were seen when examining the proportions of drivers in fatal crashes at .01 percent or higher.

Thus, independent 0.08 percent law effects were seen in these states, albeit smaller than in the effects seen in studies of states adopting 0.08 percent and ALR in combination or close proximity (Hingson 1996; Rogers 1995). It appears 0.08 percent laws have effects independent of ALR laws, but their greatest impact is when .08 percent laws are enacted in combination with ALR, administrative license revocation. Currently 11 states which experienced 20 percent of the alcohol related fatal crashes in the U.S. in 1996 have adopted neither 0.08 percent laws nor administrative license revocation.

SPECIFIC DETERRENCE LAWS

Persons convicted of alcohol-impaired driving are more likely than other drivers to be subsequently arrested for driving while intoxicated and to be involved in alcohol-related crashes (NHTSA and NIAAA 1996). Specific deterrence laws seek to reduce this recidivism through license actions, treatment or rehabilitation, jail sentences, dedicated detention, probation, actions against vehicles and vehicle tags, lower legal BAC's for offenders, or some combination of these measures.

License Actions

Mandatory license suspensions are more effective than discretionary suspension in reducing total crashes and violations. Their effectiveness is attributed to the fact that the laws generate a perceived certainty of punishment and reduce the influence of judicial discretion. Evidence also indicates that diversion to treatment with either a restricted or a limited license leads to higher crash and violation rates than full license suspension. Several studies also report that full license suspension reduces DUI recidivism. Much of this benefit may result from reduced driving exposure.

NHTSA and NIAAA (1996) prepared *A Guide to Sentencing DUI Offenders* and reported the following:

- Suspension periods between 12 and 18 months appear to be optimal for reducing DUI recidivism.
- Suspension periods of less than 3 months seem to be ineffective.
- Although more than 50 percent of persons with suspended licenses continue to drive, they seem to drive less frequently and more cautiously in order to avoid arrest.

Treatment or Rehabilitation

Wells-Parker and colleagues (1995) recently completed a meta-analysis of treatment efficacy for DUI offenders. Compared with standard sanctions (i.e., jail or fines) or no treatment, rehabilitation generated a 7- to 9- percent reduction in the incidence of alcohol-related driving recidivism and crashes when averaged across all typed of offenders and rehabilitation. Alcohol-related crashes and violations constitute only a minority of total crashes and violations. Actions to restrict license use (e.g., daytime-only driving permits) combined with some kind of remedial treatment have been found to be more effective in preventing alcohol-related traffic incidents than full suspension.

The analysis by Wells-Parker and colleagues (1995) also indicated that treatments combining punishment strategies, education, and therapy with followup monitoring and aftercare were more effective for first-time as well as repeat offenders than any single approach. For example, combining treatment with licensing action was more effective than either tactic alone. According to this analysis, treatment alone never substitutes for sanctions or remedies, and remedies and sanctions do not substitute for treatment. Finally, weekend intervention programs designed to evaluate alcohol and other drug abuse and create an individualized treatment pan for offenders have been found to produce lower recidivism rates than jail, suspended sentences, or fines.

Jail Sentences

Although incarceration incapacitates drivers during the period of confinement, minimal evidence exists on the postincarceration effect of jail. Nichols and Ross (1990) examined the specific deterrent effects of jail sentences for first-time and repeat DUI offenders in a review of more than 80 studies of legal deterrence. Eight studies reported no reductions in DUI recidivism as a result

of jail sentences, and only one recent study provided reasonably convincing evidence of a 3-year reduction for first-time repeat offenders who received mandatory 2-day jail sentences in Tennessee. In one study, long periods of incarceration were actually associated with higher recidivism (Mann et al. 1991). Although jail sentences may have some short-term general deterrent effects, as well as deterrent effects for first-time offenders, mandatory jail sentences tend to affect court operations and the correctional process negatively by increasing the demand for jury trials and plea bargains and by crowding jails (NHTSA and NIAAA 1996).

Dedicated Detention

Detention facilities specifically for DUI offenders can offer both incapacitation and supervised rehabilitation services. One program of this type, in Prince Georges County, Maryland, has been found to reduce recidivism among both first-time and repeat offenders (Harding et al. 1989).

Probation

The 1996 NHTSA-NIAAA review of sentencing options found that probation may slightly reduce recidivism among drivers at low risk for being repeat offenders, but probation alone does not measurably reduce recidivism among those at high risk. The effects of intensive supervised probation with treatment and in-home confinement with electronic monitoring have recently been evaluated by Jones and Lacey (1996). They found significant decreases in recidivism due to both of those programs relative to comparison groups.

Actions Against Vehicles and Tags

Although license actions have been shown to reduce recidivism, many people with suspended licenses continue to drive. Unlicensed drivers can be apprehended only when police have probable cause to stop their vehicle. Washington and Oregon have enacted legislation that allows police to seize the vehicle registration of drivers caught driving after suspension, leaving the motorist with a temporary, 60-day registration. A sticker on the vehicle gives the police probable cause to stop the vehicle to ask for proof of license. Researchers have reported evidence of the law's effectiveness in Oregon but not in Washington. (Voas and Tippetts, 1994)

Voas et al. (1997) examined the effects of a 1993 law in Ohio that permitted vehicle immobilization of drivers who drove even though their license was suspended for a DUI. Immobilization was 30 days for a first time offender, 60 days for a second time offender, and 180 days for a third time offender. Third and fourth time offenders were also subject to vehicle forfeiture. In a two year follow-up study, they found reductions in driving while suspended and driving under the influence recidivism among those whose vehicles were immobilized or impounded both before and after they reclaimed their vehicles relative to offenders whose vehicles were not impounded.

Rodgers (1994) measured the effectiveness of the 1988 license-plate impoundment law for one-third of the DUI offenders in Minnesota. During the 29 months that the courts administered the system, only 6 percent of 7,698 eligible third-time offenders had their licenses impounded. During the 21 months in which the law was managed through the Department of Public Safety, 68 percent of the 4,593 third-time DUI offenders had vehicle plates impounded. The law had

little deterrent effect while the courts administered the system. In contrast, when the program was managed administratively, offenders who lost their plates had a lower rate of recidivism than those who did not.

Another approach – ignition interlocks to prevent vehicle operation when a driver's breath alcohol exceeds a designated limit has been found to reduce recidivism, but recidivism may rise after the device is removed. In Maryland, 1380 multiple DUI offenders whose driver's license was suspended or revoked were at the time of license reinstatement randomly assigned to either a treatment program or an experimental interlock program (Beck et al., in press). One year after assignment the alcohol traffic violation rate was significantly lower for participants in the interlock program.

The NHTSA-NIAAA (1996) sentencing guide identified several other sentencing approaches that have not been systematically evaluated, including financial sanctions, publication of offenders' names in newspapers, attendance at victim-impact panels, victim-restitution programs, and court-ordered visits to emergency rooms.

Lower Legal Blood Alcohol Limits for Convicted DUI Offenders

Despite the fact that persons convicted of DUI are more likely than other drivers to be subsequently arrested for DUI or to be involved in crashes almost all states allow the same legal BAC for these drivers as for drivers who have never been convicted of DUI. One exception is Maine. In 1988, the state set the legal limit at 0.05 percent for drivers previously convicted for DUI, lower than the 0.08 percent limit for other drivers. Convicted drivers have their licenses reinstated on the provision that they will be administratively suspended if they are caught driving with BAC's above .05 percent. This law reduced fatal crashes involving drivers previously convicted of DUI (Hingson 1995). During the first five years of the law compared to the preceding ten years, the annual number of fatal crashes involving drivers previously convicted of OUI declined 23%, from 16.7 to 12.8, while in the rest of New England it rose 24%, from 52.9 to 65.6, $p<.001$.

Because of these benefits, Maine adopted a Zero Tolerance Level for Convicted Offenders in 1995.

ENFORCEMENT OF IMPAIRED DRIVING LAWS

The extent to which drunk driving laws are enforced can influence their impact on impaired driving. Drunk driving arrests increased dramatically between 1978 and 1983, from 1.3 to 1.9 million, but arrests have dropped each year since then, to 1.4 million in 1994 (NHTSA 1996b).

The most dramatic example of the potential deterrent impact of police enforcement of drunk-driving laws occurred in Australia in New South Wales and Victoria, where random breath testing was introduced on a massive scale. In a given year, as many as one driver in three was stopped by the police. There was an immediate 37 percent drop in alcohol-related fatal crashes, compared with the previous three years, and a sustained 24 percent decrease over the next five years. (Homel, 1994)

In the United States police must use surveillance or sobriety checkpoints at designated high risk areas which usually involve several patrol officers. Several studies have demonstrated the effectiveness of sobriety checkpoints. According to one study in California, regardless of whether 3 to 5 or 8 to 12 officers were used or whether single or multiple locations were used in an evening alcohol related crashes were reduced. (Stutser and Blower, 1995)

Perhaps the most extensive statewide sobriety checkpoint program in the U.S. was implemented in Tennessee. From April 1994 through March 1995 more than 150,000 drivers were stopped at 900 checkpoints widely publicized on television, radio, and in newspapers. The program yielded a 22 percent reduction in alcohol related fatal crashes relative to five contiguous states during the same time period (Lacey and Fell,.1997)

Of course, enforcement is most effective if highly publicized and police are most likely to actively pursue enforcement if they believe they have strong community backing. Evidence is emerging that comprehensive community interventions that coordinate the efforts of multiple departments of city government with that of private citizens and that link education and enforcement can enhance the effects of legislation to reduce alcohol related traffic crashes, injuries, and death (Holder et al 1997, Hingson et al 1996).

ALCOHOL CONTROL POLICIES

In addition to laws that seek to deter drinkers from driving other laws have attempted to reduce alcohol impaired driving deaths by reducing alcohol consumption.

There are a number of policies that control the availability of alcohol discourage drinking, particularly among persons under 21. Restricting sales to government run monopolies, limiting the number and location of alcohol outlets, reducing hours and days of sale have all been demonstrated to reduce alcohol consumption. Density of alcohol outlets has also been found to be related to increased numbers of alcohol related crashes.

Taxes

As alcohol becomes more expensive consumption drops even among heavy and dependent drinkers. Increases in beer taxes have been shown to reduce motor vehicle fatality rates for persons 15 to 24(Saffer and Grossman, 1987). Between 1975 and 1990, the real prices declined for distilled spirits by 32 percent, wine 28 percent and beer by 20 percent. Chaloupka (1993) has recently summarized the work of Cook 1981, Saffer and Grossman 1987a, 1987b which consistently found that alcohol tax increases can reduce alcohol related traffic fatalities. Of note, Cook found that a $1 increase in state excise tax on distilled spirits lowered both per capita consumption and cirrhosis death rates at the same rate. That means that even heavy chronic addictive drinking likely to be found among persistent drinking drivers can be influenced by tax increases.

Grossman and colleagues (1991) examined motor vehicle fatalities using a time series of annual state cross sections covering the 48 contiguous states from 1982-1988. Three different fatality rates were examined both for the overall population and for young people age 18 to 20. The

effect of the recent 1991 tax increase on alcohol was simulated. They reported that had the 32 cent per six pack tax been present throughout the period, an estimated 1,744 fewer people might have died each year and 671 of those each year would have been 18 to 20 year olds. They further estimated that if beer tax had been set at 81 cents per six pack from 1982-1988 (based on a tax of 25 cents per ounce of pure alcohol) an estimated 7,142 fewer people of all ages would have been killed annually, 2,187 of whom would be youth and young adults, a considerably greater life saving in the 18-20 year old age group than has been attributed to the minimum legal drinking age of 21.

