



SENSATION SEEKING AND RISKY DRIVING: A REVIEW AND SYNTHESIS OF THE LITERATURE

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Abstract—The relationship between sensation seeking and risky behaviour has been observed since the 1970s. During the late 1980s and early 1990s, road safety researchers have examined the relationship between sensation seeking and risky driving (e.g. driving while impaired, speeding, following too closely), as well as its consequences (e.g. collisions, violations). There is also growing evidence that sensation seeking may also moderate the manner in which drivers respond to other factors such as alcohol impairment and perceived risk. This paper reviews and synthesizes the literature on sensation seeking as a direct influencer of risky driving and its consequences and as a moderator of the influence of other factors. The vast majority of the 40 studies reviewed showed positive relationships between sensation seeking (SS) and risky driving, with correlations in the 0.30–0.40 range, depending on gender and the measure of risky driving and SS employed. Of those studies that have looked at the subscales of Zuckerman's Sensation Seeking Scale, Thrill and Adventure Seeking appears to have the strongest relationship to risky driving. The biological bases of SS is discussed as are the implications for collision prevention measures. © 1997 Elsevier Science Ltd.

Keywords—Sensation seeking, Risky driving, Collisions, Violations

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 an underlying causal factor in driver behaviour. This interest has waxed and waned through the intervening decades with periodic reviews to punctuate the present state of knowledge (e.g. Adams, 1970; Beirness, 1993; Donovan et al., 1983; Signori and Bowman, 1974). Wilde (1994) has contended that personality has little role to play in collision involvement and that where relationships are found, they are generally weak and inconsistent.

There is a considerable body of literature which examines the relationship between the personality construct of sensation seeking (SS) and risky driving. Yet, there has never been a comprehensive review of this literature which attempts to integrate and synthesize the findings and draw conclusions about the role of SS as a causal factor underlying risky driving. There is also research which suggests that not only are these individual differences embedded in biological differences in the brain but that the latter may in

fact be, to some extent, hereditary (Eysenck, 1983; Zuckerman, 1994).

The purpose of this paper is to review the literature on the relationship between SS and risky driving and its consequences (i.e. collisions and traffic violations). First, however, the nature and measurement of the SS construct is outlined briefly.

THE NATURE AND MEASUREMENT OF SENSATION SEEKING

According to Zuckerman (1994), 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). Key to this trait is “the optimistic tendency to approach novel stimuli and explore the environment” (p. 384). Zuckerman (1994) views SS as part of a broader trait referred to as “impulsive sensation seeking” which is closely related to, if not part of, Eysenck's (1983) Psychoticism dimension. SS correlates moderately with impulsivity and weakly with extraversion (Zuckerman, 1994). For the most part, the present review concentrates on SS, as opposed to these related constructs.

Sensation seeking is operationally defined in

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terms of scores on the Sensation Seeking Scale (SSS) which was first published by Zuckerman et al. (1964). This measure has been revised several times in order to develop a total SSS score, to reduce the degree of correlation among the subscales, and to reduce its length. Form V of SSS is the most commonly used measure of SS (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"). It is important to note that there are no items on the SSS which refer to driving behaviour.

Factor analyses have indicated that there are four dimensions which make up the scale:

- (1) Thrill and Adventure Seeking (TAS);
- (2) Experience Seeking (ES);
- (3) Boredom Susceptibility (BS); and
- (4) Disinhibition (Dis).

These dimensions of SS, while modestly correlated, appear to measure different components of SS which have been found to relate differently to various risky behaviours (Zuckerman, 1994). This factor structure has been replicated by researchers in the United States (Zuckerman, 1971) and in Canada (Rowland and Franken, 1986), as well as a number of countries using translated versions of Form V [e.g. Carton et al. (1992) in France; Birenbaum (1986) in Israel; and Bjorck-Akesson (1990), in Sweden].

The SSS generates a total score as well as subscale scores on each dimension. Internal reliabilities for the total SSS range between 0.83 and 0.86 while the reliabilities for the subscales are: TAS, 0.77–0.82; ES, 0.61–0.67; Dis, 0.74–0.78; and BS, 0.56–0.65 (Zuckerman, 1994). Test–retest reliability over a 3-week period is reported by Zuckerman (1994) to be 0.94 for the total SSS. Abbreviated versions of Form V have been developed by other researchers (e.g. Madsen et al., 1987) but these measures generally tend to be less reliable both in terms of internal consistency and stability over time.

Sensation seeking has been found to be higher in males than females, and for both males and females, SS increases with age until about age 16 and then declines with age. SSS scores also tend to increase with the level of education and occupational status of the individuals and that of their parents although the relationship is not linear. In terms of construct validity, SSS scores positively correlate with a variety of risky behaviours, including injury proneness, sexual activity, gambling, financial risk taking and smoking (see Zuckerman, 1994, Chapter 5), as well as risky driving.

REVIEW OF THE LITERATURE

The review of the literature is organized into three sections which focus on drinking and driving, the most frequently studied risky driving behaviour, other risky behaviours such as non-use of seat belts and speeding, and the consequences of risky driving (i.e. collisions and citations for traffic violations). Essentially, three types of analyses have been performed by researchers: correlations/regressions of SS with risky driving; *t*-tests/analyses of variance on mean SS differences between high and low risk groups or on mean risky driving differences between high and low SSs; and factor/cluster analyses which have attempted to identify the characteristics of various types of risky drivers.

Sensation seeking and drinking and driving

Table 1 summarizes the literature on the relationship between drinking and driving and SS. Arnett (1990) administered the complete SSS (Form V) to 181 high school students, as well as a measure of egocentrism which reflects a tendency to believe that one is immune from disasters (e.g. "Driving drunk is unlikely to result in an accident"). These students also indicated whether they had driven drunk during the past year. Those admitting to drunk driving had higher scores on the total SS scale and on all subscales except ES. Students who drove drunk were also less likely to perceive that such behaviour would result in collisions or traffic tickets (i.e. egocentric). Interestingly, high SS subjects expected to be able to drive drunk on more occasions before being involved in a collision or getting a ticket compared to low SSs ($r_s = 0.44$ and 0.27 , respectively), suggesting an optimism bias on the part of the high SSs. Recently, Arnett et al. (1997), using his own SS measure, obtained a correlation of 0.23 between reported driving while impaired (DWI) and SS for grade 12 high school students.

Donovan et al. (1985) compared three groups of drivers on a wide variety of personality, attitudinal and drinking measures: DWI arrestees, high risk (HR) drivers (i.e. multiple accidents or violations) and drivers from the general population. Eight items from SSS (excluding BS) were combined with similar items developed by Plomin (1976). DWIs and HR drivers had higher SS scores than general drivers but did not differ from each other. An earlier study of the same drivers by Donovan and Marlatt (1982) used cluster analysis in order to identify various types of arrested DWIs. The most deviant cluster, referred to as 'Aggressive', had the highest SS scores and the highest incidence of reported driving after drinking. Donovan et al. (1990) following-up the HR drivers

