Prediction of Problem Driving Risk in Novice Drivers in Ontario: Part II Outcome at Two Years

In Dorn L (Ed) *Driver Behaviour and Training Vol. 3.*
Human Factors in Road and Rail Transport. Ashgate, Aldershot. 2008
Chapter 7. Pp.75-88.

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Introduction

There are six million drivers in Ontario, 1.3 million or 22% of whom are deemed to be problem drivers who have had previous driving offences or crashes and are at increased risk for "problem driving" (Ministry of Transport of Ontario 1991). One specific target group known to be at increased risk are younger, new drivers. New drivers are three times more likely to be killed than the average driver. They make up 15% of licensed drivers and have 30% of driver fatalities.

In 2003, 1678 youths aged 15–24 years died as a result of injury, which represents 73% of all deaths in this age group, one death in Canada, every five hours. Motor vehicle crashes account for the majority (about 60%) of unintentional injuries. Even more disturbing, for every youth who dies from trauma, more than 10 have severe injuries often requiring one or more surgeries, prolonged hospital stays and rehabilitation. The consequences of severe trauma, especially to the brain, are often so devastating and permanent that prevention is a far better investment than late interventions and supportive care, (Statistics Canada, *Causes of Death 2003*, Canadian Institute for Health Information 2005). This is not just a problem just in Canada: motor vehicle collisions continue to be the leading cause of death for 16–20-year-olds in the United States, Australia, New Zealand and most Western European countries (American Academy of Paediatrics Committees on Injury 2006). A recent editorial opines, “We all appear to have become acclimatised to this public health epidemic. If 32 youths in Canada were dying each week from heart disease, influenza or meningitis, a huge outcry to stop this epidemic would be heard (Canadian Medical Association Journal. March 13, 2007).

Statistics from "Drinking and Driving in Ontario Statistical Yearbook 1990" indicates that the 19 - 24 year-old groups are over-represented both in terms of non-drinking accidents as well as drinking related accidents. The search for “the holy grail” of predicting which novice drivers will fall into the high-risk group remains elusive. Over a decade ago the then current best estimates were that two thirds of all accidents were not predictable on the basis of current knowledge of driver characteristics and training (Ministry of Transport of Ontario 1994). This statistic reflects the current state of knowledge.

This study reports on a two year follow up of a group of novice drivers attending a high school driving program who were screened at base line with on the road observation by experienced driving instructors who also completed a screening instrument based on the human factor literature thought to predict non-accidental traffic injury and shown in part one of this study to correlate with the current gold standard of risk prediction. The outcome at two years was measured by official driving records listing moving violations and collisions. The findings in this study will argue that human factors measured prior to obtaining a drivers licence will have significant power to predict risk.

Human Factor Research

Gerald Wilde writing in 1994 in his book Target Risk found no statistical support that personal characteristics correlated with general accident risk. Although acknowledging some correlations with individual characteristics and collisions he found the evidence unconvincing that there is a powerful effect within specific individuals. Whilst acknowledging demographic predictors such as age and gender he emphasised the utility of changing the level of risk tolerance of the population as a whole as having more utility in accident prevention than concentrating on human factor research (Wilde, Robertson Pless, 2002). However there is an extensive literature on high risk driving populations. A recent report on contributing factors to collisions stated that human factors, as opposed to vehicle and environmental factors are the predominant contributor to collisions (United States General Accounting Office [GAO], 2003).

Risky driving behaviours are found to predict collisions and moving violations (Blows, Ameratunga, Ivers, Lo, & Norton, 2005; McKnight & McKnight, 2000). Such behaviors include; speeding, following too close, driving under the influence of alcohol, cell phone use and not using seatbelts while driving. These behaviours cluster in young drivers and a propensity to risk-taking contributes to increased rates of unintentional injury beyond the risk due to inexperience alone (Jonah, 1986). Numerous factors including demographic variables, personality and cognitive abilities have been explored to further understand their contribution to risky driving and collisions. Young males (Turner & McClure, 2003; Williams & Shabanova, 2003) as well as older (>65 years) drivers (Preusser, Williams, Ferguson, Ulmer, & Weinstein, 1998; Williams & Shabanova, 2003; Zhang, Fraser, Lindsay, Clarke, & Mao, 1998) have been consistently related to increased negative driving outcomes. The evidence shows that both educational attainment and occupational status are inversely related to motor vehicle driver collision and injury (Hasselberg & Laflamme, 2003; Murray, 1998). The concept of accident proneness as it relates to unintentional driving injury was first elucidated in the psychiatric literature by Tillman and Hobbes (1949), Professors of Psychiatry at the University of Western Ontario. They described a characterological style in a group of accident-prone drivers referred by the Ministry of Transportation for recurrent accidents. The authors coined the phrase, often repeated in this literature, “a man drives as he lives”. Many studies have since presented evidence for associations between personality traits including risk taking, sensation seeking, impulsivity, difficulty in dealing with tension and controlling anger, substance abuse, antisocial tendencies as well as non-conformity and risky driving behaviours or collision (Deffenbacher, Deffenbacher, Lynch, & Richards, 2003; Jonah, 2001; Tsuang, 1985). Psychosocial models of high risk driving including descriptions of temporary states involving high stress (Lagarde, Chastang, Gueguen, Coeuret-Pellicer, Chiron, & Lafont, 2004) and Problem Behaviour Theory emphasizing lifestyle factors including low parental involvement and negative peer and parental influence (Shope, Waller, Raghunathan, & Patil, 2001; Shope, Raghunathan, & Patil, 2003) have been related to risky driving and problem driving events.