Server Intervention

The largest single point of departure of alcohol impaired drivers in the U.S. is bars and restaurants (McKnight, 1993). Between one-third and one-half of intoxicated drivers consumed their last alcohol at these locations based on drivers given alcohol tests in roadside surveys (Palmer 1988 and Foss 1990) and drivers injured in automobile crashes (Santona and Martinez, 1992). Breath tests given patrons leaving bars have revealed that approximately one-third have BAL's above the legal limit (Werch, 1988, Stockwell, 1992).

Worden (1989) reported a community study in which bartenders and counter clerks were trained to demonstrate the use of calculators to identify customer BAC levels based on customer weight and the number of drinks consumed. Television spots reinforced the messages. Roadside surveys conducted in both the intervention and the comparison communities before the program was implemented and 6 months after it was implemented revealed no differences between communities before the program was initiated. At the 6 month survey, 5.8 percent of nighttime drivers in the program communities had BAC's of 0.05 percent or higher, compared with 11.1 percent in the comparison communities.

Yet research indicates servers rarely refuse drinks to intoxicated patrons. McKnight (1991) reported that in more than 1,000 visits to 238 drinking establishments in 8 states, research personnel simulating obvious signs of intoxication were refused a drink only 5 percent of the time.

During the 1980's, server training programs proliferated and in some communities and in some states server training became a condition of licensing.

McKnight (1996) divides server training programs into awareness, server and manager programs. Awareness courses seek to persuade community leaders of the need for these courses. Server courses help servers avoid serving alcohol to minors and intoxicated patrons. Management courses discuss ways to enhance hospitality that do not encourage over drinking.

Evaluations of server training have produced mixed results but some studies show they can modify serving practices that help reduce the rate and amount of alcohol consumed by patrons (Salz, 1987).

The first controlled evaluation of server training was completed by Salz (1987) in a naval base bar in San Diego. Compared to a matched bar which received no server training, the bar that received training experienced reductions in self reported consumption of customers and actual BAL levels.

Geller, Russ and Delphos (1987) and Gliksman and Single (1988) in separate studies found server training yielded more direct interventions with intoxicated customers.

Hennessey (1991) evaluated server training in civilian alcohol establishments in 2 Northern California communities. He found lower BAL's among customers in one community but no effect in others. McKnight (1987) found server training yielded more interventions with customers following training in Michigan but not Louisiana.

The magnitude of change however, is not always large. McKnight (1991) compared 100 establishments in 8 states given extensive server training to 138 establishments that did not receive training. He reported that the rate of refusal of service to researchers simulating intoxication increased only from a baseline of 5 percent to a post training 7 percent while intervention with truly intoxicated patrons increased from 3 percent to 6 percent.

Holder and Wagenaar (1994) published the first evaluation of mandated server training on a statewide level that examined the effects of the law on single vehicle night time crashes. Oregon in 1985 became the first state to mandate server training. Effective January 2, 1987, all new applicants for beverage service permits were required to successfully complete a state approved server training course. The bill also required all persons holding alcohol retail licenses or applying for new licenses to complete management training programs on the five year anniversary when their permit expired resulting in all license holder being trained by 1991. By the end of 1988, 36,000 servers and 6,000 owner managers had completed the course and an additional 13,000 new servers completed it each year.

An ARIMA time series analysis comparing Oregon to the rest of the contiguous U.S. states from 1976 to 1990 indicated that in the first 6 months of the law, single-vehicle nighttime crashes declined 4 percent. The decline increased to 11 percent by the end of the first year, 18 percent the end of the second year, and 23 percent the end of the third year.

Unfortunately, the authors did not have direct evidence of changes in alcohol server behavior although 68 percent of those who completed the course self reported changes in their behavior (Oregon Liquor Control Commission). This makes it difficult to assess whether all of the substantial 23 percent reduction can be directly attributed to this specific legislation.

Sanctions Against Service to Intoxicated Persons

Active enforcement can enhance the effects of server training laws. All states have either criminal or civil sanctions against serving patrons who are obviously intoxicated (Holder 1992). McKnight (1993) found that frequency of service intervention or termination with intoxicated patrons dropped from 84 percent to 47 percent after visits and warnings by law enforcement. It then rose to 58 percent several months later. There was a corresponding drop in the percentage of persons arrested for DUI who came from a bar or restaurant from 32 percent to 23 percent.

Dram Shop Laws

All but 7 states recognize some form of server liability either by legislative enactment or by common law principally. These regulations permit persons to sue for damages they may have incurred as a result of service to a minor or intoxicated patron.

Wagenaar and Holder (1991) studied single vehicle night time motor vehicle crashes that resulted in injury or death following major dram shop cases in Texas in 1983 and 1984 and reported declines of 6.6 percent and 5.3 percent respectively when compared in a time series analysis to the rest of the contiguous United States. The reductions occurred when the cases were filed not when the verdicts were reached suggesting pre trial publicity had an impact on server behavior in establishments throughout the state.

State Monopoly vs. Privatized Sales Outlets

Eighteen states have some form of monopoly control. Gruenwald in a recent review (1993) concluded physical availability of spirits is greatest in license states and least in monopoly states. Physical availability of beer is greatest in monopoly states and least in license states and alcoholic beverage prices tend to be greatest in monopoly states.

However, relatively little research has examined the impact of state alcohol sales regulation on alcohol use or related problems. Implementation of liquor by the drink in North Carolina resulted in an increase in spirits sales between 6 and 7 percent. Police reported alcohol related accidents and single vehicle night time accidents both rose 16 to 24 percent (Blose and Holder 1987, Holder and Blose 1987).

Conversion of Iowa and West Virginia from monopoly to license states (allowing private retail sales of wine and spirits resulted in increased sales of alcoholic beverages in both states (Wagenaar and Holder 1991, Holder and Wagenaar 1990). Unfortunately, those analyses did not examine the impact of increased sales on alcohol related traffic crashes thus leaving questions about the effects of these policies.

Outlet Density

Gruenwald et al have also reported that greater the geographic spread between people and outlets and the lower the ratio of outlets to people the lower the observed sales of alcohol. A state level 10 percent increase in outlet density results in a 4 percent increase in sales of spirits and a 3 percent increase in sales of wine. Research by Relch and colleagues (1986) and Watts and Rabow (1983) suggest the greater physical availability of alcohol is related to higher arrest rates for public drunkenness and drunk driving.

Dull and Giacopassi (1988) examined alcohol control regulation (wet vs. dry) and outlet density in 95 counties of Tennessee. After analytically controlling for population size, percent change in population, urbanization and percent non-white they found both outlet density and absence of restrictions on alcohol sales were associated with increased motor vehicle mortality.

CONCLUSIONS

Since the early 1980's, the United States has experienced marked reductions in alcohol related fatal crashes particularly among persons 15-20. A large part of this decline has resulted from the passage of state level legislation such as

- general deterrence laws
  - minimum legal drinking age of 21
  - criminal per se legislation
  - administrative license revocation
  - zero tolerance laws for drivers under 21
  - .08% legislation for adult drivers

- and specific deterrence laws
  - mandatory license suspension
  - mandatory treatment and rehabilitation
  - dedicated detention and probation
  - actions against vehicles and tags.

Most of this legislative activity was stimulated at the state level, although federal initiatives did promote passage of age 21 minimum drinking ages and zero tolerance laws. Key to the passage of this state level legislation has been the work of grass roots citizen activist groups such as Mothers Against Drunk Driving and Remove Intoxicated Drivers and the political coalitions they have formed with medical, public health, community, and business groups.

Active enforcement and education about these laws at the community level is critical to their success. The evidence is clear from numerous studies that highly publicized educational and police enforcement can enhance the benefits of state level legal changes.

In recent years, researchers have also begun exploring the potential of comprehensive interventions at the community level. Coordination of the efforts of multiple departments of city government with that of private citizens has lead to promising new educational strategies and alcohol related crash reductions. Certain alcohol control policies can also be implemented at he community level such as

- server intervention programs
- enforcement of alcohol service laws
- zoning alcohol outlet density.

Taxation and state monopoly as opposed to privatization of alcohol sales can also influence alcohol availability, particularly to young drivers.

Despite the overall dramatic reductions since the early 1980's, alcohol related traffic deaths have not declined in the last three years and actually increased 5 percent last year among persons 15-20. One possible contributing factor has been a decline in police enforcement. Drunk driving arrests nationwide have declined 23 percent since 1983 (Hingson 1996). Respondents in a 1995 national survey of 4000 randomly selected drivers believed people who drink and drive are more

likely to be in an crash than to be stopped by the police. Only 23 percent of the respondents thought it very likely that people who driver after drinking will be stopped by the police, down from 26 percent in 1993 (NHTSA 1996).

Declining arrest rates are attributed by some to reductions in the numbers of intoxicated drivers on the road, but estimates indicate only one arrest is made for every 300-1000 drunk driving trips (Voas and Lacey 1989). Another possibility is that the public views the alcohol impaired driving problem as less urgent than in the early 1980's. An important task for those concerned about the million alcohol related injuries and 17,000 alcohol related traffic deaths annually, is to rekindle public concern about this problem.

In the early 1980's, the formation of citizen groups like Mothers Against Drunk Driving reflected a sense among the public that private citizens could participate in identifying more effective solutions to the problem, and indeed many needed legislative reforms at the state level were enacted. These laws have the greatest impact in reducing alcohol impaired driving when actively enforced and publicized at the community level. Consequently, developing new ways to also engage collaboration and involvement of private citizens to work with multiple departments of government at the community level is a key challenge for the next decade.

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ROAD SAFETY MEASURES FOR PROFESSIONAL DRIVERS: A COMPARISON OF FOUR DIFFERENT SAFETY MEASURES

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ABSTRACT There are many different potentially effective measures available to improve driving behaviour and safety among professional drivers. In order to decide which measure should be chosen in the Swedish telephone company, an experiment was carried out where four different measures were compared. The four measures were specially adjusted versions of driver training with risk awareness, group discussions about road safety problems and countermeasures, seasonally relevant campaigns, and monetary bonuses to groups of drivers for accident free driving. Compared to a control group the driver training and the group discussions were shown to reduce accident involvement. Campaigns and bonuses did not improve safety significantly.

OBJECTIVES

The problem of traffic accidents within a company need not be extremely large to cause large personal suffering and economic costs. This is why many companies have a serious interest in finding effective measures to reduce accident involvement. It is, however, not easy to decide what measures to introduce, since there are uncertainties about predicting the effect of most types of safety actions.

This uncertainty was the main reason why the Swedish telephone company asked VTI to help them find the best way to reduce the accidents among their professional drivers. Their accident statistics were not extreme in any way, but nevertheless the consequences for the company and for the drivers involved were severe enough.

METHODS

A study was designed where four different measures were carried out in four different groups of drivers. The measures were as follows (driver training and group discussion will be discussed further below):

- **Driver training**: Focus on risk awareness, no skill training (except manoeuvring of the vehicle in low speed and narrow places). The different blocks of training included were low speed manoeuvring, risk awareness on icy roads, commentary driving and general driving style.

- **Group discussions**: A carefully designed series of discussions concerning road safety related problems and how these problems could be solved by the company and by the driver

- **Campaigns**: Five specially designed campaigns covering important season dependent road safety aspects throughout the year. The aim of the first campaign was to introduce the safety work and to motivate the drivers to be interested in the measure. The second part took place during the autumn and covered driving in darkness, stopping distances and warning for the first ice on the road. The specific winter problems were covered during the third campaign, which included low friction, tyres, etc. The spring campaign included aspects of unprotected road users as well as a number of company specific problems such as loading tools and equipment. On the fifth and last occasion, the content of the other four campaigns was summarised and discussed in a meeting.