Table 1. Relationship between SS and drinking and driving

Study	Subjects	SS measures	Risky driving measures	Analytical methods	Results
Arnett (1990)	181 Male high school students	SSS	Driven while drunk in past year	ANOVA	DWI group had higher total SSS scores. All subscales significantly related to DWI except ES. Dis was strongest predictor. DWI correlated 0.23 with SS scores
Arnett et al. (1997)	139 Male and female high school students	Arnett Inventory of SS	Reported DWI	Correlations	Cluster with highest SS scores reported greatest DWI
Donovan and Marlatt (1982)	172 DWI arrestees in education program	Eight items from SSS excluding Boredom items from Plomin (1976) scale	Reported DWI	Cluster analysis	
Donovan et al. (1985)	172 DWI arrestees, 193 HRDs, 154 Male drivers	Same as Donovan and Marlatt (1982)	Differences among groups in SSS score	Comparison of three groups by ANOVA	DWI and HRDs had higher SSS scores than general drivers but two groups did not differ
Donovan et al. (1990)	254 Male high risk drivers	Same as Donovan and Marlatt (1982)	DWI arrest during 3 year period	Hotellings T2	No difference between HRDs who were arrested for DWI and those who were not
Johnson and Raskin (1989)	556 Men and women aged 18 and 21	Dis and ES scales of SSS with PRF items to form risk taking/impulsive scale	Self-reported driving after drinking or use of marijuana	Regression analyses	Coefficients in 0.20–0.30 range depending on measure. Relationship stronger for males than females and for 18-year-olds than 21-year-olds. Risk-taking has direct effect on driving and indirect effect through use of alcohol/marijuana to cope. Three groups did not differ on SSS but DWIs had higher impulsivity scores
Jonah and Wilson (1986)	53 Convicted DWIs, 93 Admitted DWIs, 34 non-DWIs	Items from SSS and impulsivity scale	DWI	Comparison of three groups by ANOVA	Cluster with highest scores on SS measure most likely to report driving after four drinks $r=0.15$ ($p<0.1$) between SSS and repeat DWI offence
Lastovicka et al. (1987)	703 Young males	Three items on speeding and taking chances	Reported DWI in last month	Factor and cluster analyses	No relationship found between SSS and DWI measures
Little and Robinson (1989)	115 Convicted DWIs in prison	Ten item SSS from Madsen et al. (1987)	DWI recidivism during average of 8 months	Correlations	Non D and D and non-drinkers had lower SS than drivers stopped or arrested for DWI as result of accident, violation or roadblock
Mann et al. (1987)	300 Second time DWI offenders	Same as Marlatt and Donovan (1982)	Self-reported DWI	Compare groups with ANOVA and <i>t</i> -tests	SSS highest if DWI charge resulted from collision or violation compared to all other groups
McMillen et al. (1991)	188 Male and female university students	SSS	Reported D and D, reported DWI, reported DWI arrests	Compare groups with ANOVA and <i>t</i> -tests	Multiple DWI offenders had higher SSS scores than first DWI offenders
McMillen et al. (1992a,b)	132 Male and female college students	Items from SSS used by Donovan and Marlatt (1982)	Reported DWI, reported DWI arrests	Compare groups with ANOVA	For males, $r=0.54$ between SSS and reported DWI
McMillen et al. (1992a,b)	499 First or multiple DWI offenders	16 items from SSS used by Huba et al. (1981)	Reported DWI during last 6 months and DWI arrest in last 4 years	Correlations, path analyses and regression	For females, $r=0.32$ between SS and reported DWI. SSS had direct relationship to DWI for males but effect was mediated through alcohol use for females. SS and alcohol consumption had interactive effect on reported DWI
Stacy et al. (1991)	614 Men and women				Male drinking drivers had higher thrill seeking scores. No relationship for females. No relationship between SSS and +ve BAC. SS included on discriminant function
Stoduto et al. (1995)	555 Students aged 16–18	TAS scale	Self-reported drinking and driving last year	<i>t</i> -test	
Vingilis et al. (1994)	96 Seriously injured drivers in hospital	Same eight items used by Donovan and Marlatt (1982)	Drinking and driving, blood tests	<i>t</i> -tests, discriminant analysis	
Wieczorek (1995)	545 DWI offenders	SSS	Alcohol-related crashes	Compare DWIs with and without crashes using ANOVA	Total SSS scores unrelated to crash involvement. Thrill and adventure seeking negatively related (i.e. crash involved had lower scores)
Wilson (1992)	238 Convicted DWIs, 285 HRDs, 374 licensed drivers	Items from SSS	DWI conviction	Comparison of groups by ANCOVA and discriminant analysis	DWI, accident and demerit point groups had higher SSS scores than control group of licensed drivers. SSS included on discriminant function

HRD, high risk driver; DWI, driving under influence; D and D, drinking and driving.

studied by Donovan and Marlatt (1982), discovered that those drivers who were convicted of driving while intoxicated during a 3-year period did not differ in SS scores from those HR drivers who were not convicted. These results suggest that the HR group may be fairly homogeneous vis-à-vis personality whereas DWIs are more heterogeneous and hence may require different rehabilitative measures.

Johnson and Raskin White (1989) combined the scores on the Dis and ES subscales of SSS with subscales of the Jackson (1984) Personality Research Form (play, impulsivity, harm avoidance and cognitive structure) to form a risk taking/impulsive orientation measure. Regression analyses were performed on the subjects' reported driving after drinking or smoking marijuana which was collected 3 years later. Regardless which criterion measure was used, the SS measure contributed to the variance explained among 18-year-old males for drinking and driving (coefficients ranged from 0.27 to 0.43) and marijuana use and driving (coefficients ranged from 0.27 to 0.33). High SSs were more likely to report driving while under the influence of alcohol and marijuana. For 18-year-old females, similar but weaker relationships were observed. Among 21-year-old males and females, the relationships were in the same direction but weaker, particularly for marijuana use and driving, suggesting that the predictive value of SS may decline with age.

Jonah and Wilson (1986) included several items from the SSS and a measure of impulse expression (Jackson, 1984) on a questionnaire completed by convicted impaired drivers and patrons of bars, the latter divided into those who admitted to DWI in the last month and those who did not. While the three groups did not differ in SS scores, the convicted and admitted DWIs did have higher levels of impulse expression.

Lastovicka et al. (1987) posed a number of questions to 18-24 year Kansans concerning their lifestyle. A factor analysis generated a SS dimension reflected in items on speeding and taking chances while driving. A cluster analysis identified four groups: 'Good Timers', 'Well Adjusted', 'Nerds' and 'Problem Kids'. When reported driving after consuming six drinks was examined by cluster, the group which had the highest scores on the SS dimension (Good Timers) were also most likely to report impaired driving (48%), while the Nerds who had the lowest SS scores were least likely to report such behaviour (12%).

Convicted impaired drivers were tested at the beginning and end of an alcohol treatment program by Little and Robinson (1989) using a ten item SS measure developed by Madsen et al. (1987) and the

drivers' DWI recidivism was monitored for 8 months. The recidivism measure correlated 0.15 with pre-program SS scores and 0.16 with post-program scores, only reaching a marginal level of significance, such that the high SSs were more likely to repeat the offence.

McMillen et al. (1991) used Zuckerman's SSS in a study of university students' reported impaired driving behaviour. Students who had been arrested or stopped for impaired driving as a result of a collision or violation had greater SS scores than students who reported never drinking and driving or never drinking. McMillen et al. (1992b) observed that students who were stopped for impaired driving following a collision or violation had higher SS scores than students who had been stopped as a result of a roadblock or stakeout and that these latter students had higher SS scores than those who did not drink and drive at all. McMillen et al. (1992a) noted that multiple impaired driving offenders had higher SS scores than first offenders.

Stacy et al. (1991) explored three general explanations of the effects of personality traits, including SS, on self-reported drinking problems which included DWI. The three explanations are direct effects on drinking problems, mediational effects (i.e. personality influences alcohol consumption which in turn creates problems) and moderating effects (i.e. personality and consumption interact to affect problem behaviours). The relative importance of these three processes in explaining the effects of SS on DWI was examined. Using an abbreviated version of the SSS developed by Huba et al. (1981), Stacy et al. reported that impaired driving increased with SS for men ($r=0.54$) and for women ($r=0.32$) but the correlations with DWI arrests were not significant due to low variance in arrests (i.e. few subjects reported DWI arrests). Path analyses revealed that SS influenced DWI directly for men but indirectly through alcohol consumption for women. Stacy et al. also conducted regression analyses to isolate the interactive effects of personality and alcohol consumption on impaired driving. The interaction term accounted for more variance than did either of the main effects alone (38% of variance for men and 23% for women).

Stoduto et al. (1995) administered the TAS subscale of the SSS to a group of high school students aged 16-18, as well as a measure of driving after drinking. Male students who acknowledged drinking and driving during the past 12 months had higher TAS scores than non-drinking drivers but there was no relationship for females. Vingilis et al. (1994) studied drivers admitted to hospital for treatment following a motor vehicle collision. Drivers who had

a positive blood alcohol concentration (BAC) did not differ from those with a negative BAC on the TAS. Nevertheless, in a discriminant function analysis, TAS loaded 0.40 on an alcohol use function which significantly discriminated between positive and negative BAC groups.

Wieczorek (1995) focused on the psychosocial characteristics of DWI offenders who either had had no alcohol-related crashes or had had several. There was no difference between the two groups on the full SSS but surprisingly, the multiple crash group had lower TAS scores. Wieczorek speculated that this effect may be the result of socio-economic status differences between the two groups which would have affected the opportunity for the multiple crash group to engage in such risky, yet expensive activities as mountain climbing and flying, which are included on the TAS.