Cognitive abilities likely play a significant role in driving risk. Inattention and distractibility, which are directly related to risky, driving behaviour, are cognitive factors that have been found to account for one fourth of collisions (Treat *et al*., 1977). Poor risk perception, as well as impaired capacity to deploy appropriate judgment and reasoning while driving, have also been found to play a role in risky behaviours and negative driving outcomes (McKnight & McKnight, 2000; Ryb, Dischinger, Kufera, & Read, 2006). Deficits in these higher order cognitive factors of executive functioning are thought to underlie risky driving behaviours. Such deficits are more evident in young and older drivers and in various clinical populations and likely contribute to the higher collision rates found in these categories of drivers (Jerome, Segal & Habinski 2006, Jerome & Segal 2000, McKnight & McKnight, 1993; Treat *et al*, 1977). Normal maturational immaturities in areas of the brain underlying executive function, evident in younger ages (Blakemore & Choudhury, 2006), together with inexperience likely contribute to increased driving risk.

Method

Participating sites and collaborators: This study was conducted through the University of Western Ontario, Department of Psychology. Dr. A. Segal and Dr Laurence Jerome are Adjunct Professors at U.W.O in the departments of Psychology and Psychiatry. Experimental participants were recruited from students enrolled in courses offered through the Driver Training Centre at Thames Secondary School. Thames Secondary School is located in London, Ontario and is part of the Thames Valley District School Board. The participants volunteered for this study and were provided with $20 compensation.

Duration of this study: Following the initial data collection, the participant new drivers in this study were followed for a period of two years following the initial assessment.

*Procedure***:** The official MTO driving records for the same sixty-six participants from Jerome and Segal (2005) were used in this study. The official driving record contained a spreadsheet for each participant listing any known moving violations and collisions. Only convictions are recorded within the official record. Previously the driving instructors evaluated the driving risk of each of the volunteers. The risk ratings were based on the driving instructors' impression of their observed driving ability. The instructors were asked to identify the students' risk based upon their observational experience of the participant's risk severity. The literature on evaluation of driving risk, suggested that individual driving instructors are reliable at predicting problem driving based on their observations of students driving. At the termination of the study at two years, all participants were to be contacted by telephone to conduct an interview designed to elicit details of moving violations collisions and driving exposure.

The Screening Instrument:

Computerised measures of inattention and impulsiveness:

The Stop-Signal Paradigm Test - The stop-signal paradigm (Schachar *et al,* 1993) was used to assess inhibitory control; subjects were engaged in a choice reaction time (go) task and attempted to inhibit their responses to the go task when they heard a stop signal. Reaction times to the stop signal (SSRT) and to the go signal (GoRT) were used to examine inhibition and response execution respectively.

The Conners' Continuous Performance Test (Conners, CPT- II) - This computerised instrument is the most widely used commercially available test of the variables of attention and behavioural inhibition (Conner's, K. A., 2000). The participant must continuously respond to non-targeted letter stimuli, but inhibit responding to infrequent visual targets. The CPT has normative data developed on both clinical and normal populations.

Subjective measures of driving behaviour made by driving instructors:

Driving Instructor Risk Rating (Risk Rating) - This is a visual analogue scale completed by the driving instructor after five hours observation of the student's driving. The driving instructor responded to the question "rate this student on your estimation of current safety based on your observations of their current driving behaviour". The instructor placed an X on a ten centimetre line; the further from the origin on the left, the higher the rating of risk.