- **Bonus**: Units of drivers could earn money by reducing their accident involvement. A group of 30 drivers could earn about $2000. Due to Swedish taxation rules the money had to be used by the group in some common activity such as a party, buying some sports equipment or sponsoring a trip somewhere.

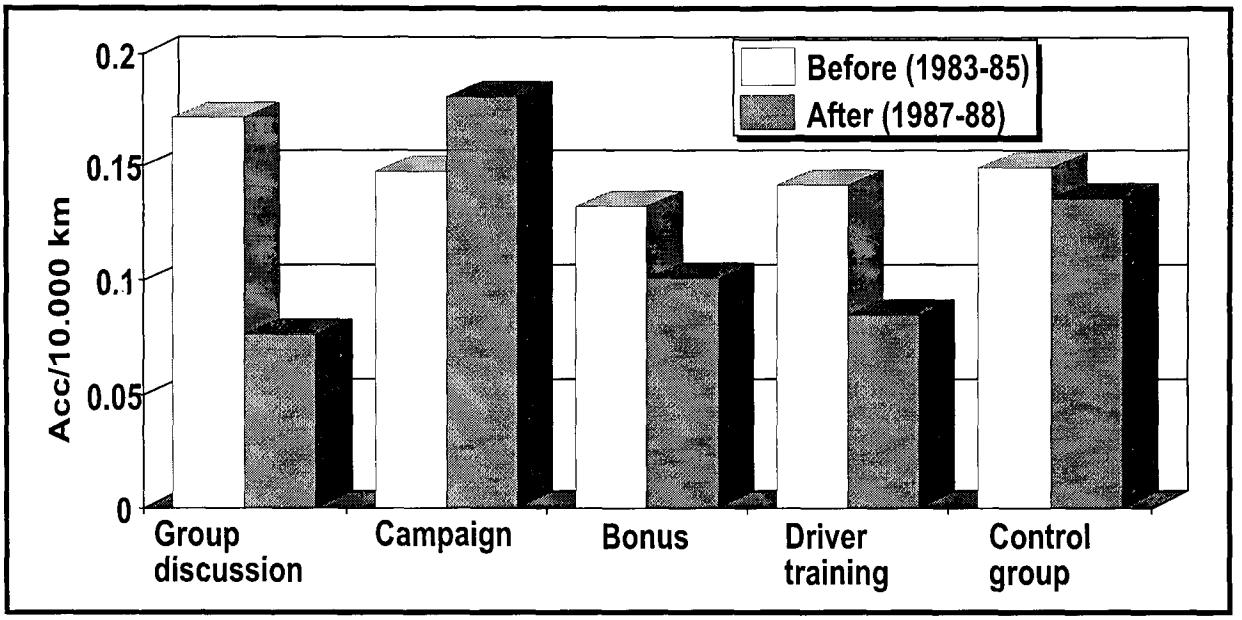
Each measure was introduced in one of the four groups of drivers. An additional group was used as a control group. The groups were randomly distributed. The sampling units were small organisational units of drivers instead of individual drivers in order to make it possible to carry out the measures within the existing organisation structure of the company. Each of the five groups consisted of approximately 900 drivers.

The effect of the measures was evaluated in terms of accident risk (accidents per kilometre). The data were based upon the internal registers of accidents and mileage.

RESULTS

The results showed the two groups who got driver training and group discussion were the ones who reduced their accident risk significantly. The size of the reduction was 40-50%. The other two measures did not succeed in this respect. In Figure 1, the accident risk of the five groups before and after the actions is shown. The risk calculations are based on the figures of accidents and exposure presented in Table 1. The change of risk in the control group is very small and not significant. In the comparative analysis of change the reduction of accident risk in the bonus group was not significant. More detailed results and calculations are presented by Gregersen et al 1996.

Figure 1. Accident risk before and after the measures in the five groups. The time indicator t_0 is when the groups were selected and the measures were started. Time t_{-1} shows retrospective data of the risk 3 years before t_0, while t_1 indicates the period of 1.5 years after the interventions.



Driver Group	Before		
	Culpable accidents	Total exposure in km	Accidents per 10,000 km
Bonus	369 (123)	27,883,610 (9,294,537)	0.1323
Driver training	311 (104)	22,0019,40 (1,333,980)	0.1414
Group discussions	333 (111)	19,833,780 (6,611,260)	0.1719
Campaigns	272 (91)	18,394,190 (6,131,397)	0.1479
Control	426 (142)	28,520,760 (9,506,920)	0.1494

Driver Group	After		
	Culpable accidents	Total exposure in km	Accidents per 10,000 km
Bonus	131 (87)	13008990 (8,672,660)	0,101
Driver training	78 (52)	9187280 (6,124,853)	0,085
Group discussions	63 (42)	8267720 (5,511,813)	0,076
Campaigns	155 (103)	8563536 (5,709,024)	0,181
Control	121 (81)	8930140 (5,953,427)	0,136

Table 1 Data on number of accidents and exposure in the five groups. The time indicator t_0 is when the groups were selected and the measures were started. Time t_{-1} shows retrospective data of the risk 3 years before t_0, while t_1 shows the period of 1.5 years after the interventions. Figures within brackets represent one-year averages.

WHY DID THE ACTIONS SUCCEED THE WAY THEY DID?

The interesting question arising from these very promising results is why the measures of driver training and group discussion succeeded the way the did. The experiment described above has only showed that the two measures were effective in reducing accidents, not why. In the case of driver training, the specific design used in this study has not been experimentally compared with other types of driver training, only with the other three completely different measures. It is thus impossible to say if this type of driver training has the best design or the best combination of blocks. There is, however no question that something in the two successful measures is worth using again. In the following sections these matters will be discussed.

Driver training

To explain the design of the training, a dichotomy of training strategy, skill training and risk awareness training will be used. We are all well aware of the problem of proving the effects of further training of drivers. One possible explanation to why driver training often fails in reducing accidents is the problem of defining the content of a good safety oriented training. Most of the existing courses are developed on the basis of an assumption that a skilled driver is also a safe driver. This is, however, not necessarily the case. The benefit of skill depends on what the skills are used for which depends on what motives are important for the driver at different times.

Many different types of motives may be satisfied during driving. The safety motive is one thread in a web of motives which differs between drivers and continuously changes during driving. This web of motives will also influence the driving behaviour and govern what the driver will use different skills and other potential safety margins for. The need to avoid accidents is one of the motives that normally is satisfied since the probability of accident involvement for each individual driver is almost zero. Sometimes the situation becomes risky and the driver will make adjustments to reduce threats but most of the time there is no such feeling of risk. For some drivers at some occasions it is important to drive fast because of a working task or for the sake of feeling the thrill. Other drivers may prefer to drive calmly for the sake of the environment or for the feeling of comfort.

When drivers are trained to be skilled in handling critical situations they achieve safety margins which could be used in critical situations. With this skill in the luggage it is, however, possible to drive a little faster, a behaviour that will reduce this potential safety margin. If the driver overestimates the possibilities of using the new skills, he may even overcompensate the margins and statistically have a potentially larger accident risk compared to the situation before the training. For drivers who seldom feel any need to drive faster and are dominated by motives that directly or indirectly increase safety, these skills may improve safety.

Based on these aspects of driver behaviour, the driver training in the Swedish experiment was designed with an effort to counteract a possible misuse of skill. Instead of teaching the drivers how to handle a critical situation when it has occurred, one important main goal was to make the drivers aware of the difficulties of handling such situations since they may happen too suddenly or may be too complicated. The focus was instead to make the drivers realise how they could drive with larger safety margins and by doing that reduce their probability of being involved in an accident. This was practically arranged by hands on driving situations, partly on artificial low

friction showing that the drivers' own assessments of safety margins often were too small and making the drivers realise, in spite of their often high driving experience, their own limitations when critical situations actually occur. More details about how this training strategy can be designed are presented in a report on training strategies for young drivers (Gregersen 1996).

Another part of the driver training was commentary driving. Commentary driving is a typical method where the driver is expected to improve his visual search and interpretation of potentially risky situations. When using the method, the learner driver keeps up a running commentary for the instructor while driving, explaining what is going on around the car. The learner's narrative is divided into various phases starting with oral reports on actions (pressing the clutch pedal, activating the left turn indicator, releasing the accelerator etc.). This first phase is for getting used to the idea of talking aloud. He then switches to the main purpose, which is to describe what he sees (other road users, traffic situations and objects), which risks may arise and which measures should be taken to reduce those risks. Through this process the student is forced to concentrate on actively searching through the environment, making himself aware of events of significance. Another ingredient is that the instructor can offer feedback on how the search is proceeding, the relevance of the learner's risk assessment and the suitability of the proposed actions.

In evaluation studies, commentary driving has been shown to improve safe driving. When used among novice drivers the benefits are small due to their high mental workload and low level of automation of driving tasks. Among experienced drivers, however, the method has shown good results.

In the Swedish experiment this part of the training was carried out in real traffic. During this commentary driving part, two extra types of practice were included. One was to make the driver realise his own stopping distance, which often was longer than expected. The other was to show the driver how different driving styles influence fuel consumption. This was demonstrated by using a fuel consumption meter. The idea behind this part was to make the drivers realise another advantage of driving calmly, since it would reduce costs for the company.

The manoeuvring parts of the training, which were carried out at low speeds and in narrow places, did not primarily aim at better road safety. The main goal was to make the driver more familiar with different cars and how to handle them in narrow places without causing a lot of unnecessary damage. Such small damages were causing large costs for the company.

The positive results of the driver training do not support the general international results of short training programmes. Many such evaluations have failed to show effects or have even shown increased accident involvement. Taking this into account, the large accident reduction here was unexpected. The most probable explanation is the purpose and the content of the training. Specifically, the aim was not primarily to increase the drivers' skill in manoeuvring the car, but to create insight about risks in traffic and about the drivers' own limitations.

Another aspect that may have contributed was that of realising how driving style influences fuel consumption. For many drivers, the well-being of the company also means job security. Reduction of costs may have been seen as a means to increase the probability of keeping a good

job. The training may thus make the driver realise the relation between driving style and costs. From a safety point of view, it is probable that a driving style that reduces fuel consumption also reduces the probability of accident involvement.

The driver was expected to become more careful and foreseeing, which from the perspective of risk compensation and of overestimation of one's own skill is more likely to reduce accident involvement than training in skills that may be used for other motives such as mobility, effectiveness, pleasure etc. We do not claim that the results prove there is any difference between two basically different strategies for training since the present alternative has not been compared with the traditional method in this study. It may, however, serve as an inspiration to develop such training strategies further in combination with making scientifically correct evaluations.

Group discussions

The second beneficial measure was group discussions. This method for behavioural change is not very commonly used in road safety work. It comprises group discussions and group decision techniques. The method was introduced by Lewin (1947a) who showed that the method could be used to change eating habits in American families as well as productivity among factory workers (Lewin 1947b). In the area of road safety, the method was used in Japan in a study of bus drivers (Misumi 1978) which showed that accident involvement decreased sharply following these group discussions. The study was repeated later with equally good results. Similar techniques were also found to reduce accidents in a shipyard (Misumi 1982). The method has also been described by Brehmer et al (1991).

The strategy used by Misumi in his study of 45 bus drivers with high accident involvement was a process of 6 steps as follows:

1. A 60-minute warming up period, designed to ease tension among the participants.

2. Division into four groups. A 40-minute discussion to identify problems at their workplaces.

3. A 20-minute meeting in the large group where the results of step two are reported. A list of the 10 most important items is produced.