Wilson (1992) compared DWI offenders, multiple collision drivers and high demerit point drivers with a group of drivers from the general population on personality, drinking, driving, DWI and lifestyle measures (e.g. smoking, drug use). Controlling for age and education in an analysis of covariance, the DWI group had the highest SS scores, the general drivers had the lowest, with the high collision and demerit point groups being intermediate. A discriminant function analysis showed that SS significantly contributed to the functions discriminating among groups.

In summary, of 18 studies that have looked at SS and drinking and driving behaviour, all but five found positive relationships. As SS increased, reported DWI increased or reported/convicted DWIs offenders had higher SS scores. Few studies compared the subscales of the SSS but the Dis subscale was found to correlate most strongly with drinking and driving by Arnett (1990). Generally, the relationship between drinking and driving and SS has been stronger among men than women and may decline with age. There is some evidence that SS may influence DWI behaviour of men and women differently (i.e. more direct for men). Finally, the perceived risk of collision involvement while drinking and driving appears to mediate the relationship between SS and impaired driving.

Sensation seeking and other risky driving behaviours

The literature on risky driving other than drinking and driving is summarized in Table 2. The full SSS (Form V) 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 ($r=0.23$). For women, speed also increased with SS ($r=0.14$) and reported seat belt use declined with SS ($r=-0.15$). These results are similar to those of Zuckerman and Neeb (1980) which indicated a positive relationship between total SSS, as well as all subscale scores, and reported driving speeds for both men and women, controlling for age.

British students and professionals completed the TAS and BS subscales of Zuckerman's SSS, as well as a risky driving questionnaire (Furnham and Saïpe, 1993). TAS and BS correlated significantly with scores on the risky driving scale ($r=0.48$ and 0.36 , respectively). In the study by Arnett et al. (1997), high school students scoring higher on Arnett's SS scale were more likely to admit to driving over 80 mph ($r=0.34$), racing other drivers ($r=0.30$) and passing in no passing zones ($r=0.34$). Among a subgroup of these students who completed a 10-day logbook describing their driving episodes, the reported incidence of driving over the speed limit increased with SS ($r=0.26$). However, in a study by Burns and Wilde (1995), where the driving of taxi drivers was assessed unobtrusively over a standard route, only the ES subscale was related ($r=0.29$) to actual risky driving (i.e. speeding, careless, competitive).

Heino et al. (1992) administered a Dutch version of the SSS to 103 male drivers, as well as a driving questionnaire. High SSs were more likely to report speeding on urban streets and highways than low SSs. Subjects who were selected based on their high or low SSS scores, drove an 18 km route between two cities and back during which time their following distance was measured (i.e. time between vehicles passing same point). When asked to select their own following distance, high SSs chose a shorter distance (1.19 seconds) than low SSs (1.87 seconds). Even though high SSs drove closer to the vehicle in front, they did not perceive the risk of collision to be any greater, suggesting that high and low SSs select following distances with which they feel comfortable in terms of perceived risk. However, when subjects' perceived risk in free following (i.e. subjects chose distance) and prescribed vehicle following (i.e. subjects required to drive closer than their preferred distance) were compared, SS moderated the effect such that the increase in perceived risk from free to prescribed following was greater for low SSs than that for high SSs. On a measure of decreased heart rate variability, which was considered to be an indicator of mental load, low SSs showed a much greater effect of driving with short prescribed following distances such that mental load was greater for low SSs than it was for high SSs. These results suggest that

Table 2. Relationship between SS and risky driving

Study	Subjects	SS Measures	Risky driving measures	Analytical methods	Results
Arnett et al. (1997)	139 Male and female high school students	Arnett Inventory of SS	Reported reckless driving (speeding, racing other drivers, unsafe passing)	Correlations	SS correlated 0.34 with driving 80 mph, 0.30 with racing, 0.34 with unsafe passing and 0.26 with speeding as reported in driving logbook
Beirness (1995)	1501 Male and female high school students	Items from TAS and ES subscales of SSS	Risky driving (impaired driving, non-use of seat belts, deliberate risk taking)	Cluster analysis	Thrill seeking cluster had higher risky driving score than other two clusters
Burns and Wilde (1995)	51 Male taxi drivers	Form V of SSS	Observed risky driving (competitive, fast, careless)	Correlations	ES correlated 0.29 with observed fast/careless driving but not with competitive driving
Clement and Jonah (1984)	130 Male and 155 female university students	SSS Form V	Reported driving speed on clear road with 100 kph limit	Partial correlations controlling age, exposure and experience	Other subscales not related to risky driving $r = 0.23$ between SS and speed for males, $r = 0.14$ between SS and speed for females, $r = -0.15$ between SSS and belt use for females but not significant for males
Furnham and Saipe (1993)	73 British students and professionals	TAS and BS scales of Form IV of SSS	Driver behaviour (risky, law breaking)	Correlations	Risky driving correlated 0.37 with TAS and 0.27 with BS
Heino et al. (1992)	42 Male Dutch drivers aged 20–30	Extreme groups based on Dutch version of SSS	Following distance, perceived risk, heart rate variability (HRV), reported speeding	Correlations, ANOVA, t -tests	Law breaking correlated 0.50 with TAS and 0.29 with BS High SS had shorter following distance than low SS High SS reported speeding more often than low SS and preferred photos showing closer following distances High SS and low SS did not differ in perceived risk Short prescribed following distances resulted in greater perceived risk and higher mental load as determined by HRV for low SS than for high SS $r = 0.53$ between SS and Crime factor which included drunk driving $r = 0.43$ between SS and Violations factor which included running red lights and speeding collisions SSS correlated -0.36 with safety motives and -0.29 with skill motives SSS correlated 0.30 with max. speed and 0.27 with acceleration
Horvath and Zuckerman (1993)	220 Male and 227 female university students	SSS Form V	Reported risky behaviours including drunk driving, running red lights and speeding	Correlations and multiple regression	High SS group made more lane changes and passed more cars than low SS group but no difference on max speed
Lajunen and Summala (1996)	195 Male Finnish soldiers	SSS Form V	Driving Behaviour Inventory. Max. speed and acceleration	Correlations	Interaction of SS and alcohol expectancy such that high SSs made more lane changes and passed more if they thought they consumed alcohol but low SSs made fewer changes and passes High SS drove at higher speed but hit fewer obstacles High SS had higher assessment of driving ability High SS rated engine power more important than did low SS while low SS rated safety higher High TAS and Dis predicted violation types of errors ($r^2 = 0.37$) but not other types
McMillen et al. (1989)	62 Male and 32 female university students	SSS Form IV	Lane changes, cars passed, time at max. speed on simulator	χ^2 tests	In all three driver groups, SS was lowest in group which always uses seat belt but never and sometimes groups did not differ
Moe and Jenssen (1990)	60 Norwegian soldiers	SSS Form VI	Speed and obstacle avoidance on icy track	N/A	Thrill seeking had variate score of 0.92 among variables predicting risky driving
Rimmo and Aberg (1996)	700 Swedish drivers aged 17–27	TAS and Dis items from SSS	Type of errors made (violation, inexperience inattention, mistake)	LISREL analysis	SS correlated 0.45 with risky driving index
Wilson (1990)	238 convicted DWIs, 285 HRDs, 374 licensed drivers	Items from SSS	Reported frequency of seat belt use	Comparison of belt use groups using ANOVA	Highly significant linear relationship between speed and SSS for males and females on all subscales
Wilson and Jonah (1988)	238 Convicted DWIs, 285 HRDs, 412 licensed drivers	Thrill seeking based on items from SSS and impulsivity scale from Jackson BPI (Jackson, 1984)	Risky driving (impaired driving, non-use of seat belts, speeding, aggressive)	Canonical Analysis	
Yu and Williford (1993)	878 Respondents from DWI programs, jails, probation, treatment centre	Ten items adapted from SSS	Reported risky driving (e.g. speeding, not stopping at signs)	Correlations	
Zuckerman and Neeb (1980)	554 Male and 646 female magazine subscribers	SSS	Reported driving speed on highway with 55 mph limit	Comparison of speed groups using ANOVA	

low SSs perceive greater risk while driving closer to a vehicle than they are used to, requiring them to concentrate more on the driving task compared to high SSs.