Driving Instructor Checklist - Objective severity ratings of problem driving were obtained from a semi-structured behavioural observation instrument, with demonstrated reliability and validity used in an English driving study, the Driving Instructor Checklist (West & Hall, 1998). This checklist was modified for North American expression and left-hand driving. No changes to content were made. This paper and pencil instrument asked driving instructors to rate the participant on driving skill, safety, and future ability and safety, i.e., *2- Current Risk, 3- Safety Risk and 4- Future Risk.*

<u>Subjective self-report measures of Driving Behaviour and personality style:</u>

Barkley Adult Attention Scale - This is an eighteen item self-report questionnaire providing scores for inattention as well as hyperactivity and impulsivity. The scale items are derived from the Diagnostic and Statistical Manual of the American Psychiatric Association 4th edition with age corrected norms. (Barkley & Murphy, 1998).

<u>Jerome Driving Questionnaire (JDQ)</u> - This is a visual analogue scale consisting of 12 measures of the subjects' impression of their current and future driving style over the next twelve months. The subject was asked to place an X on the line distant from the origin to indicate their subjective rating of risk. The scale provides a measure of emotional and cognitive factors thought to reflect underlying executive function as it relates to driving.

Health & Life style <u>Questionnaire</u> (HLS) - Standard information regarding health status, current medication usage, and current recreational drug usage and accident history was collected.

The Temperament and Character Inventory (TCI) - (TCI Cloninger, 1996) was given which evaluated the temperamental profile of impulsivity (Novelty Seeking) within the context of a broader assessment of other temperament and character traits. The TCI is a widely reference research instrument which has been shown to evaluate the temperamental characteristic of impulsivity. The TCI is computerised and presents 240 descriptive statements to which the participant responds 'true', (this statement describes me), or 'false', (indicating the statement is incorrect). Normative data is available and the test is self-scoring within the software program. There are no offensive or sexually provocative statements in the TCI.

Youth Risk Behaviour Surveillance System (YRBS) - This is a widely used epidemiological survey instrument with known validated characteristics used in numerous studies evaluating health risk problem behaviours in community youth samples. (Youth Risk Survey, 2001).

Demographic <u>Questionnaire</u> - In addition to the above measures, standard demographic information in relation to age, gender, height, weight, grade point average in school, family composition, and family occupation was collected.

Telephone Interview <u>Questionnaire</u> - This was a 22-item telephone questionnaire modelled after a questionnaire used by Russell Barkley (2002). A research assistant attempted to contact participants by phone and arrange a suitable time to administer the questionnaire.

Results

Outcome Data: The human factors and self-report predictors reported in Jerome and Segal (2005) were analysed with respect to the prediction of problem driving events as recorded in the official Ministry of Transportation of Ontario driving record taken approximately two years after licensing. Of the original sample of novice drivers (N= 66) approximately 27% of students (18) had at least one problem-driving event that included either a moving violation or collision. Twenty violations and 16 collisions were found in the official record. There were no mortalities in the sample. Four participants had multiple collisions. These four drivers were identified by the driving instructor's Risk Rating to be falling within the moderate to high-risk categories. A single participant had two alcohol-related violations and received a driving instructor high-risk rating. Whilst these anecdotal observations are interesting, when the entire dataset was considered, all four types of the driving instructor's risk ratings and one additional composite risk rating (Driving Instructor Checklist, Total Score) was not statistically significantly associated with any measure of driving outcome. Furthermore, the driving instructor's risk ratings whilst identifying low risk participants failed to distinguish moderate from high-risk participant outcome.

A follow-up telephone survey at two years post-licensing gathered information about driving exposure, collisions and violations. Only 32 of the original 66 participants could be traced. Eight collisions and six violations were self-reported that did not appear on the official driving record. Again these additional problem-driving events were unrelated to Driving Instructor's Risk Rating.

Prediction of Driving Outcome: Table 1(a), (b), (c) shows the statistically significant correlations of human factor predictors to driving outcome as recorded in the official driving record. Section 1(a) describes the results for the total problem driving incidents; sections (b) and (c) report on collisions and violations, respectively.