4. Each small group discusses which problems could be solved by themselves and which problems the company should try to solve.

5. The results are reported in the large group.

6. Concluding discussions in small groups about countermeasures and changes in driver behaviour. Each driver is told "Please write down on this piece of paper what you yourself have determined to practice from tomorrow on. You do not have to show this to other people. Just keep it in your pocket. This is to help you remember what you have promised yourself to do. You can throw it in the waste-basket tomorrow if you feel you do not need it." (Misumi 1978).

There is a considerable number of studies showing that group decision techniques are effective. One example where group methods have been successfully used is in the health improvement area, e.g. among schoolchildren to improve health behaviour (Arborelius and Bremberg 1988).

The Misumi trials have formed the base for the Swedish design of the group discussion. The discussions were led by drivers from their own working unit who had attended a special introduction course. Thus the leader was one of the group who was able to share the experiences and the suggestions in a more natural way.

The company had agreed to do their best to meet the suggestions from the drivers about measures that should be activated by the company.

The reduction in accident risk as a consequence of group discussion was expected but the size of the reduction was surprising. There may be several explanations for this. One explanation could be that the company actually got an opportunity to demonstrate its commitment to safety. Another may be that the measures actually taken by the company based on the suggestions by the groups were effective. This does not seem to be the most important explanation, since in the questionnaire sent out to all drivers as part of the evaluation, they reported that many of their suggestions had not been acted upon yet (Gregersen and Morén 1990).

Lewin's theory, which forms the basis for this intervention, attributes the effect to the fact that the drivers have made a personal decision. Lewin saw the decision as the cement that joined intention and action, and without a decision, changes in intentions that may well result from information campaigns for example, will not affect safety because the intentions have not been linked with the drivers' behaviour.

However, the group discussion intervention was a complex one, and in addition to the possible effects of having made a personal decision, it should be noted that the discussions served to make the group norms more explicit. It breaks the pluralistic ignorance concerning the drivers' commitment to safety and makes the group norms visible. In perspective of Fishbein and Ajzen in their theory of reasoned action, these corrections of the subjective norms will have important effects on the subjects' behavioural intentions, creating intentions that are positive with respect to safe driving. When these intentions are also linked with behaviour by means of personal decisions, positive effects on safety would follow.

Moreover, the discussions are likely to have served as an important means of exchanging information about possible dangers and ways of avoiding them in traffic. Without the group discussions, such information exchange might not have taken place.

All these factors may contribute to the effect of the group discussion intervention, and it is not possible to draw any definite conclusions about the reasons for the effect without further research that seeks to disentangle the effects of the various factors.

CONCLUSIONS

Since the two beneficial measures only have been compared to each other and not to other versions of training and discussion there may be a potential for further improvement. One possible improvement may be to combine the two methods or to combine them with other measures such as better passive safety in the vehicles, more specified rules for which drivers are allowed to drive certain vehicles, working time rules, seat belt use etc. Many such suggestions were delivered by the drivers in the discussion group.

A general conclusion from the study is that it is possible to improve safety among drivers by means of measures focusing on risk awareness. The findings of this experiment have inspired several other large companies to use group discussions and/or driver training among their drivers. In some cases there are also evaluations included, which will show if the results of the Swedish study can be generalised.

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WHAT DO DRIVERS LEARN THROUGH EXPERIENCE - AND CAN IT BE TAUGHT?

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INTRODUCTION

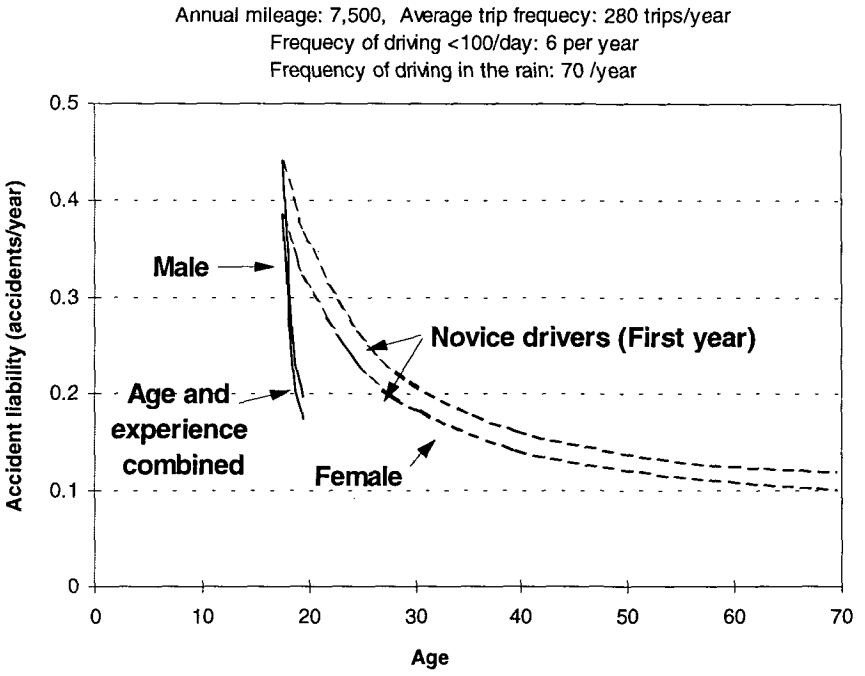
It is more than a quarter of a century since Pelz and Schuman (1971) asked the question 'Are young drivers really more dangerous after controlling for exposure and experience?'. In concluding that young drivers had higher accident rates than their elders, they reflected the prevailing view at the time. In the same year, Goldstein (1971) stated 'that youthful drivers are over-represented in accidents ... has been well known for several decades', while a subsequent OECD report maintained that 'young drivers are over-represented at all time periods and at all levels of severity of accidents' (OECD, 1975). Young drivers have also been a major focus of research and policy in traffic safety in all developed countries in the world for many years.

Pelz and Schuman also concluded - though less convincingly - that young drivers were more dangerous even after controlling for experience. The age versus experience debate has been a protracted and often inconclusive one. Although Mayhew and Simpson (1990) maintained that 'age related factors are more strongly associated with collision risk than are those that are experientially related', this was by no means a consensus view. The problem in a driving context, of course, is that age and experience are usually highly correlated, in that the majority of inexperienced drivers are young drivers. The age versus experience issue is not just of academic interest, for there are clear implications for safety countermeasures. At a practical level, maturity cannot be accelerated, while the lessons of experience can - in principle - be taught. Attempts to disentangle the separate effects of age and experience in the past have often encountered problems, largely because of the methodological issues involved.

In the late 1980s, a programme of research was started at TRL with the aim of making more explicit the separate effects of age and experience on accident liability. The approach adopted was a statistical one using Generalised Linear Modelling techniques. The first study in the programme was a cross-sectional survey of a structured sample in which older and younger drivers, and drivers with limited experience were over-sampled. Self-report accident data was obtained from about 13,500 drivers; accidents were confined to those on public roads, and were mainly damage only (Maycock *et al.*, 1991). In a more recent study, data has been obtained from some 18,000 novice drivers, in which cohorts of drivers reported accidents year by year for the first three years of their driving experience (Forsyth *et al.*, 1995). The two studies gave very similar results.

Figure 1 shows the modelled accident liabilities for drivers from the cohort study. The rapid decrease in accidents in the first three years of driving is clearly evident in the figure. The model showed that, for young drivers, the effect of experience alone over the first three years of driving was some four times that of age. There was a 40% reduction in accident liability between the first and second years of driving for 17 - 18 year olds that was attributable to experience.

FIGURE 1. Age, experience, and the accident liability of novice drivers



One of the main outcomes of the TRL work was an increased interest in driving experience in its own right, as opposed to regarding experience as a variable that is inextricably confounded with age.

WHAT IS EXPERIENCE?

An Uncontrolled Learning Situation

The reduction in accident liability in the first years of driving identified in the TRL work was most marked in the youngest age groups, but was evident at *all* ages, demonstrating unequivocally the importance of experience. The question that needs to be asked is just what happens in the first two or three years of driving to turn a high risk novice into a low risk driver in a relatively short period of time. One model that has proved helpful in this context is the Skills - Rules - Knowledge framework of Rasmussen (1983). Although developed to describe human performance in complex industrial systems, this framework has clear relevance to driving, and in particular the way in which a driver progresses from novice to expert as experience is gained.

In Rasmussen's framework, the skill-based level refers to the implementation of highly practised routines, the rule-based level to the selection of appropriate courses of action in well defined situations, and the knowledge-based level to procedures for coping with new situations not previously encountered. In Rasmussen's terminology, a new driver operates almost exclusively at a knowledge-based level. Vehicle handling and control skills become rapidly established at the skill-based level, but there is a frequent need to revert to the knowledge-based level whenever new situations are encountered (thereby developing new rules). However, demonstrating that vehicle handling can be successfully performed at the skill-based level is usually sufficient in many countries to guarantee entry into the licensed driving population. There then follows a second learning process, longer and more complex, during which the driver builds up a repertoire of rules that can be used to guide behaviour. These rules are learned not through controlled formal instruction, but through uncontrolled informal experience.

The appreciation by researchers of the way in which this takes place has changed over the years. Grayson (1991) has identified three broad approaches. The first was to regard the driver as an operator who needed to produce a skilled performance in order to cope with external demands. This largely mechanistic view of driver behaviour stressed the importance of skill in response to information input, but proved inadequate to explain the errors that occurred as a result of driver output. This type of model was discarded when it became recognised that drivers on the whole were not responders, but initiators. The 'new-look' models saw driving as a largely self-paced task, in which performance was more influenced by the characteristics of the driver than by external conditions. The third approach sees the driver as an 'interactor', and recognises that the driver does not operate alone, but in a social context. Here, stress is placed on patterns of interaction between road users, and how these interactions influence both accident involvement and accident avoidance. Learning such patterns of interaction plays only a small part in traditional driver training (Groeger and Clegg, 1994), and takes place for the most part in an unstructured and informal way, with no guarantee that what is learned is the most appropriate for the safety of the traffic system.

Thus, in the first few years of his driving career, a new driver is learning not just new skills, but formulating new rules, developing a new repertoire of strategies, and learning new patterns of interaction. How should this knowledge best be acquired - by uncontrolled exposure to risk, or by some more formal intervention? Clearly, some form of instruction is preferable, but what is to be taught?

Candidate Variables

There have been two main strands in research on young and new drivers. The first is concerned with motivation, the second with cognition. Both are active and important fields of research, but the possibilities for intervention are different. The modification of motivational and attitudinal factors at a societal level is a long term process. This is not to deny that marked changes in social norms can take place (drink-driving being the obvious example), but such changes do not come about quickly or easily. By contrast, cognitive variables offer - in principle - more scope for intervention at an individual level. A candidate variable for this needs to be able to meet four criteria. It requires to be:

- related to accident involvement
- capable of being measured objectively and reliably
- related to driving experience
- amenable to improvement through training.

Undoubtedly, the first of these requirements is the most formidable. Despite the growth in cognitive psychology and the interest in higher order skills in driving, the evidence to date for relationships between cognitive factors and accident liability among drivers is very limited (see, e.g. Lester, 1991; Elander *et al.*, 1993). For several years, measures of 'cognitive style' such as field dependence/independence were thought to hold great promise. It seems plausible that the ability to identify salient 'figures' within a complex scene should be very relevant to safe driving. Despite this, the study of field dependence has not been one of traffic safety's success stories, and early promise has not been sustained. The relation between field dependence and accident involvement conforms to an all too familiar pattern of early successful studies being followed by better controlled designs and less impressive results.