Horvath and Zuckerman's (1993) factor analysis of their Risk Appraisal Scale identified a Crime factor, which included driving while drunk, and a Minor Violations factor, which included involvement in collisions as a result of running red lights or speeding. High SSs scored higher than low SSs on the Crime and Minor Violation factors ($r=0.53$ and 0.43 , respectively). Perceived personal risk of engaging in the risky activities was negatively correlated with SS such that high SSs believed their risk was lower than that of low SSs ($r=-0.32$ and -0.23). Perceived risk also was negatively correlated with the Crime and Minor Violations scales ($r=-0.35$ and -0.27) such that people who perceived less risk were more likely to engage in the risky behaviours. A regression analysis revealed SS as the best predictor of the subjects' risky behaviour after the reported risky behaviour of peers. Structural equation modelling suggested that perceived risk does not mediate the SS-risky behaviour relationship but rather is a consequence of the behaviour (i.e. as a result of successfully engaging in risky behaviour, high SSs reduce their perceived risk of the behaviour, while low SSs retain their apprehension).

Lajunen and Summala (1996) requested male Finnish soldiers to complete the SSS, as well as a Driving Behaviour Inventory (DBI), and then measured the driving performance of a sub-sample of soldiers. High SSs expressed greater skill orientation in completing the DBI ($r=0.29$) but a lower safety orientation ($r=-0.36$). Skill oriented drivers tend to drive to satisfy their need for sensation (e.g. "driving fast if necessary, managing car through slide"), whereas safety oriented drivers see driving more from a safety perspective (e.g. "driving carefully, avoiding unnecessary risks"). SSS scores also correlated 0.30 with maximum speed during the driving performance and 0.27 with acceleration.

McMillen et al. (1989) investigated risky driving 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 SS. Overall, high SSs passed more cars and changed lanes more often than low SSs. Moreover, SS and alcohol expectancy interacted such that regardless of actual consumption, high SSs who thought they had consumed alcohol passed more cars and changed lanes more often than those who did not think they had been drinking. In contrast, low SSs who thought that they had been drinking actually took fewer risks compared to those who expected no

alcohol, suggesting that low SSs may drive more carefully if they feel that their performance is impaired.

Moe and Jenssen (1990) used Form VI of the SSS to divide 90 Norwegian soldiers into high, medium and low SS groups. The high and low subjects completed a driving test on a snowy and icy track where their task was to drive as fast as possible while avoiding obstacles. A reward was offered to the winner in each of six groups made up of equal numbers of high and low SSs. The high SS group drove faster and were more daring but they drove better (i.e. hit fewer obstacles). The highs also had a more elevated assessment of their driving ability. On a questionnaire, high SSs rated engine power to be a more important characteristic of a car than did low SSs, whereas the lows were more likely to indicate that collision safety and fuel consumption were more important compared to high SSs.

Rimmo and Aberg (1996) examined the relationship between the types of driving errors committed by Swedish drivers and their SS scores. Using Reason et al.'s (1991) typology of errors which distinguishes among violations (e.g. speeding), mistakes (e.g. misjudging gaps), inattention and inexperience (e.g. using wrong gear), high SS drivers committed more violation types of errors than low SSs, while SS was unrelated to the other types of errors. The relationship was stronger for the Dis subscale than for the TAS subscale.

Wilson and Jonah (1988) noted that the TAS subscale combined with an impulsivity measure was a major predictor of risky driving (i.e. non-use of seat belts, speeding, aggressive driving, impaired driving) as determined by canonical correlations. 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, the latter two groups not differing. Beirness (1995) reported that in a cluster analysis, the students in the cluster with the highest TAS scores also had experienced the greatest risky driving (i.e. impaired driving, non-use of belts, deliberate risk taking).

Yu and Williford (1993) tested impaired driving offenders on a measure of driving risk (i.e. speeding, failure to stop at traffic signs) and a measure of SS which included items from the SSS. Driving risk correlated 0.45 with SS. Also, high SS subjects felt that they could handle more drinks and still drive

well than did low SSs ($r=0.28$), suggesting lower perceived risk by high SSs.

In summary, all 15 of the studies that have investigated SS and risky driving other than drinking and driving have evidenced positive relationships, particularly for men. Also high SSs perceive less danger in risky driving behaviour. Although not often studied, TAS appeared to be the subscale most strongly related to risky driving.

Sensation seeking and the consequences of risky driving

The ultimate measure of risky driving is involvement in collisions, particularly where the driver has been deemed at fault. Driver licence regulators have implemented elaborate demerit point systems assuming that drivers with multiple moving traffic violations are more likely to become involved in collisions in the future, and hence should be taken off the road and/or directed to improvement programs. Hence, traffic violations are often used as an intermediate measure of risky driving between behavioural measures, observed or reported and the ultimate measure of collision involvement. Several studies have looked at the relationship between SS and these consequences. While in some studies actual driver records have been used, in others, self-reported collisions and violations have been related to SS. The studies which have focused on the relationship between the consequences of risky driving and SS are summarized in Table 3.

Beirness (1995) conducted a multi-year cohort study whereby high school students completed a lifestyle questionnaire, initially in grades 9 and 10, and then in each subsequent grade for 3 years. The TAS and ES subscales from the SSS were included as part of the questionnaire, as were items concerning self-reported collisions. Based on their driving record during the fourth year of the study, the students were classified into Crash and No Crash groups. The Crash group had higher TAS and ES scores in each of the three preceding years than the No Crash group. In contrast, Clement and Jonah (1984) found no relationship between university students' SS scores and self-reported collisions or violations.

Burns and Wilde (1995) correlated taxi drivers' SS scores with their driver records. The total SSS was positively correlated with speeding ($r=0.42$) and other types of violations ($r=0.35$) but not with collisions or demerit points. The TAS subscale was most strongly related to speeding violations, whereas the BS subscale had the highest correlation with other traffic violations. Furnham and Saipé (1993) noted that TAS and BS correlated significantly with viol-

ations ($r=0.19$ and 0.31 , respectively) but not with collisions.

Donovan et al. (1988) conducted cluster analyses among HR drivers, identifying three clusters characterized as 'Well Adjusted', 'Impulsive' and 'Personal Maladjustment' (i.e. drivers going through a difficult time in their life, as a result of divorce, job loss, etc.). The latter two clusters had higher SS scores than the 'Well Adjusted' cluster and they also had more violations on their driving records during the follow-up period but not collisions. Wilson (1991) performed cluster analyses on measures gathered from DWI offenders and HR drivers (i.e. multiple collisions or violations) in order to replicate the earlier work of Donovan et al. (1988). Of the four clusters derived, the 'Deviant' and the 'Irresponsible' clusters had the highest SS scores and the highest incidence of traffic violations, demerit points and licence suspensions. There were no differences in collision involvement.

Gregersen and Berg (1994) administered a lifestyle questionnaire to 20-year-old Swedish students. Factor analysis revealed several dimensions, one of which was referred to as "extra motives for driving", including SS. A cluster analysis resulted in four HR and two low risk clusters of drivers. The two clusters with the highest scores on the extra motives dimension (i.e. SS) were overrepresented in terms of collision involvement. A Finnish study by Hilakivi and Veilahti (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. Another Finnish study by Lajunen and Summala reported a correlation of 0.24 between soldiers' SS scores and self-reported collision involvement but a near zero correlation with violations.