Table 1: Human factors predictors of problem driving events

a) Total Driving Incidents

Predictors	Correlation	
Gender	.384	p<.001
JDQ-risk taking (b)	.403	p<.001
JDQ-anger (b)	.326	p<.01
JDQ-daydreaming	.325	p<.01
TCI-sentimentality	-.253	p<.04
TCI-cooperation	-.293	p<.01
TCI-compassion	-.303	p<.01
Barkley-Inattentive	.292	p<.02
Barkley-Total	.315	p<.01
CPT-variability	.250	p<.04

b) Collisions

Predictors	Correlation	
JDQ-risk taking (a)	.282	p<.02
JDQ-risk taking (b)	.237	p<.05
JDQ-alertness (b)	.279	p<.03

c) Violations

Predictors	Correlation	
Gender	.380	p<.002
Grade average	-.291	p<.01
JDQ-anger (b)	.364	p<.004
JDQ-daydreaming	.477	p<.0001
JDQ-risk taking (b)	.383	p<.002
TCI-disorderliness	.275	p<.02
TCI-cooperation	.283	p<.02
Barkley-Inattentive	.369	p<.005
Barkley-Total	.368	p<.005

Linear regression analysis was applied to the Total Driving Incidents data. The model incorporated all the identified human factor predictors, accounting for 32% of the common variance (using the Adjusted R^2). The linear regression model for collisions only identified the JDQ-risk taking variable, accounting for six percent of the variance. The JDQ-daydreaming variable and male gender were related to violations, accounting for approximately 37% of the common variation.

Table 2(a), (b) and (c) presents the statistically significant results for the self-report predictors of problem-driving events. Section 2(a) describes the results for the total problem driving incidents; sections (b) and (c) report on collisions and violations, respectively.

Table 2. Self-report predictors of problem driving events

a) Total Driving Incidents

Predictors	Correlation	
HLS-Substance Use -Concern	.345	p<.005
YRBS-Personal safety	.546	p<.0001
YRBS-Marijuana use	.252	p<.04
YRBS-Other drugs	.514	p<.0001

b) Collisions

Predictors	Correlation	
HLS-Rx medication use	-.285	p<.02
HLS-Head Injury	.253	p<.04
HLS-Accidental Poisoning	.411	p<.001
YRBS-Personal safety	.311	p<.01

c) Violations

Predictors	Correlation	
HLS-Other Drug Use	.340	p<.01
HLS-Substance Use- Concern	.391	p<.001
HLS-Criticism for Drug Use	.275	p<.03
HLS-Guilt-for Drug Use	.356	p<.004
HLS-Morning Alcohol Use	.281	p<.02
HLS-Fighting while intoxicated	.322	p<.008
YRBS-Personal safety	.532	p<.0001
YRBS-Violence	.329	p<.009
YRBS-Marijuana use	.338	p<.006
YRBS -Other drugs	.622	p<.0001
YRBS -Physical conditioning	-.270	p<.03

Linear regression analysis was applied to the Total Driving Incidents data. The model involved only the YRBS-other drugs predictor, accounting for 36% of the common variance. The linear regression model for collisions only identified the HLS-head injury predictor. This accounted for roughly 19% of the variance. A combination of YRBS-other drugs and HLS-other drugs used predictors accounted for 62% of the violations variance.

Linear Regression Models of Problem Driving Outcome: As part of the initial stages of constructing a screening instrument for the prediction of problem driving, stepwise linear regression analysis was conducted on all statistically significant predictors of problem-driving events. These results are shown in Table 3 (a), (b) and (c).

Table 3. Linear regression models of problem driving events

a) Total driving incidents

Predictors	Adjusted R^2
YRBS-Other drugs, Gender, CPT-Variability	.480

b) Collisions

Predictors	Adjusted R^2
YRBS-Personal safety, HLS-Head Injury, HLS-Accidental Poisoning, JDQ-Alertness (b), JDQ-Risk taking, JDQ-Risk taking (b)	.340

c) Violations

Predictors	Adjusted R^2
YRBS-Other drugs, HLS-Other drug use	.616

As shown in this table, the Total Driving Incidents regression model involved a combination of human factor and self-report predictors accounting for 48% of the variance. Similarly, a combination of human factor and self-report predictors yielded a model of collision prediction that accounted for 34% of the common variance. Lastly, violations were only associated with two self-report measures of "other drug use" that accounted for approximately 62% of the variance.

Discussion

Limitations of this study include the small sample size. Whilst the period of exposure and the exposure dose (distance driven) was not measured directly, we feel confident that the relatively long period of observation and follow up combined with objective official MTO data should have captured most of the problem driving events in this group of novice drivers. Current research suggests the maximum period of collision and violation risk in novice drivers peaks within the first months of independent driving and declines rapidly after six months. (McCArrt, *et al* 2003, Mayhew, *et al* 2003.) Others have indicated that the official record prevalence figures are likely to be underestimations, excluding unreported minor collisions and moving violations that never came to police attention. The results of our telephone interview questionnaire demonstrate this. Whilst 50% of participants' self-report data could not be traced at two years, the available data indicated moving violations and collisions not reported in the official record. The under-reporting may reflect a delay in data entry in the official record, failure to be convicted or minor collisions that were not reported where official reporting reflects more financially costly collisions. Our findings support those of Barkley (1993) and Nada Raja (1997) arguing that a combination of self-report and official driving record will likely produce the most comprehensive picture of driving outcome.