Another factor that enjoyed a brief popularity was selective attention. This is an even higher level factor than field dependence, and relates to the active information-processing ability of the driver. However, it suffered much the same fate, in that early results showing a significant relationship with accident history were not replicated in later and better controlled studies.

Both field dependence and selective attention had high face validity, in that the ability to identify and process appropriate information must play an important part in the driving task. Their lack of success may perhaps be attributed to the fact that the manner in which they were assessed was far removed from the 'real world' of driving - by listening to digits through earphones in one case, and examining complex geometric patterns in the other. However, there is one further candidate that is much more closely based on driving, that has high face validity, and has a sound research background. This is hazard perception.

HAZARD PERCEPTION

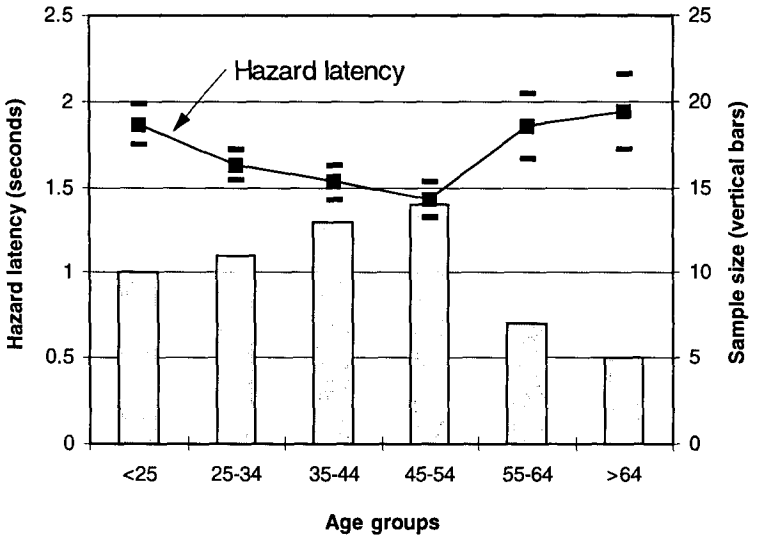
Background

Hazard perception is a surprisingly old concept, dating back nearly 30 years to the work of Currie (1969). Currie used model cars to assess a subject's speed of response in identifying potential collisions. He found that accident involved subjects responded to these more slowly than did the accident free, although the groups did not differ in reaction time. This finding set the scene for all further research on the topic in two ways. First, by suggesting that there was some ability over and above simple reaction time that was related to accident involvement, and second by showing that it could be measured using simulation in a laboratory setting.

Pelz and Krupat (1974) developed this line of research further, using cine-film of 'real road' situations in a non-interactive driving simulator. They found that students with 'good' driving records detected danger more promptly than did students with records of violations or accidents.

Quimby and Watts (1981) made an important contribution by comparing the performance of subjects both on the roads and in a simulator. A variety of measures were taken in the simulator, both continuous and in response to discrete events. The Quimby and Watts study thus attempted to encompass the two elements that run (often confusingly) through this field - assessment of risk and response to risk. Of these two, it was found that only response time to hazard was related - albeit weakly - to accident history. The relation between hazard detection latency and age is shown in Figure 2.

FIGURE 2. Hazard detection latency and age



Stronger evidence was provided by a follow-up study by Quimby *et al.* (1986) in which hazard perception was included in a large test battery. This study employed multivariate statistical techniques that could deal with the high degree of inter-correlation among variables that had made interpretation of results difficult in the past. The results from this study were clear. Once age and mileage had been accounted for, none of the low-level sensory or psychomotor variables made any contribution to explaining the variability in accident involvement. One of the few factors that did contribute, however, was response time to hazards.

Hazard perception was not yet ready to occupy a lead position in the potential countermeasure stakes; before this could happen, it was necessary to demonstrate that it was related to experience and could be trained. This evidence was provided by McKenna and Crick (1991), and the scene was set.

The earlier studies of Pelz and Krupat (1964) and Quimby and Watts (1981) had used cine-film in driving simulators. Cine was rapidly being replaced by video, and interest was growing in more portable laboratory-based, as opposed to simulator-based environments. Hazard perception tests using video material were developed for research purposes at TRL and in parallel by McKenna and Crick. At the same time, important developments were taking place on the policy front. In the Australian state of Victoria, tests of hazard perception were being proposed as part of the licensing procedure for new drivers, and a European Union directive required a more

broadly based driving test including - in principle - elements of hazard detection. From both a research and a policy standpoint, hazard perception had arrived.

The Current Situation

It will be noted that no definition of 'hazard perception' has yet been offered. This was no oversight; many of the early workers in this field seem to have been more concerned with measurement than with definition. Definitions of the concept are usually less than illuminating. Pelz and Krupat (1964) did not use the term, preferring the phrase 'caution profile' instead. Quimby and Watts (1981) referred to 'reaction to hazardous events', while Quimby *et al.* (1986) introduced more than a hint of circularity in defining hazard perception as 'the ability to perceive and respond to hazards'. McKenna and Crick broadened the concept by referring to 'ability to respond to potentially dangerous traffic situations' - but without defining what these might be. Despite the somewhat limited contribution of researchers to the definition of hazard perception, at a practical level the concept seems to be easily recognised by trainers and instructors in their use of terms such as 'appreciation', 'anticipation', and 'reading the road'.

There are at present four main tests of hazard perception; two have been developed as research tools, and two as tests for use in licensing procedures. The first research tool is the TRL test, developed from the early work of Quimby and Watts (1981). The original test went through a series of modifications, using video instead of cine film, changing the subject's response mode, revising the instructions, and using a PC for administering the test and recording the data. The test has retained the eclectic approach to hazard perception that was a characteristic of its predecessor, in that it attempts to assess both assessment of hazard and response to hazard. The measures taken include reaction time to specific hazards, the numbers of hazards detected, the average response to hazard, and the variability in this response. The test has been used in a number of research projects; details of a recent application are given in Quimby *et al.* (1997).

The other research tool is that developed for the UK Department of Transport by McKenna et al at Reading University. This test also uses video clips presented on a PC. However, the major difference is that the test concentrates on measuring time of reaction to hazard. This was done for two reasons. First, it avoids the possibility of confusion between what are held to be the theoretically distinct concepts of hazard assessment and hazard response, and second, because the previous work of Quimby *et al.* (1986) had shown that it was reaction time to hazard that was most strongly associated with accident involvement. The Reading test comprises 35 items, selected on the basis that they distinguished best between novice and experienced drivers in pilot trials. It has also been shown that highly trained expert drivers scored more highly on this test than drivers matched for experience, which indicated the potential for training. The 'trainability' of hazard perception was demonstrated in a series of experiments by McKenna and Crick (1994), which showed that their test of reaction time to hazard was measuring something more than simple reaction time, and that scores on their hazard perception test were capable of improvement through training. A later experiment (McKenna and Crick, 1997) suggested ways in which the content of this training could be made more efficient.

The other two tests, the VicRoads and the NFER, have been developed specifically for use in the licensing process. It should be noted that in doing this, the aim has not been to restrict entry into the driving population by selecting only those candidates with good hazard perception abilities,

but rather to encourage novice drivers to undertake appropriate training. The argument is that if hazard perception ability is related to accident involvement, and if the ability is amenable to improvement, then introducing training on a wide scale could lead to a reduction in accident liability in the early years of driving. Further, the most effective way of ensuring that hazard perception training is undertaken on a voluntary basis is to include a hazard perception test in the procedure for acquiring a licence to drive.

Such a test is already in force in the Australian state of Victoria. There, new drivers are required to pass a hazard perception test before giving up their L-plates and being granted a full licence. The VicRoads test (as it is known) is a PC based test using video clips of traffic scenes, but is very different from the two that have just been described. The items in the test are derived from an analysis of road accidents in Victoria in which young drivers are over-represented. In the test, subjects are asked to indicate on a touch screen if and when they would initiate a manoeuvre in a particular situation. The situations include close following, overtaking, curve negotiation, and gap acceptance. The test is relatively short, with only 12 items as opposed to McKenna's 35. The scoring is also simple, in that it is based on the subject giving the correct response within a specified time window (note that the correct response can be to refrain from using the touch screen). Respectable levels of psychometric reliability are claimed for the test.

With its emphasis on the initiation of manoeuvres, and the nature of the material used, the VicRoads test is unlike that of the other tests developed in the UK. It would appear therefore that the term 'hazard perception' as used in connection with the Australian tests is a rather different concept from that being used in the UK. Some empirical support for this view comes from recent work by McKenna and Horswill (1997), in which the performance of subjects on four computerised tests was factor analysed. The tests were tests of close following, overtaking, gap acceptance, and a short version of McKenna's hazard perception test. The analysis showed that the four tests loaded on largely orthogonal factors; from this finding the authors argue that close following, overtaking, and gap acceptance should not be regarded as measures of general hazard perception, but should be regarded as separate skills and ideally should be included individually in test batteries for driver assessment.

The fourth, and probably the most extensively researched, test of hazard perception was developed by the National Foundation for Educational Research (NFER), again for the UK Department of Transport. This PC based test was designed for use as part of the national driver licensing procedure, and as such was required to meet high standards of psychometric reliability. McKenna was involved in the development, and this is reflected in its focus on reaction time as the dependent variable. Four parallel forms of the test were produced, each with some 20 hazardous incidents to which the subject was instructed to respond as quickly as possible by pressing a button. A time window was specified for each hazard, and subjects were given a score of between 0 and 5 depending on how soon they responded within these time windows. Excessive button pressing was discouraged by setting the score to zero if a pre-determined number of button presses was exceeded in any time window.

The four parallel forms achieved high levels of reliability, with values of Cronbach's alpha ranging from 0.82 to 0.86. The whole system of test administration was extensively piloted over a range of ability and ethnic sub-groups in the population to ensure that every effort was made to ensure that the NFER test could be incorporated into the national driver testing system.

From Research Tool to Test Instrument

In the previous section, four tests were described; two were research tools, and two had been developed for use in licensing procedures. The transition from research tool to test instrument necessarily imposes constraints. The most obvious is the issue of psychometric reliability; highly desirable in a research tool but essential in a test instrument. An associated topic is face validity, which again is essential if a public test procedure is to be deemed acceptable. Subjects in laboratory experiments will happily submit to incomprehensible test protocols if they are being paid for doing so. By contrast, if they have to do the paying, then the same subjects will expect the benefits of taking and passing the test to be clear to them (as should be the benefits of less competent subjects failing the test).

Probably more influential is the question of the experimental setting. Research is carried out in laboratories, with procedures for subject handling that are designed to ensure co-operation. Test instruments are employed in public test centres, with impersonal machines replacing keen experimenters. In laboratories, instructions can be detailed and comprehensive - and subjects incapable of understanding them can easily be dropped from the sample. Instructions on official test instruments have to be capable of being understood by as wide a range of the population as possible if the tests are not to be open to the criticism that they are testing intellectual ability rather than the ability to drive in a safe manner. To illustrate this point, the written instructions for the TRL test run to over 800 words, while the NFER test gives two sentences of on-screen introduction.

In addition, test instruments need to meet the criteria set out earlier for candidate variables to improve safety, in that they should be:

- objective and reliable
- amenable to improvement through training
- related to driving experience
- related to accident involvement.