Although Hartman and Rawson (1992) were studying the SS scores of athletes and non-athletes, they also inquired about traffic collision involvement. High SS subjects who had completed Form VI of the SSS reported more collisions than low SS subjects ($r=0.34$). Loo (1979) reported that the SS component of Eysenck's Personality Inventory correlated 0.26 with report traffic violations but not with collision involvement. In a follow-up study of 120 convicted impaired drivers, Mann et al. (1987) had offenders complete several items from the SSS. High SS offenders were more likely to report involvement in alcohol-related collisions during the 5 years since

Table 3. Relationship between SS and consequences of risky driving

Study	Subjects	SS measures	Risky driving measures	Analytical methods	Results
Beirness (1995)	1501 Male and female high school students	Items from TAS and ES subscales of SSS	Crash involvement in fourth year of driving	ANOVA comparing crash and no crash. Cluster analysis	Crash group had higher TAS and ES scores than no-crash group for both sexes
Burns and Wilde (1995)	51 Male taxi drivers	Form V of SSS	Recorded violations and collisions	Correlations	SS correlated 0.35 with violations and 0.42 with speeding violations but not with collisions TAS correlated highest with speeding violations and BS highest with other moving violations No relationship between SSS and collisions or violations
Clement and Jonah (1984)	130 Male and 155 female university students	SSS Form V	Reported collisions and violations	Partial correlations controlling age, experience and exposure	Three HRD clusters identified Cluster with lowest SS scores had lowest number of violations and lowest risk index during follow-up record TAS correlated 0.19 with violations and 0.06 with crashes BS correlated 0.31 with violations and 0.10 with crashes Two clusters with highest scores on SS motives for car driving had higher crash rates than two clusters scoring low on these motives SS correlated 0.34 with reported collisions
Donovan et al. (1988)	193 Male HRDs	Same as Donovan and Marlatt (1982)	Crashes and violations. Risk index	Cluster analysis	Twice as many high SSs had one or more collisions as low SSs Major predictors of crashes were L, Q3 and H factors Major predictor of at fault crashes were L and Q3 factors Subjects who had accidents and/or violations had higher SS scores. SS was best predictor of driving record accounting for 10% of variance SSS correlated 0.24 with collisions and -0.03 with violations Sensation seeking component of extraversion scale correlated 0.49 with traffic violations SS correlated 0.32 with alcohol-related crashes
Furnham and Saipie (1993)	73 British students and professionals	TAS and BS scales of Form IV of SSS	Crashes and violations	Correlations	Low SS group drove more kilometres per collision than medium or low SS groups but not significant Low SS group drove more kilometres per reckless or speeding offence than other two groups Traffic violations increase with SSS scores
Gregersen and Berg (1994)	1774 20-year-old Swedish drivers	Items measuring car driving for SS motive	Crash risk	Correlations	Cluster which had highest SSS scores also had greatest number of violations and cluster which had lowest SSS scores had least violations Two clusters with highest SSS scores had highest numbers of violations, suspensions and demerits No differences on collisions Thrill seeking correlated 0.32 with risk index
Hartman and Rawson (1992)	179 University male and female students	TAS and Dis subscales of SSS Form VI	Self-reported collisions	Correlations	
Heino et al. (1992)	103 Dutch drivers	Dutch version of SSS	Self-reported collisions	Wald statistic	
Hilakivi and Veilahiti (1989)	597 Male Finnish army conscripts	Cattell's 16 PF	Crashes.	Logistic regression	
Jamison and McGlothlin (1973)	164 Participants who had used LSD	SSS Form IV	Crashes and violations during 3-year period	χ^2 and <i>t</i> -tests. Regression analyses	
Lajunen and Summala (1996)	195 Male Finnish soldiers	SSS Form V	Self-reported collisions and traffic violations	Correlations	
Loo (1979)	28 Female university students	Eysenck Personality Inventory	Traffic violations	Correlations	
Mann et al. (1987)	300 Second time DWI offenders	Same as Marlatt and Donovan (1982)	Self-reported alcohol related collisions	Correlations	
Moe and Jenssen (1993)	927 Driver education students	SSS Form VI	Self-reported collision and violation rates	N/A	
Rimmo and Aberg (1996)	700 Swedish drivers aged 17-27	TAS and Dis items from SSS	Reported traffic offences (speeding, DWI, running red) Traffic violations	Bar graph but no statistics	
Wells-Parker et al. (1993)	517 DWI offenders in education program	Same as Donovan and Marlatt (1982)	Traffic violations	Cluster analysis	
Wilson (1991)	238 Convicted DWIs, 285 HRDs	Items from SSS	Crashes, violations and suspensions	Cluster analysis	
Wilson and Jonah (1988)	238 Convicted DWIs, 285 HRDs, 412 licensed drivers	Thrill seeking based on items from SSS and impulsivity scale from Jackson BPI (Jackson, 1984)	Risk Index based on crashes, violations and suspensions	Correlations. Regression analyses. Canonical analysis	

their conviction than low SS offenders ($r=0.32$). Heino et al. (1992) reported that twice as many high SS Dutch drivers had one or more collisions compared to low SS drivers.

One of the earliest studies to examine SS involved people who had used LSD as part of psychotherapy or had participated in experiments with the drug (Jamison and McGlothlin, 1973). Subjects were categorized on the basis of their three year driving record into four groups: no accidents or violations; no accidents but one violation; two or more violations; one or more accidents. SS was higher in the two violation and accident groups. Multiple regression revealed that SS was the best predictor of driver record, accounting for 10% of the variance.

Moe and Jenssen (1993) had Norwegian driver education students complete a questionnaire which measured SS using Form VI and self-reported collision involvement, as well as distance traveled. Low SSs had a higher number of kilometres traveled per violation compared to medium or high SS subjects (i.e. lower violation rate), but there was no significant difference on collision rate. The Dis subscale appeared to better discriminate among the three groups than the TAS subscale.

Wells-Parker et al. (1993) performed cluster analyses on measures of personality, driving attitudes, reasons for alcohol use and driving violations gathered on DWI offenders taking an alcohol safety education program. The cluster with the highest SS score also had the highest number of traffic offences prior to the DWI conviction, whereas the cluster with the lowest SS scores had the lowest number of offences. Wilson and Jonah (1988) applied the Problem Behaviour Theory (Jessor, 1987) to predict scores on a risk index consisting of responsible collisions, traffic violations and licence suspensions, among convicted DWIs, HR drivers and a sample of drivers from the general population. Thrill seeking was measured with TAS subscale items and the impulsivity scale of the Basic Personality Inventory (Jackson, 1984). Scores on the risk index correlated 0.32 with thrill-seeking.

In summary, of the 18 studies relating SS to the consequences of risky driving, most have reported positive relationships. Of the 11 studies examining traffic violations, six reported significant correlations, and three identified clusters which included drivers with high SS scores and violations. Of the 12 studies including a separate measure of collision involvement, as opposed to an index which combined collisions and violations, seven studies reported significant differences between high and low SSs on collision involvement using correlations or analyses of variance, and another study using cluster analyses iden-

tified a positive relationship between SS and collisions. High SSs are more likely to experience collisions and violations than low SSs. Although few studies have looked at the SSS subscales, the TAS would appear to be most strongly related to driver records.

DISCUSSION

The purpose of this study was to review the literature on the relationship between SS and risky driving. Of the 40 studies reviewed, only four did not find a significant positive relationship between SS and some aspect of risky driving. The relationship has been stronger with observed or reported driving behaviour than with traffic violations or collision involvement. Collision involvement has been less strongly associated with SS, possibly because of the lack of variance in the collision measure (i.e. collisions are relatively rare events) and because being involved in a collision does not necessarily mean that the driver behaved incorrectly. Very few studies have examined the relationship between at fault collisions and SS and no studies have addressed whether high SSs are over-represented in serious collisions involving injuries or fatalities.

The relationship between SS and risky driving has been observed among drivers from Canada, the United States, Great Britain, the Netherlands, Sweden, Norway and Finland and has been stronger for men than women. Since most of the studies reviewed have studied men exclusively, future research should examine differences between men and women in the SS-risky driving relationship. There is some evidence that this relationship may weaken with age (e.g. Johnson and Raskin White, 1989), which may occur because of the growing importance of other influencers of risky driving (e.g. driving experience, maturity) or it could simply be due to reduced variability in SS scores with increasing age which limits the ability to obtain statistically significant relationships. Further research should confirm this finding, and the reasons for it. While the subscales of SSS have not been examined very often, when they have been, TAS is most strongly related to risky driving, followed by Dis and ES.

When correlations have been reported, they tend to be in the 0.30–0.40 range, depending on the measures of risky driving and SS, indicating that SS may account for only ca 10–15% of the variance in risky driving. This may be an underestimate of the strength of the relationship given the error in the measurement of the SS construct on the one hand, and risky driving, on the other. Furthermore, only 13 of the studies reviewed used the complete

Zuckerman SSS, while in another 17 studies, only some of the subscales or items of SSS were used. The remaining studies used other measures, the psychometric properties (i.e. reliability, validity) of which have not always been reported. Clearly, there has been a lack of uniformity in the operationalization of the SS construct in the literature. Of the studies which have included the complete SSS, only one failed to find a relationship with risky driving. In the future, researchers should use the complete Form V of the SSS to ensure that the same construct is being measured by all researchers.

Several studies note that high SSs perceive less risk in various driving situations and that perceived risk and risky driving are negatively correlated (Arnett, 1990; Heino et al., 1992; Horvath and Zuckerman, 1993; Yu and Williford, 1993), suggesting that risk perception may mediate the relationship between SS and risky driving. High SSs may not perceive certain driving behaviours as being risky because they feel that they can speed, follow closely, or drive after drinking and still drive safely as a result of their perceived superior driving skills.