The current prevalence of 27% of our sample having problem driving is in keeping with the figures reported in Ontario of 25% of random samples of drivers manifesting problem driving (Ministry of Transport of Ontario, 1991; 1994). Our study casts doubt on the utility of Driving Instructor ratings as the best measure of future risk (Donnelly, *et al* 1992, Dobbs, Heller, *et al* 1998; Dobbs and McCracken, *et al* 1998; West & Hall, 1998). This is the first study to report on the predicative validity of a driving instructor's evaluation done at the time of the initial training two years after independent driving. To our knowledge there are no published studies evaluating the contribution of both "objective "measures of ecological valid real time driving instructor evaluations at base line along with human factor measures of impulsivity and attention after two years of independent driving experience. Our data demonstrate that for novice drivers, the driving instructors' future predictive accuracy was "no better than chance".

Previous authors have argued strongly against the predictive power of human factors in identifying at risk groups of drivers (Wilde *et al* 2002). Our data demonstrate that a combination of subjective self-report from novice drivers combined with human factors measures of attention and impulsiveness and temperament profiling predicts a significant percentage of the problem driving events.

Interestingly, our self-report data on problem behaviour as assessed by the YRSB and HLS, unrelated to problem driving, did not support the notion of a more general factor of risky problem behaviour. The linear regression model of general problem behaviour excluded aggressive behaviours, accidental ingestion of poisonous substances, tobacco, alcohol and cannabis use, and sexual promiscuity as significant problem behaviour predictors of problem driving. This finding supports those of Beggs *et al* (1999) who argued against a general factor of risk taking behaviour predicting problem driving. The exposure to "other" recreational drugs was associated with moving violations but not collisions in this relatively young population. This may reflect a smaller, but more behaviourally deviant sub-group in our sample, where human factors are subordinate to specific problem behavioural patterns related to substance use. Collisions, an infrequent event compared with moving violations, are complex events likely influenced by a combination of human factors, deviant problem behaviour and the unpredictable nature of the road environment.

Our findings support a model of problem driving based on human factors related to inattention and impulsiveness and a second more restricted model of life style factors of deviant problem behaviour arguing for a transaction between predisposing and precipitating biological and environmental factors. All the human factor instruments used in this study are normally used to measure symptoms of inattention and impulsiveness, measures of executive function in clinical populations. The fact that clinical measures of executive function have such strong predictive power in normal populations is a unique finding in this field of study that has previously relied on instruments that assume human factors lie on a continuum. We would argue that indeed the utility of these clinical instruments measuring executive function in a normal population argues for the same continuum of severity of these human factors in both clinical and non-clinical populations. As we have previously argued deficits in executive function as it relates to problem driving can be seen as lying along a continuum across a range of categorical clinical diagnoses and ages ranging from ADHD, Depressive Illness and Dementia (Jerome & Segal, 2000). Similarly, the findings in this study of deficits of impulsiveness and inattention might best be considered as continuous orthogonal variables that cut across the categorical distinction between normal and clinical populations.

The findings of this study argue that the application of human factor research to predicting problem driving behaviours holds the promise of developing an instrument that could be both a sensitive and specific tool for detecting a high-risk population of young drivers. The negative findings regarding the predictive power of trained driving instructors, although counter-intuitive, is supported by other research findings that showed little benefit of current driving instruction techniques and later driving safety. (Mayhew, *et al*., 1998). Our findings argue that given the underlying cognitive and temperamental vulnerabilities in these high-risk normal populations, the development of screening instruments to measure future risk of problem driving in normal populations should use measures of executive function as well as self report data. Such instruments may be used to guide cognitive behavioural interventions for at-risk individuals to improve their attention capacities and reduce impulsiveness. Indeed, this instrument may provide a metric for assessing improvement and predicting increased safety for driving. Such instruments could well incorporate driving simulators designed to measure the critical factors found to be predictive of problem driving. Perhaps a modified approach to driving instruction for these high-risk groups emphasising cognitive and behavioural measures of driving competence might incorporate the use of such instruments to assist driving instructors, as well as official examiners in deciding the readiness of novice drivers to graduate to the next level, i.e., independent driving.

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