Both of the test instruments under consideration meet the first criterion of providing an objective and reliable measure of the construct being tested. The NFER test, because it is based closely on that of McKenna, should also be trainable. The NFER test (and, to a lesser extent, the VicRoads test) have been shown to discriminate between novice and experienced drivers in cross-sectional studies, and it is assumed that this would be true in a longitudinal sense also. The final, and most crucial of the four criteria has proved more problematic.

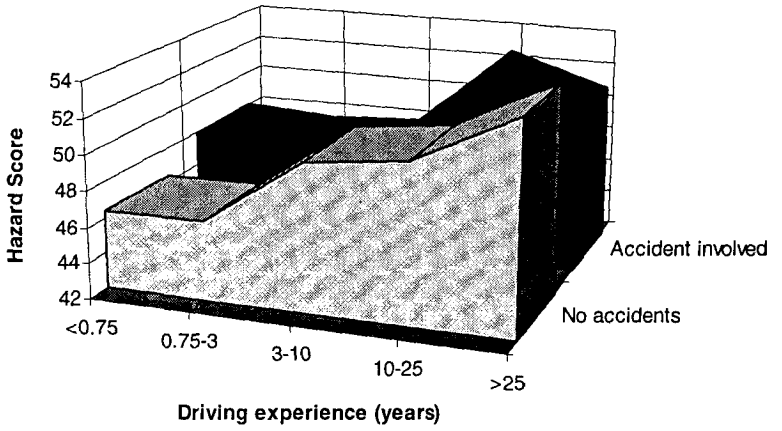
Before being implemented, the VicRoads test was tried out in the 'Geelong Trial', involving more than 3000 participants (Hull and Christie, 1993). The results of that trial indicated a significant difference in hazard perception scores in the expected direction between accident involved and accident free subjects over a wide age range. A more extensive evaluation study is now in progress, based on the data obtained after the test was introduced into the state driver licensing system.

The NFER test has been less successful in meeting this criterion. Despite the high level of psychometric standards employed in its construction, and despite its ability to discriminate

between novice and experienced drivers, the NFER test has not yet been shown to relate to accident involvement. This conclusion is based on three separate analyses. The first was a small scale retrospective study of experienced drivers, where the analysis showed no relation between hazard perception scores and accident rates for the experienced drivers. The second was a prospective study in which novice drivers who had taken the NFER test were followed up after one year of driving and asked about their accident record. Multivariate analysis of the data indicated that the test was not predictive of the accident involvement of subjects in this study.

Thirdly, in a separate study the NFER test was included in a large test battery that was administered to a sample of drivers across the whole range of age and experience. The results showed the expected negative correlation of accidents with age and experience characteristic of all previous TRL studies, but no significant association between the NFER scores and accidents. The data is shown in Figure 3. Thus one appears to have a well designed test that is reliably measuring something, but the 'something' would not appear to be accident liability. Given the encouraging results from early work in the field, and the persuasive theoretical arguments for focusing on skills such as hazard perception, some explanation must be sought for this disappointing state of affairs.

FIGURE 3. Hazard score, experience, and accidents



The first possibility is that it is the content of the test that is causing the problem. By focusing on reaction time, the test is tapping too large a component of low level psychomotor skills, and not enough higher level cognitive skills. Some support for this view comes from the data from the test battery mentioned above, in which NFER scores are strongly correlated with tests of reaction time, but showed little or no association with a variety of tests of cognitive function. Although based on McKenna's work, the NFER test incorporated a wider range of scenarios in terms of events and road types, which may have had the effect of increasing the 'noise' in the data.

The second possibility is the nature of the measurement process. Although Pelz and Krupat (1974) and Quimby *et al.* (1986) both found significant associations between accidents and reaction time to hazards, they used a continuous measuring technique, whereas the NFER test

requires the subject to make a series of discrete responses. This could have the effect of turning the test into a forced pace task, and penalising the cautious subject who may anticipate a hazard early, but not respond to it quickly. However, this explanation is not supported by evidence from a recent study by Quimby *et al.* (1997) using the current TRL test, which does use a continuous measure of response. Although based on a relatively small sample of subjects, the study showed no relation between accidents and reaction time to hazard - or indeed with any other measure of hazard perception.

The third candidate is the difference in the way stimulus material is presented in the test. The positive evidence which has acted as a spur to activity in this area was derived from experiments in simulators (Pelz and Krupat, 1974; Quimby *et al*, 1986), which, although non-interactive and relatively modest by today's standards, were nevertheless capable of producing a high degree of visual realism. The current tests, which involve watching a PC screen or TV monitor on a table in a laboratory, are far removed from the driving task itself. A recent study by Staplin (1995) may be relevant here, in that it suggests that a high level of resolution in the stimulus material is necessary to obtain laboratory measures that match those taken on the real road.

A fourth possibility is that the functional form of the relation between hazard perception and accident involvement is such that it does not become apparent in the early stages of driving. Thus, hazard perception skills may only emerge as a result of experience, and testing novices will therefore not be predictive. This is a pessimistic and also a simplistic view of experience. Passengers, as well as drivers, are in principle capable of developing internal models of road user interaction. 'Experience' does not start from zero on the first occasion that a novice driver sits behind the wheel. A more telling argument might be that hazard detection is only a necessary condition of safe driving, and that hazard assessment and risk tolerance may be more influential in determining behaviour. Particularly with young drivers, the effects of attitudinal and motivational factors may make it difficult to identify any benefits from improved hazard perception.

While plausible, this argument can easily become a reason for doing nothing. As pointed out earlier, motivational factors have proved difficult to change, certainly in the short term, and training in skills offers the better prospect. Even if the effect on accidents is small, intervention on a national scale may still a worthwhile exercise

THE FUTURE

The path from research to implementation is rarely a smooth one, and the development of hazard perception tests has proved no exception. However, the difficulties that have been encountered on the path must be seen as problems to be solved, not as insurmountable obstacles. The questions that have been raised about measurement techniques and test procedures are open to empirical test, and it should be a relatively simple matter to devise experiments for this purpose. At the same time, a balance is required. The comment by McKenna and Horswill (1997) that 'useful applied measures are often employed long before their full theoretical significance is realised' may be a reflection of a long-standing British empirical tradition, but attempts to gain a better understanding of the concept of hazard perception must accompany efforts to improve the accuracy of its measurement. The evidence from the past indicates that hazard perception

includes more than just response to hazardous situations; the task now is to formalise this 'something more'.

An attractive option for exploring this issue would be to link hazard perception with the Rasmussen Skills-Rules-Knowledge framework outlined earlier. Hazard perception ability (or perhaps hazard detection ability) would seem to be a manifestation of the adequacy or otherwise of the individual driver's 'rule base'. A method of assessing a trainee driver's 'rule base' and an approach to driver testing and training aimed at enhancing it and ensuring its adequacy, could conceptually provide a useful way forward in this area. The finding reported earlier (if confirmed) that different manoeuvres - for example, close following, overtaking, and gap acceptance - cannot simply be regarded as representing a common hazard, emphasises the need to focus on specific driving situations and specific 'rules' for coping with them safely. Beyond hazard detection, there is also the important issue of the driver's response to the hazard. Once the hazard has been detected, the driver has to assess the threat posed by the hazard and to judge his or her own ability to cope with it safely. This aspect of a driver's ability merges cognition with motivation, so that it would not seem sensible to dissociate advances in the improvement of cognitive skills by hazard detection training from attempts to modify attitudinal factors and social norms within the same training and testing framework.

The title of this paper asked whether experience could be taught. It has been proposed that hazard perception training - in its broadest sense - is a strong candidate for this. No claims can be made at present that this will lead to dramatic improvements in traffic safety. However it seems clear that the learning process is too important to be left to 'blind' exposure to risk; exposure in the early years is certainly effective as a training agent, but it is uncontrolled, hazardous, and wasteful of life and limb.

Finally, it should not be forgotten that new developments in testing and training technology have considerable potential for speeding up the evaluation cycle. In the past, the design, implementation, and assessment of a safety measure was a slow and often cumbersome process. New technology for driver testing in principle allows for on-line evaluation not just of tests, but of items within tests, providing feedback that is quicker and more detailed than has ever been available in the past. New technology offers the potential for assessing improvements to licensing and training systems, but old-fashioned understanding will always be needed if effective innovations are to be made.

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THE ELECTRONIC DRIVING LICENCE SAVES LIVES

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ABSTRACT An electronic driving licence which also acts as the ignition key to your car is called the "KitteLock-system". It will make it impossible to start your car if you do not have a valid driving licence. Your car will be theftproof and the system will also prevent a drunken person from starting a car if he previously had been convicted for drunken driving and had his licence suspended. The electronic driving licence system will be a nightmare for car thieves, make life easier for the police and most important by making traffic safer by keeping unlicenced drivers off the roads. In addition to the normal driving licence information, the advanced computer chip hidden in the licence could also contain medical information (on a voluntary basis) which could be important for medical personnel to know if the holder is injured in a car accident. Additionally useful information which could be imbedded is the name and address of the driver's doctor and relatives and if the holder is an organ donor. The latter information could be useful in case of accident and if his life can not be saved, he might save the life of another.

INTRODUCTION

Recent studies of car accident statistics in Sweden have revealed that 80% of all drunken drivers involved in traffic accidents were found to have had a previous criminal record. The investigation also showed that 50% of these drivers did not have a valid driver's licence. The authorities were very surprised at the high correlation between drunken driving and criminality. It demonstrates that current actions against these offenders - withdrawn licences, fines or jail sentences - were having very little effect. This group of drivers is small but is responsible for a very large part of the serious traffic accidents.

In the USA, 10.000 people are killed and 50,000 injured every year by unlicenced drunken drivers at an economic cost to the American society of $30 billion.. In the state of New Jersey alone, with 8 million inhabitants, it is estimated that 754,000 people are driving without a valid licence and that in addition there are another 200,000 out of state unlicenced drivers on their roads. In the state of California there are 2 million unlicenced drivers from a total of 20 million, which means that every tenth driver in the state is driving illegally.

The most effective method to prevent unlicenced driving is to develop and install a system that prevents people from driving without a valid driving licence.

The concept of an electronic driving licence emerged as a result of a personal tragedy. In November 1992 my 22-year old step-daughter was crossing the street outside the University of Stockholm, where she was studying, to go to the bus-stop. A car driving 140 km/h (where the legal speed was 70 km/h) hit and instantly killed her. The driver, who immediately left the scene of the accident, was found the next day. It was discovered that he had a suspended licence and had been sentenced a month earlier to one month in jail for severe drunken driving.

THE ELECTRONIC DRIVING LICENCE

Shortly after this accident I started to consider how such villains could be stopped. I quickly reasoned that the best solution must be to have the driving licence also serve as the ignition key to the car. What should such a combined driving licence and ignition key look like? The solution was found in the newly developed "smart-cards" that were beginning to emerge in the market. Some types of these cards have very sophisticated built in programmable chips which can store a lot of information.

I discussed my idea with Lennart Fogel, the president of the Swedish National Society for Road Safety (NTF). He became very excited about my idea and inspired me to raise support for the development of an electronic driving licence. The Swedish National Road Administration agreed to support my concept. In the fall of 1993 work started.on building the first functional prototype unit. This type of development needs people with very special talents. Therefore this work was carried out in cooperation with several specialized firms and the automotive industry in Sweden. At the National Traffic Safety Seminar in Tylösand Sweden in August 1994 the first prototypes were demonstrated in a SAAB 9000, a Volvo 850 and a Volvo FH12 heavy truck. The system was named KitteLock after our daughter Christine, who was also known as Kitte.