Alternatively, high SSs may initially perceive their behaviour as being risky but accept the risk in order to experience the thrill of engaging in it. Once high SSs have experienced risky driving behaviour which has not resulted in negative consequences, however, they may lower their perceived level of risk, and engage in the behaviour more often in the future.

This notion is consistent with Fuller (1984) conceptualization of driving as threat avoidance. When confronted with a discriminative stimulus (e.g. approaching a sharp bend), the driver may choose to elicit an anticipatory response (e.g. slowing down) or a non-avoidance response (i.e. continue at the current speed). This decision depends on a number of factors, one of which is whether previous responses in similar situations have resulted in positive or negative outcomes. For example, if drivers have slowed down in the past at this curve and have discovered that there has never been any oncoming vehicles, they may conclude that slowing down is a waste of time, and consequently see no need to slow down next time. On the other hand, if they have occasionally seen vehicles coming the other way, they may engage in a partial anticipatory response by slowing down slightly or by focusing their attention and using both hands on the wheel. Once into the curve, it may become necessary to engage in a delayed avoidance response such as hard braking or swerving to avoid an approaching vehicle. The intense arousal associated with such an outcome would likely result in the driver slowing down next time.

Fuller speculates that there may be two predomi-

nant driving styles: anticipatory avoidance driving and delayed avoidance driving. He characterizes drivers exhibiting the latter style as driving faster approaching hazards, experiencing high arousal in driving, tolerating HR, being more extroverted and having higher collision involvement. This characterization sounds similar to the profile of the high SS driver. Future research should further explore the relationships among SS, perceived risk, arousal while driving, perceived driving skill and risky driving.

Sensation seeking may not only affect risky driving directly. Johnson and Raskin White (1989) and Stacy et al. (1991) have discovered that SS appears to influence alcohol use as a coping mechanism to handle stress, which in turn precipitates DWI. Also, alcohol expectancy and SS appear to interact such that high SSs take greater risks if they think they have been drinking but low SSs take fewer, even when they have not actually consumed any alcohol (McMillen et al., 1989). These results suggest that alcohol may serve as a disinhibitor of risky driving for high SSs. Further research should investigate the interactive relationship between SS and alcohol and other drugs to determine whether SS results in greater consumption and/or consumption disinhibits SS tendencies that are displayed as risky driving.

Biological basis of sensation seeking

Given the ubiquitous relationship between SS and risky behaviour, Zuckerman (1994) and his colleagues have been studying the biological bases of SS. Zuckerman believes that monamine neurotransmitters like dopamine, norepinephrine and serotonin underlie the trait of SS. These neurotransmitters are involved in the production of the neuronal synapses which transmit messages from the brain throughout the body. Dopamine appears to motivate the exploration of the physical and social environment and provides positive arousal and reward associated with novel and intense stimulation. Similarly, norepinephrine provides the arousal associated with novel stimuli and amplifies reactions to them, while serotonin tends to inhibit behaviour in the face of potentially threatening stimuli. The enzyme monoamine oxidase (MAO) appears to regulate the production of these monoamine neurotransmitters by keeping them in balance. Figure 1 shows a schematic drawing of the biological basis of SS.

Zuckerman (1994) notes that MAO, which has a strong genetic determination, has consistently been lower in high SSs than in low SSs. Zuckerman (1994) cites nine studies of this relationship and reports that the median correlation between SSS scores and MAO levels was -0.24 , with only one study not observing a significant correlation. In a study of 1000 Swedish

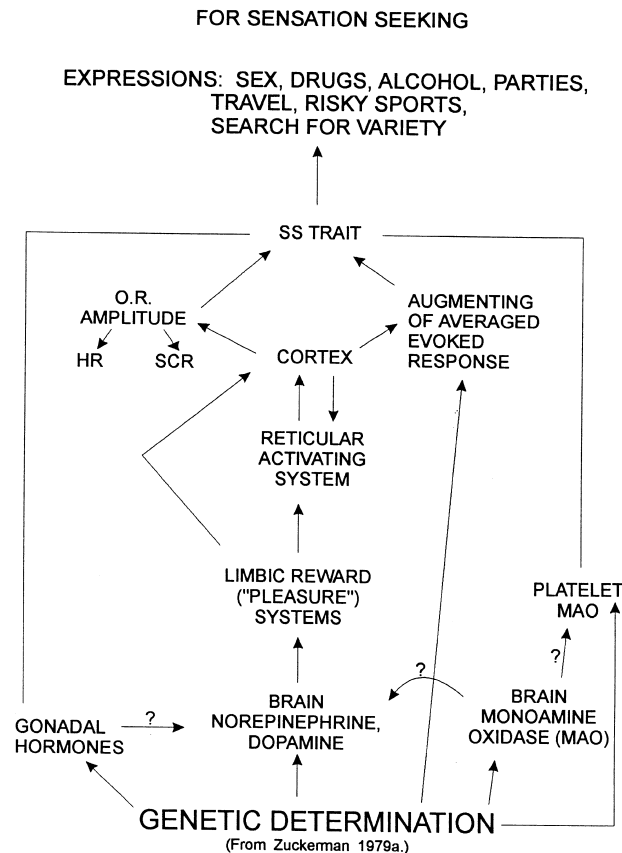


Fig. 1. A biological model for SS [genetic determination from Zuckerman (1979)].

army recruits by von Knorring and Oreland (1984), subjects with high levels of MAO had significantly lower levels of SS and SS was the only personality measure that contributed to the discrimination between high and low MAO groups. Other biological evidence reviewed by Zuckerman (1994) indicates that among normal subjects, there is a negative correlation between SS and norepinephrine (i.e. high SSs have lower levels) but no consistent relationship with dopamine or serotonin metabolites.

There is also intriguing evidence to suggest that individual differences in SS may be genetically based and that these genetic differences are reflected in the different biological makeup of high and low SSs. Eysenck (1983) has estimated, using twin study data, that as much as 70% of the reliable variance of the underlying trait of SS is genetic in origin. In recent studies by Ebstein et al. (1996) and Benjamin et al. (1996), novelty seeking, as measured by the NEO Personality Inventory and the Tridimensional Personality Questionnaire, has been related to the seven-repeat allele in the locus for the D4 dopamine receptor gene (D4DR). These results are impressive because they were conducted in different countries (i.e. Israel and United States), using different person-

ality measures and controlling for age and sex differences. Nevertheless, a great deal more research is required to elaborate our understanding of the biological basis of SS. It would be interesting to compare the correlation between SS and risky driving among twins to ascertain whether it is stronger than that for non-twins. Such research may provide evidence for the genetic basis of risky driving.

Implications for prevention

The body of research on the relationships among SS, risky driving and biological differences, suggest that risky driving may be, at least to some extent, genetically predisposed. This leads one to consider the implications for road safety of such a genetic predisposition, if in fact it is borne out by further research. If high SS drivers can be reliably identified, what prevention measures could be implemented to reduce the incidence of their risky driving?

The most direct avenue for influencing these drivers is through the licensing system. If applicants for a new licence were screened through the use of the SSS, high SSs could be identified. While it seems improbable that these drivers could be denied a licence on the basis of their SSS scores alone, high

SSs could be required to complete an educational program focused on deterring them from using driving as a means of stimulation. The educational program could highlight the consequences of risky driving and encourage high SSs to pursue sensation through other less destructive activities such as skiing, mountain biking or rock climbing. Through greater self-awareness, some high SSs might modify their risky driving tendencies. Similarly, problem drivers who come to the attention of the licensing authorities due to the accumulation of collisions and demerit points could be screened using the SSS to identify high SSs.

In order to identify those high SSs who are at greatest risk of collision involvement, it is necessary to conduct prospective research with new licencees and problem drivers to determine how well SSS scores predict collisions, particularly serious ones where the driver is at fault. Driving records could be tracked over several years to determine the appropriate threshold score on the SSS which could be used to trigger the requirement to participate in the educational program.

Other measures could be used in combination with SS during the licensing process to detect at risk drivers. For example, impulsiveness and aggressiveness have been related to collision involvement (Beirness et al., 1993). Ideally a battery of tests could be used to identify HR drivers. Since HR driving may be rooted in more than one problem, educational programs should be tailored to address the specific nature of the problem or set of problems identified (i.e. program matching).

Undoubtedly, some high SSs will not be influenced by educational measures since these drivers actually enjoy the thrill of risky driving and avoiding negative consequences. Furthermore, enforcement programs may fail to deter some high SSs risky driving since they enjoy the thrill of breaking the law and avoiding detection. These drivers may only be protected by engineering solutions, whereby they do not have to alter their behaviour to improve their safety (e.g. airbags, anti-lock brakes). On the other hand, it is conceivable that high SSs would readily adapt to any perceived improvements in their level of risk by accepting greater risks.

Wilde (1982, 1994), in his Risk Homeostasis Theory, contends that drivers will adapt their behaviour to lowered levels of perceived risk by accepting greater risks either by traveling more often or further, or by driving faster, closer to other vehicles or while impaired by alcohol, etc. Is it possible that such behavioural adaptation, rather than being a general phenomenon among all drivers, as purported by Wilde, is pursued mainly by those drivers who are

attempting to optimize their level of risk and the potential rewards from those risks (i.e. high SSs)? With the emergence of intelligent transportation systems, vehicles are being equipped with an increasing variety of technological hardware intended to enhance road safety (e.g. head-up display, headway warning device). Will the expected safety benefits of these devices actually be observed once they are implemented or will some drivers adapt to a safer vehicle by driving greater distances, faster or closer to the vehicle in front?

It is postulated that high SSs adapt their behaviour to take advantage of such improvements in safety to a greater extent than low SSs and that consequently, they exhibit greater risky driving. For example, if drivers were provided with a warning device which alerts them to the fact that they are becoming tired, it might be expected that high SSs, over time, would adapt to the presence of this device more than low SSs and hence would drive longer, drive at higher speeds, take fewer breaks and make more driving errors. Future research is being pursued to test this hypothesis.

In conclusion, it is clear that SS is moderately related to risky driving, although the exact psychological mechanisms through which SS influences driving and the nature of the biological bases of SS require further research. It is important to recognize that high and low SSs alike contribute to the survival of our species. As Zuckerman (1983) has aptly pointed out, "The biological value of a Columbus to the species is incalculable, but for every Columbus, there must be more cautious types who stay at home and keep the books, make the star charts, codify the laws, and plant the crops" (p. 38).

Disclaimer

The views expressed in this paper are not necessarily those of Transport Canada.

REFERENCES

- Adams, J.R. (1970) Personality variables associated with traffic accidents. *Behavioural Research in Highway Safety* **1**, 3–18.
- Arnett, J. (1990) Drunk driving, sensation seeking, and egocentrism among adolescents. *Personality and Individual Differences* **11**, 541–546.
- Arnett, J., Offer, D. and Fine, M.A. (1997) Reckless driving in adolescence: "state" and "trait" factors. *Accident Analysis and Prevention* **29**, 57–63.
- Beirness, D.J. (1993) Do we really drive as we live? The role of personality factors in road crashes. *Alcohol, Drugs and Driving* **9**, 129–143.
- Beirness, D.J. (1995) The relationship between lifestyle factors and collisions involving young drivers. In *New to the Road: Reducing the Risks for Young Motorists International Symposium*, 8–11 June, p. 17. UCLA Brain

- Information Service/Brain Research Institute, Los Angeles.
- Beirness, D.J., Simpson, H.M. and Mayhew, D.R. (1993) Predicting crash involvement among young drivers. In *Alcohol, Drugs and Traffic Safety—T92. Proceedings of the 12th International Conference on Alcohol, Drugs and Traffic Safety, ICADTS—T92*, eds H.D. Utzelmann, G. Berghaus and G. Kroj, pp. 885–890. International Committee on Alcohol, Drugs and Traffic Safety, Cologne.
- Benjamin, J., Li, L., Patterson, C., Greenberg, B.D., Murphy, D.L. and Hamer, D.H. (1996) Population and familial association between the D4 dopamine receptor gene and measures of novelty seeking. *Nature Genetics* **12**, 81–84.
- Birenbaum, M. (1986) On the construct validity of the Sensation Seeking Scale in a non-English speaking culture. *Personality and Individual Differences* **7**, 431–434.
- Bjorck-Akesson, E. (1990) Measuring sensation seeking. *Goteberg Studies in Education Sciences*, p. 75. Acta Universitatis Gothoburgensis, Goteburg, Sweden.
- Burns, P.C. and Wilde, G.J.S. (1995) Risk taking in male taxi drivers: relationships among personality, observational data and driver records. *Personality and Individual Differences* **18**, 267–278.
- Carton, S., Jouvent, R. and Widlocher, D. (1992) Cross-cultural validity of the Sensation Seeking Scale. Development of a French abbreviated form. *European Psychiatry* **7**, 225–234.
- Clement, R. and Jonah, B.A. (1984) Field dependence, sensation seeking and driving behaviour. *Personality and Individual Differences* **5**, 87–93.
- Donovan, D.M. and Marlatt, G.A. (1982) Personality subtypes among driving-while-intoxicated offenders: relationship to drinking behavior and driving risk. *Journal of Consulting and Clinical Psychology* **50**, 241–249.
- Donovan, D.M., Marlatt, G.A. and Salzberg, P.M. (1983) Drinking behavior, personality factors and high-risk driving: a review and theoretical formulation. *Journal of Studies on Alcohol* **44**, 395–428.
- Donovan, D.M., Queisser, H.R., Salzberg, P.M. and Umlauf, R.L. (1985) Intoxicated and bad drivers: subgroups within the same population of high-risk men drivers. *Journal of Studies on Alcohol* **46**, 375–382.
- Donovan, D.M., Umlauf, R.L. and Salzberg, P.M. (1988) Derivation of personality subtypes among high-risk drivers. *Alcohol, Drugs and Driving* **4**, 233–244.
- Donovan, D.M., Umlauf, R.L. and Salzberg, P.M. (1990) Bad drivers: identification of a target group for alcohol-related prevention and early intervention. *Journal of Studies on Alcohol* **51**, 136–141.
- Ebstein, R.P., Novick, O., Umansky, R., Priel, B., Osher, Y., Blaine, D., Bennett, E.R., Nemanov, L., Katz, M. and Belmaker, R.H. (1996) Dopamine D4 receptor (D4DR) exon III polymorphism associated with the human personality trait of novelty seeking. *Nature Genetics* **12**, 78–80.
- Eysenck, H.J. (1983) A biometrical-genetical analysis of impulsive and sensation seeking behavior. In *Biological Bases of Sensation Seeking, Impulsivity, and Anxiety*, ed. M. Zuckerman, pp. 1–35. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Fuller, R. (1984) A conceptualization of driving behaviour as threat avoidance. *Ergonomics* **27**, 1139–1155.
- Furnham, A. and Saipé, J. (1993) Personality correlates of convicted drivers. *Personality and Individual Differences* **14**, 329–338.
- Gregersen, N.P. and Berg, H.Y. (1994) Lifestyle and accidents among young drivers. *Accident Analysis and Prevention* **26**, 297–303.
- Hartman, M.L. and Rawson, H.E. (1992) Differences in and correlates of sensation seeking in male and female athletes and non-athletes. *Personality and Individual Differences* **13**, 805–812.
- Heino A., van den Molen, H.H. and Wilde, G.J.S. (1992) Risk homeostasis process in car following behaviour: individual differences in car following and perceived risk. Report VK 92-02, Rijksuniversiteit Groningen Haven, The Netherlands.
- Hilakivi, I. and Veilahti, J. (1989) A sixteen-factor personality test for predicting automobile driving accidents of young drivers. *Accident Analysis and Prevention* **21**, 413–418.
- Horvath, P. and Zuckerman, M. (1993) Sensation seeking, risk appraisal, and risky behavior. *Personality and Individual Differences* **14**, 41–52.
- Huba, G.J., Newcomb, M.D. and Bentler, P.M. (1981) Comparison of canonical correlation and interbattery factor analysis on sensation seeking and drug use domains. *Applied Psychological Measurement* **5**, 291–306.
- Jackson, D.N. (1984) *Basic Personality Inventory*. Research Psychologists' Press, Port Huron, MI.
- Jamison, K. and McGlothlin, W.H. (1973) Drug usage, personality, attitudinal, and behavioral correlates of driving behavior. *The Journal of Psychology* **83**, 123–130.
- Jessor, R. (1987) Risky driving and adolescent problem behavior: an extension of Problem Behavior Theory. *Alcohol, Drugs and Driving* **3**, 1–11.
- Johnson, V. and Raskin White, H. (1989) An investigation of factors related to intoxicated driving behaviors among youth. *Journal of Studies on Alcohol* **50**, 320–330.
- Jonah, B.A. and Wilson, R.J. (1986) Impaired drivers who have never been caught: are they different from convicted impaired drivers? SAE Technical Paper Series, No. 860195, pp. 83–93.
- von Knorring, L. and Orelund, L. (1984) Personality traits related to monoamine oxidase activity in platelets. *Psychiatry Research* **12**, 11–26.
- Lajunen, T. and Summala, H. (1996) Effects of driving experience, personality, driver's skill and safety orientation on speed regulation and accidents. Paper presented at the *International Conference on Traffic and Transport Psychology*, Valencia, Spain, May 1996.
- Lastovicka, J.L., Murray, J.P., Joachimsthaler, E.A., Bhalla, G. and Scheurich, J. (1987) A lifestyle typology to model young male drinking and driving. *Journal of Consumer Research* **14**, 257–263.
- Little, G.L. and Robinson, K.D. (1989) Relationship of DUI recidivism to moral reasoning, sensation seeking, and MacAndrew alcoholism scores. *Psychological Reports* **65**, 1171–1174.
- Loo, R. (1979) Role of primary personality factors in the perception of traffic signs and driver violations and accidents. *Accident Analysis and Prevention* **11**, 125–127.
- Madsen, D.B., Das, A.K., Bogen, I. and Grossman, E.E. (1987) A short sensation seeking scale. *Psychological Reports* **60**, 1179–1184.
- Mann, R.E., Vingilis, E.R., Anglin, L., Suurvali, H., Poudrier, L.M., and Vaga, K. (1987) Long-term follow up of convicted drinking drivers. In *Alcohol, Drugs and Traffic Safety—T86. Proceedings of the 10th International*