A theft proof car

The first units had the following functions. A smart-card reader was mounted in the dash-board which, in turn, was connected to a small programmable computer. The computer, in turn, was connected to various functions in the car through relays and serial connection for encrypted computer communication and to the fully computerized electronic ignition in the SAAB 9000. To start the car a coded message was sent from the car's computer to its ignition system. This system made it virtually impossible to jump-start the car and it would, therefore, drastically reduce car theft.

The driving licence

Today, very sophisticated smart-cards are available containing a processor with three different kinds of memory, a calculation unit for encryption of very large number series, a timer and in- and out-put communication control. Information stored in the memory can be fixed, and/or eraseable or reprogrammable. This means that a driving licence, in addition to the graphic information on its outside, may contain a lot more information stored digitally in its inside chip.

Some smart-card chips can store as much as 64 kB- equal to 13 pages of typewritten text. Some of the information may be stored so that it cannot be changed or copied. In other parts of the memory, information may be added, erased, changed or updated. The electronic driving licence as developed to date has the following functions and information.

a) In a fixed memory we have stored information regarding driving licence number, surname, given names with a special mark for the name used, place and date of birth, citizenship (if the citizenship is marked on an approved ID-card, it may be used as a passport within the European Community), vehicle category and its expiry date and last but not least special conditions. Examples of the latter are that the driver must wear glasses, cannot drive in the dark, must take an alcohol test before starting the car, may only drive a car with automatic transmission, etc.

b) The color photograph on the front of the driving licence of the bearer may also be stored digitally, which would enhance the security aspects of the card.

c) For commercial drivers it might be useful to store a coded fingerprint thereby preventing a commerical driver, for example, from driving overtime by using a friend´s driver´s licence.

d) If a driver were involved in a serious accident it would be very helpful to have his medical information stored in the driving licence, especially if the driver suffered from diabetes, AIDS, blood diseases or has a pacemaker etc. This information is recorded on a volunteer basis and is primarily for the benefit of the driver. The driver could also indicate if he wishes to be an organ donor; if his life can not be saved he may be able to save somebody else's life by such a designation.

e) If the driver is involved in a serious accident, or killed, it would greatly aid the police if the name and address of the nearest relatives to be contacted were stored on the chip. Also the name, address and contact information of the driver's doctor having his medical history might be very valuable.

f) On commercial driving licences storing the driving time during the last 14 days could prevent drivers from driving overtime by changing vehicles.

g) The electronic driving licence may be used not only as a very secure identity card, but also as an entry pass where extra tight security is needed. When the electronic driving licence has been introduced and is in extensive use, the driving licence may replace special company cards as entry passes, reducing the proliferation of cards.

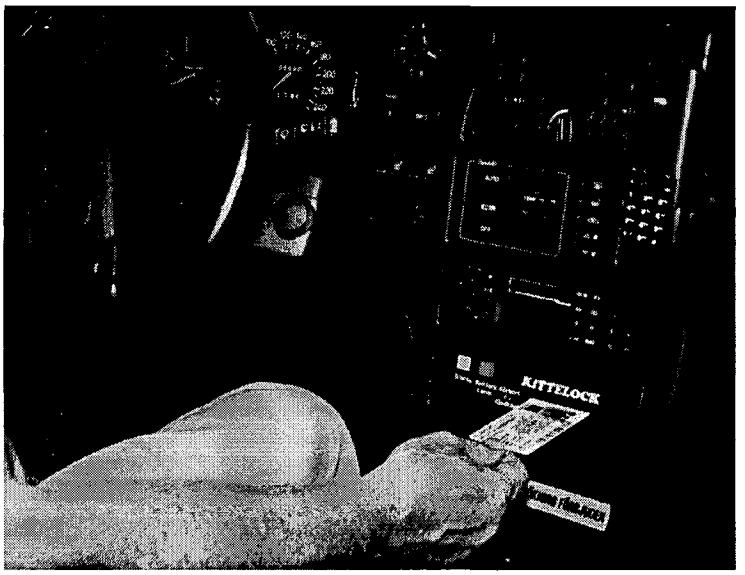
h) Memory on the smart-card chip can also be reserved for the car manufacturers, e.g. making it possible to have automatic adjustment of the driver's seat and mirrors.

i) A language code might be stored on the smart-card chip so that the driver could get messages on the dashboard display in his preferred language.

Computer Electronics Replace Ignition Key and Wheel-Lock

When a driver wants to start a car with the KitteLock system he inserts his smart-card driving licence into a card-reader situated in the dashboard (Figure 1). The card-reader is connected to a small computer which is preprogrammed with information about who may drive the car. In a standard computer 20 different persons may be preprogrammed. This means that who can drive a certain car must have been programmed in advance into the car computer by an authorized official.

Figure 1. The electronic driving licence replaces the ignition key and wheel lock.



When the driving licence is inserted, the car computer checks that the person is authorized to drive the car, then the expiration date and then if there are any special conditions connected with the licence. One condition could be that he must take an alcohol test before he can start the car. This information, for example, could be stored on the driving licence and would automatically activate a testing device which is kept in the glove compartment.

The computer in the car also records whose licence is inserted in a separate register including the date and time. If a driver is involved in an accident and runs away from it, the police may tap the car computer and read out who drove it. This will make it difficult for two drunken people in a car that goes off the road, or are involved in an accident, to blame each other for having driven, thereby avoiding a conviction, because the court cannot establish which one is the guilty.driver.

With this kind of computer installed in the car it is also easy to record the speed of the car ten times per second for the last five minutes. If the car is involved in an accident the police can with high precision read out the initial speed of the car, the breaking distance, the speed at impact and if the driver used the brakes at all. The latter will reveal if the driver had fallen asleep and thereby created the accident. If two cars run into each other at a street corner, both drivers will blame each other in court for having driven too fast thus creating a problem for the court to judge fairly. With the read-out from both vehicles these facts may be ascertained much more precisely.

THE KEY TO A NEW TRAFFIC SAFETY SYSTEM

If the electronic driving licence system is implemented in all cars it will be impossible to drive without a valid driving licence. There will, however, always be a risk that some hard-core criminals will highjack cars at red lights or in parking lots. A way to avoid this from happening is to install a paging device in the car computer. If a car is highjacked the owner or a witness calls the police. The police, or the highway administration, has a register with a secret code to every car and this code will be transmitted. When the code is picked up by the built-in paging unit it triggers a series of events. A message will show up on the dashboard display indicating that the car will stop in 30 seconds, 29 seconds etc. At the same time the hazard lights are turned on warning the surrounding traffic. When the count down has reached 0 an encrypted signal is sent to the ignition system which turns off the engine and will not allow it to be started again. With this kind of system in all cars it is our belief that most cars could not be highjacked. This method of stopping cars will also be very effective in eliminating dangerous car chases.

If and when all cars are equipped with this paging unit it could also be used for a nationwide traffic information system distributing strict local information. Small transmitters could be installed in every water tower around the country. Each transmitter has a range of approximately 20 km. The traffic control centres then only need address a paging message to a specific water tower and the message will then automatically be retransmitted to all cars in the vicinity. These small transmitters could also be carried in police cars and be activited at the scene of an accident along a highway to inform drivers of road blockage and alternative routes etc.

I also do not see any reason why such a paging system cannot be used for private purposes. With the help of a PC and modem or with a telephone and a code-list anyone can send short messages to the car such as "Buy more milk on your way home" or "Pick up the kids in kindergarten at 5".

The KitteLock-System Solves Many Problems

A common problem is the handling of car keys in a police station with many cars. When the alarm goes off, the keys for a specific car must be picked up and the keys might be locked up etc. With the KitteLock system each police officer has his own smart-card and this card operates all the different cars, so there are no keys to worry about.

Another problem may arise when a police car is left at the site of an accident and often must have the engine running to keep all the electrical equipment operating in the car. It then happens occasionally that a passer-by jumps into the car and takes off with it. With a KitteLock system in the car the policeman just picks up his pocket phone and dials a secret code and the car will stop after 30 seconds. This will also avoid dangerous car chases.

If you rent a car today you usually have to show your driver's licence. But the car rental companies are not competent to judge if the licence is falsified or not. With the KitteLock system in place the driver will have his licence inserted in a card reader hooked up to the registry. If it is a valid licence a green light comes on, if not a red light comes on. The ignition key to the rental car is the same physical card as the driving licence and it will be programmed with an expiration date that coincides with the rental agreement. That means that a rental car cannot be used when the hiring contract has expired, and in addition the car is not of much use if it is sold or kept.

How Expensive is the KitteLock System

Electronics with a lot of functions are very inexpensive today. A simple car radio costs less than $15 if produced in large volumes. The electronic equipment needed in the KitteLock system will probably not be more expensive than the ignition key lock, wheel lock and immobilizer system installed in today's cars. To convert older cars may cost $300-400 but it should be possible to recover the money through reduced insurance premiums since these cars will be much more difficult to steal.

A New Common European Driving Licence

In November 1995 the European transport ministers agreed on a new European driving licence to be introduced the first of July 1996. The licence has the same size as a regular credit card and has the necessary driving licence information printed on the front together with a photograph and signature. The manufacturing of the licence will utilize security functions so that it can be used as a secure identity card and if the bearer´s citizenship is printed on it, the driving licence can also be used as a passport document within the European community. The transport ministers also agreed that the card may be equipped with a chip. This important decision leaves the doors wide open to implement the KitteLock system in Europe. It is, however, my hope that it will be agreed upon and implemented simultaneously in all European countries. Otherwise people from a country without the KitteLock system may still have their cars stolen when they visit a country which has implemented the system.

Swedish Ministry of Communications Recommend the Introduction of the Electronic Driving Licence

In March 1997 the Swedish Ministry of Communications issued a memorandum called *På väg mot det trafiksäkra samhället*, Ds 1997:13, (" *On the Road to the Traffic Safe Society.*") In this memorandum a separate chapter has been dedicated to the electronic driving licence. In the introduction to this chapter it says: *It is important that Sweden is active in creating conditions for an introduction of an electronic driving licence and its related applications as soon as possible. This should be done by actively participating in the development work which is taking place within the framework of the current driving licence directive and by working for necessary changes in the related vehicle directives.*

Field Test of the KitteLock-System

As part of the work being carried out in developing the electronic driving licence concept, a field-test was initiated by the Swedish National Road Administration last year. A dozen cars, including some police cars, were equipped with the KitteLock-system of the first generation and have been tested for half a year. Some of the cars were also equipped with an alcohol testing device.

The drivers who volunteered for the field test all liked the idea of replacing the ignition key with a smart-card. The smart card used was a so called CP8-card using a chip read through physical contacts. One result of the field-test was that this type of smart card is exposed to wear which

after 6-12 months may result in occasional misreadings. In addition, sometimes a problem with the built in relay-switch in the card readers arose.

During the coldest days of the winter (below minus 10 Centigrade) some cars had starting problems. During the starting sequence, before the starting engine turns, there is a very short and sharp drop in voltage. If the battery is less than half charged the voltage might drop below 7 Volts, which will result in the KitteLock-system falling out and cutting off the starting sequence.

Some problems were also encountered with the alcohol interlock devices at low temperatures. The problem was mainly a timing problem and will be solved when reprogramming the main computer in the KitteLock-system.

During the field-test some police cars were also equipped with the KitteLock-system. The idea was that all police in the traffic department had their own "driving licences" which also served as their car keys. This facilitated shift changes and access to cars when an alarm was sounded. The remote stop-function was also successfully tested during realistic traffic conditions and it was found that the 30 seconds warning time seems to be a proper timeframe.