- Conference on Alcohol, Drugs and Traffic Safety—T86*, eds P.C. Noordzij and R. Roszbach, International Committee on Alcohol, Drugs and Traffic Safety.
- McMillen, D.L., Adams, M.S., Wells-Parker, E., Pang, M.G. and Anderson, B.J. (1992a) Personality traits and behaviors of alcohol impaired drivers: a comparison of first and multiple offenders. *Addictive Behaviors* **17**, 407–414.
- McMillen, D.L., Pang, M.G., Wells-Parker, E. and Anderson, B.J. (1991) Behavior and personality traits among DUI arrestees, nonarrested impaired drivers, and nonimpaired drivers. *The International Journal of the Addictions* **26**, 227–235.
- McMillen, D.L., Pang, M.G., Wells-Parker, E. and Anderson, B.J. (1992b) Alcohol, personality traits, and high risk driving: a comparison of young, drinking driver groups. *Addictive Behaviors* **17**, 525–532.
- McMillen, D.L., Smith, S.M. and Wells-Parker, E. (1989) Brief report: the effects of alcohol, expectancy, and sensation seeking on driving risk taking. *Addictive Behaviors* **14**, 477–483.
- Moe, D. and Jenssen, G.D. (1990) *Unge forere, risikotaking og pedagogiske konsekvenser* (Young drivers, risktaking and pedagogical consequences). SINTEF Transport Engineering, Trondheim, Norway.
- Moe, D. and Jenssen, G.D. (1993) *Ungdom, risikotaking og bilkjøring* (Young drivers, risk taking and traffic accidents). SINTEF Transport Engineering, Trondheim, Norway.
- Plomin, R., Extraversion: sociability and impulsiveness?. *Journal of Personality Assessment* **40**, 2430. (1976)
- Reason, J.T., Manstead, A.S., Stradling, S.G., Parker, D. and Baxter, J.S. (1991) The social and cognitive determinants of aberrant driving behaviours (Transport and Road Research Laboratory Contractor's Report 253).
- Rimmo, P.A. and Aberg, L. (1996) Do sensation seekers make more violations and errors as drivers. Paper presented at the *International Conference on Traffic and Transport Psychology*, Valencia, Spain, May, 1996.
- Rowland, G.L. and Franken, R.E. (1986) The four dimensions of sensation seeking: a confirmatory factor analysis. *Personality and Individual Differences* **7**, 237–240.
- Signori, E.I. and Bowman, R.G. (1974) On the study of personality factors in research on driving behavior. *Perception and Motor Skills* **38**, 1067–1076.
- Stacy, A.W., Newcomb, M.D. and Bentler, P.M. (1991) Personality, problem drinking, and drunk driving: mediating, moderating, and direct-effect models. *Journal of Personality and Social Psychology* **60**, 795–811.
- Stoduto, G., Mann, R.E., Anglin, L., Pavic, B., Fallon, F. and Lauzon, R. (1995) Profile of adolescent drinking drivers. In *Alcohol, Drugs and Traffic Safety—T95. Proceedings of the 13th International Conference on Alcohol, Drugs and Traffic Safety, ICADTS—T'95*, eds Kloeden, C.N. and McLean, A.J., pp. 265–270. International Council on Alcohol, Drugs and Traffic Safety, Adelaide.
- Tillman, W.A. and Hobbs, G.E. (1949) The accident prone automobile driver: a study of the psychiatric and social background. *American Journal of Psychiatry* **106**, 321–331.
- Vingilis, E., Stoduto, G., Macartney-Filgate, M.S., Liban, C.B. and McLellan, B.A. (1994) Psychosocial characteristics of alcohol-involved and nonalcohol-involved seriously injured drivers. *Accident Analysis and Prevention* **26**, 195–206.
- Wells-Parker, E., Anderson, B., Pang, M. and Timken, D. (1993) An examination of cluster-based classification schemes for DUI offenders. *Journal of Studies on Alcohol* **54**, 209–218.
- Wieczorek, W.F. (1995) DWI offenders and alcohol-related crashes. In *Alcohol, Drugs and Traffic Safety—T95. Proceedings of the 13th International Conference on Alcohol, Drugs and Traffic Safety, ICADTS—T'95*, eds Kloeden, C.N. and McLean, A.J., pp. 231–236. International Council on Alcohol, Drugs and Traffic Safety, Adelaide.
- Wilde, G.J.S. (1982) The theory of risk homeostasis: implications for safety and health. *Risk Analysis* **2**, 209–225.
- Wilde, G.J.S. (1994) *Target Risk*. PDE Publications, Toronto, Ontario, Canada.
- Wilson, R.J. (1990) The relationship of seat belt non-use to personality, lifestyle and driving record. *Health Education Research Theory and Practice* **5**, 175–185.
- Wilson, R.J. (1991) Subtypes of DWIs and high-risk drivers: implications for differential intervention. *Alcohol, Drugs and Driving* **7**, 1–12.
- Wilson, R.J. (1992) Convicted impaired drivers and high-risk drivers: how similar are they? . *Journal of Studies on Alcohol* **53**, 335–344.
- Wilson, R.J. and Jonah, B.A. (1988) The application of problem behavior theory to the understanding of risky driving. *Alcohol, Drugs and Driving* **4**, 173–191.
- Yu, J. and Williford, W.R. (1993) Alcohol and risk/sensation seeking: specifying a causal model on high-risk driving. *Journal of Addictive Diseases* **12**, 79–96.
- Zuckerman, M. (1971) Dimensions of sensation seeking. *Journal of Consulting and Clinical Psychology* **36**, 45–52.
- Zuckerman, M. (1979) *Sensation Seeking: Beyond the Optimal Level of Arousal*. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Zuckerman, M. (1983) A biological theory of sensation seeking. In *Biological Bases of Sensation Seeking, Impulsivity, and Anxiety*, ed. M. Zuckerman, pp. 37–76. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Zuckerman, M. (1994) *Behavioural Expressions and Biosocial Bases of Sensation Seeking*. University of Cambridge Press, Cambridge.
- Zuckerman, M., Kolin, I., Price, L. and Zoob, I. (1964) Development of a sensation seeking scale. *Journal of Consulting Psychology* **28**, 477–482.
- Zuckerman, M. and Neeb, M. (1980) Demographic influences in sensation seeking and expressions of sensation seeking in religion, smoking and driving habits. *Personality and Individual Differences* **1**, 197–206.