It was also suggested that it could be dangerous to stop a car at high speed because the driver would loose control of the vehicle when the engine is shut off. Tests were made at speeds up to 100 m.p.h. at an enclosed airfield. The ignition was turned off and the braking distances were measured. The results showed no significant differences in braking distance with or without engine power. The only difference that was found was when comparing cars with automatic versus manual transmission during steering tests. At speeds below 45 m.p.h. a car with automatic transmission loses its power-steering and therefore has more difficulty in following a slalom course.

CONCLUSIONS

The conclusion of the field-test was that the KitteLock-system should be modified by using a new type of contactless smart-cards with RF-ID communication. With these cards we eliminate the contact and reader problems hitherto encountered. Furthermore the card may be inserted in any direction and may also replace both the ignition key and the door keys. To open the door the card is swiped past the outside mirror and is then read and approved. When approved the doors and alarm-system will unlock automatically.

The technology is now developed and the components needed for an electronic driving licence are now produced in large numbers. It is therefor possible to introduce an electronic driving licence and thereby drastically increase traffic safety by making cars theftproof, stopping unlicenced driving and by removing approximately 60% of all drunken drivers from the road - statistics show that 60% of all drunken drivers are repeat offenders. It is now up to the politicians and authorities to act.

CHAPTER 5:
WHAT HAVE WE LEARNED?

The symposium ended, as all good things must, and participants returned to their homes and jobs. Most participants agreed that the symposium fulfilled its purpose of providing a forum for researchers and policymakers to discuss the nature of risk-taking and traffic safety and to assess measures that may have some impact on the problem. Participants learned firsthand about new results from researchers at the forefront of current thinking. Many participants left with a resolve to incorporate what they had learned into action through further research, policy initiatives, or legislation.

But the symposium's real value should reach beyond those who were fortunate enough to attend. This is why we are publishing these proceedings -- so the symposium's information and ideas can be shared broadly. Using one of the few benefits of our symposium co-chair positions, we offer our views on the symposium's themes and key ideas and on how these can be used by the traffic safety community to help reduce risk-taking behavior.

The symposium examined the causes of risk-taking, illustrated how different methods to reduce risk-taking have succeeded or failed, and suggested some new approaches that might be useful. But we believe the symposium's more important contribution was broader. Taken together, the papers presented at the symposium and collected in these proceedings illustrate the diversity and complexity of risk-taking behavior. They provide several useful perspectives and general principles for those who wish to reduce risk-taking on the road.

Risk-taking behavior on the road has several dimensions. When asked to give examples of risk-taking on the road, most people likely would respond with specific short-term driving actions such as driving too fast for conditions, following too closely, or running red lights (see Summala, Shinar) or pedestrian actions such as crossing heavy traffic in mid-block (Peden and van der Spuy). But risk-taking also includes premeditated actions that may have little or no direct connection with minute-to-minute driving decisions, such as drinking before driving (Beirness, Hingson) or failing to wear safety belts (Mackay). Finally, risk-taking can result from habitual driving practices such as regularly exceeding posted speed limits (Nilsson). These risky actions may not be seen as unusual but may be standard behavior throughout the community (Van Houten).

Risk-taking behavior on the road has several fundamental causes. Some risk-taking is clearly related to an individual's basic personality, psychological makeup, or level of development and maturity (Jonah, Shope, Williams, Beirness). Other risky behavior arises from frustration with the traffic system (Shinar) or other immediate driving circumstances (Summala). Another source is the change in judgment due to alcohol or drugs (Peden and van der Spuy, Beirness, Hingson). Finally, some risk-taking is a product of community norms (Van Houten).

Risk-taking behavior on the road can be reduced. The methods are varied, as the causes and dimensions of risk also are varied. No one method succeeds in each situation.

- **Legislation - enforcement - sanction - public education**, the standard system used in traffic safety, has been effective in reducing many risky behaviors such as drinking and driving (Hingson), speeding (Nilsson), and failure to use safety belts (Mackay, Marchetti). Systematic programs encompassing all driving behavior are particularly appealing and can affect the entire driving population (Ogden) or a particular population group (Williams).

- **Education** typically is effective when used together with other components noted above (Williams, Marchetti, Ogden). But education by itself shows promise if directed at specific driver groups (Gregersen, Grayson and Maycock).

- **Technology** can assist education (Gregersen), improve enforcement (Ogden, Nilssen), reduce frustration by improving traffic flow (Shinar), or may provide entirely new methods of driver control (Goldberg).

- **Community norms** are critical. If the community rewards risk or accepts risky behavior as the norm, the methods above are unlikely to succeed. But if the community encourages and rewards safer behavior, these community norms may alter the behavior of even high-risk drivers (Van Houten).

Taken together, these papers give a number of effective ways to reduce risky behavior on the road. They also illustrate the limits of our current knowledge and suggest areas for further research on the fundamental causes of risky behavior, on useful strategies for reducing risk-taking, and on how these strategies can be implemented most effectively. But we must not let what we don't know stand in the way of action based on what we very clearly do know. We can save lives by implementing effective risk-reduction strategies right now. This takes societal commitment, political will, and economic resources.

We believe the symposium has in fact achieved its goal. It's now up to us all, in our roles in industry, government, academics, special interest organizations, and as citizens, to take what we have learned and use it for our ultimate goal: safer travel on the road for everyone.

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Dr. Goldberg (The Electronic Driving License Saves Lives) graduated from The Royal Institute of Technology (KTH) and received his doctorate degree at the Department of Welding Technology. He was founder and CEO of both Materialdata AB and Card Safety System AB. He developed the electronic driving license with a grant from the Swedish National Road Administration. He received the ITEA award from the European Commission in 1995 and the MHF Motorist Union Traffic Safety Gold Medal in 1996. Dr. Goldberg has lectured on five continents from Svalbard in the North to Antarctica in the South.

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Mr. Grayson (What Do Drivers Learn Through Experiences - and Can It Be Taught?) is a psychologist with degrees from the universities of London and Nottingham. He has worked at the Transport Research Laboratory in Crowthorne, England, for the last 25 years on studies of the behavioral aspects of traffic safety ranging from the behavior of child pedestrians to the assessment of new technologies for drivers.

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Dr. Ogden (Safer Because We Chose to Be: Engineering Perceptions of Risk and Safety in Victoria, Australia) is a consultant in clinical forensic medicine and is an Associate in the Department of Public Health and Community Medicine at Melbourne University. He also is a consultant to the Victoria Police. He is the only Australian clinician who is a member of the International Committee on Alcohol, Drugs, and Traffic Safety. Dr. Ogden has conducted experiments on the metabolism of alcohol and its effects and has taught the medical aspects of the Breath Analysis Instrument Operators Course at the Victoria State Forensic Science Laboratory.

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Dr. Peden (Crossing the Road in South Africa: A Risky Business) obtained a BSc degree in nursing from the University of Cape Town in 1983. After many years in clinical practice, she switched directions and obtained a BSc (Med) (Hons) in epidemiology *cum laude*. She joined the Medical Research Council in 1993 and obtained a PhD for her work on the role of alcohol in adult pedestrian collisions. She is currently a specialist scientist at the MRC and is researching the role of illicit drugs on injury causation.

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Dr. Summala (Speed, Time, and Risk Taking) is Professor of Traffic Psychology and head of the Traffic Research Unit at the University of Helsinki, Finland. He has a PhD in general psychology and has been working with theoretical and experimental issues in driver behavior and road safety since 1971. He has published more than 100 journal papers and research reports on driver behavior. Dr. Summala received the A.R. Lauer Award from the Human Factors and Ergonomics Society in 1988. He presently conducts research in the areas of driver skill learning and decaying, attention problems and fatigue, driver interface and time-sharing, and the abilities of different patient groups.

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Dr. Van Houten (Changing the Behavior of High Risk Takers by Modifying Community Norms: Taking Advantage of Powerful Social Contingencies) is Professor of Psychology at Mount Saint Vincent University of Halifax, Nova Scotia. He received his PhD from the Department of Psychology at Dalhousie University. Dr. Van Houten has been involved with traffic safety for many years and has published extensively in this area. In 1984 he received the Solicitor General Crime Prevention Award for his work in traffic safety.

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Dr. Williams (Graduated Licensing and Other Approaches to Controlling Young Driver Risk Taking) is Senior Vice President for Research with the Insurance Institute for Highway Safety. He has a PhD in social psychology from Harvard University and has published more than 200 scientific papers in a wide variety of research areas with particular emphasis on the role of alcohol and drugs in driving and on preventing motor vehicle injuries among teenagers.

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Dr. Michael Henderson

Dr. Henderson (Discussion of "Safer Because We Chose to Be" by Dr. Edward Ogden) is a physician who has spent his professional life in the field of road trauma prevention. In 1970 he established the first major road crash research center in Australia. He is now a consultant and chairman of the Australian Advisory Committee on Road Trauma, a federal statutory committee.

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Dr. Janssen (Discussion of "Sensation Seeking and Risky Driving" by Jonah et al.) is an experimental psychologist working in the areas of human information processing and decision making. His present research is on the behavioral and safety effects of both traditional and advanced driver information and support systems. He heads the Traffic Behavior Research Group of the TNO Human Factors Research Institute in Soesterberg, The Netherlands.

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Dr. Malott (Discussion of "Legislative Strategies to Reduce Alcohol Impaired Driving" by Ralph Hingson) is Professor of Psychology at Western Michigan University. He just completed the third edition of *Elementary Principles of Behavior* and is now writing *I'll Stop Procrastinating When I Get Around to It.* His specialty is behavioral approaches to university education, staff management in organizations, and self-management in everyday life.

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Dr. Wang (Requirements for Drivers in China) is Professor of Traumatic Surgery and a member of the Chinese Academy of Engineering (Division of Medicine and Health Sciences). He graduated from the China Medical University in 1956. Dr. Wang is also the Chairman of the Chinese Society of Traffic Medicine, editor-in-chief of the *Chinese Journal of Traumatology*, and associate editor of the *Journal of Traffic Medicine*.

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Dr. Council (Innovations with High Potential) is the Director of the University of North Carolina Highway Safety Research Center. His experience ranges from studies of motor vehicle injuries for specific subpopulations (children, beginning drivers, seat-belted occupants) to projects aimed at identifying and strengthening research methodologies in the roadway safety field. He coordinated a national series of NHTSA seminars on child safety restraints, helped form the North Carolina Child Passenger Safety Association, and served as President of the National Child Passenger Safety Association. He is currently working on the Graduated Licensing concept for teenage drivers.

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Dr. Graham (The Nature of the Problem: Risk-taking and Traffic Casualties) is Professor of Policy and Decision Sciences at the Harvard School of Public Health. He helped launch the Harvard Injury Control Center and he founded the Harvard Center for Risk Analysis. In 1991 he received the Award for Outstanding Service in Helping to Develop and Support the National Agenda for Injury Control. He was active in influencing policies on air bags, the Clean Air Act Amendments, and health, safety, and environmental regulation reform.

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Dr. Rockwell (Specific Behaviors) has conducted transportation human factors research since 1959 at Ohio State University using instrumented vehicles to study driver performance under a variety of experimental protocols and combining driver control measures and vehicle performance measures with driver eye-movement techniques to measure visual search patterns. Now Professor Emeritus, he serves as President of R&R Research, Inc., where he continues his research on driver performance.

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Ms. Waller (Successful Legislative and Motivational Interventions) is the Director of the University of Michigan Transportation Research Institute and Professor in the School of Public Health. Her interests include older drivers and pedestrians, alcohol and driving, the potentiating effects of alcohol on injury, young novice drivers, heavy truck safety, and driver licensing.

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