Department for Transport

Road Safety Research Report No. 70

Review of Judgement and Decision-making Literature Pertinent to the Development of Traffic Offender Training/ Improvement Programmes (S301Q) Technical Report

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March 2007

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EXECUTIVE SUMMARY

Purpose

A comprehensive review was conducted to examine psychosocial, judgement and decision-making models and constructs considered relevant to traffic safety and related behaviours. The longer-term goal of this review is to improve the quality of traffic safety interventions and serious offender training/improvement programmes through theoretically-informed approaches.

Methods

Two approaches were taken for this review:

(a) a large-scale review of the research literature; and

(b) an analysis of relevant theoretical approaches and constructs.

Prior to conducting a literature review, the research team developed a list of relevant categories for searching the empirical and theoretical literature on traffic safety and driving behaviour. From approximately 9,000 potential studies published between January 1985 and August 2005, the research team reviewed article titles and abstracts and retained studies that were relevant to the review's goals and objectives.

The studies agreed on by the research team were obtained and reviewed using an interactive database specifically developed for this review. The research team appraised 377 studies. Of the 377 studies, 107 did not measure psychosocial, judgement or decision-making variables, though this was suggested in the abstract. A total of 270 studies were therefore reviewed for this report. Of these studies, 23 were reviews, 12 were meta-analyses and 18 were commentaries. Of the remaining 217 studies, 96 were experimental studies and 116 were observational studies. Twenty-nine studies were relevant to children, 201 studies were relevant for adolescents, 189 studies were relevant for young adults, and 29 studies were specifically relevant to adult serious traffic safety offenders. Agreement in reviewer evaluations ranged between 87% and 92%.

The analysis of theoretical approaches started with models, theories and constructs developed within the traffic safety field, then considered safe driving behaviour from more general cognitive, psychosocial and physiological perspectives. These theoretical approaches were examined vis-à-vis data from the literature review.

Results

Based on the data from the literature review, combined with our theoretical analysis, a conceptual framework was developed that identified:

- well-studied predictors of driving behaviour;
- less-studied potential predictors of driving behaviour; and
- specific relationships between predictors and driving behaviour.

The conceptual framework incorporates elements of Fuller's Task-Capability Interface (TCI) model (Fuller, 2005), Wilde's Homeostasis Theory (Wilde *et al.*, 2002), Deery's model of crash risk perception (Deery, 1999), Bandura's concept of reciprocal determinism within his Social Learning Theory (Bandura, 1978), Fishbein and Ajzen's Theory of Reasoned Action (Fishbein and Ajzen, 1975), Weinstein's Protection Motivation Theory (Weinstein, 1988), and Rosenstock's Health Belief Model (Rosenstock, 1974).

The conceptual model also includes a physiological perspective related to separate influences of neuroendocrine and pre-frontal cortical activity on psychosocial, judgement and decision-making constructs. Psychosocial factors are examined in reference to this conceptual framework for both their relevance to driving behaviour and their relationships with other factors. The conceptual framework is examined for both adolescent/young adult drivers and for serious offenders.

On the basis of the psychosocial factors examined, we make a number of comments about interventions for traffic safety programmes for adolescents and young adults, and for serious traffic offenders. These comments focus on the influences of interventions aimed at:

- risk perception;
- hazard detection;
- attitudes;
- social norms;
- self-efficacy;
- physiological impairment;
- biases in judgment and decision-making; and
- laws and policies.

A more detailed, systematic study of intervention modalities is provided in the Primary Report related to this review (Strecher *et al*., 2007).

Finally, we make recommendations for future psychosocial, judgement and decision-making research in this field. These include recommendations for:

(a) consistency in construct nomenclature, specification and operationalisation;

(b) further consideration of the reciprocal nature of driving behaviour, resulting consequences, cognitive processing and subsequent behaviour;

(c) further examination of homeostatic processes in driving behaviour, particularly interactions between the driver's ability and demands of driving task and the driver's perceptions of these abilities and demands;

(d) examination of the predictors of risk acceptance, particularly personality, identity, attitude, affect, social norm, urgency, and law/policy factors;

(e) the influence of perceived ability and perceived driving demands on crash risk perception;

(f) the influence of crash risk perception and target level of risk acceptance on intention to drive safely;

(g) the influence of intention to drive safely, task difficulty and driving behaviour;

(h) consideration of the physiological influences of neurological development and impairment to both neuroendocrine and pre-frontal cortical activities;

(i) consideration of constructs specified in other models of health-related behaviour, particularly the distinction between perceptions of susceptibility and severity in overall crash risk perception, and the distinction between behavioural intention and actual behaviour; and

(j) greater specification in analyses of moderating and mediating relationships between constructs.

1 INTRODUCTION

This review provides an overview of the scientific evidence that could guide improvements in theory-informed approaches to traffic safety. In particular, this review focuses on two groups of road users with high rates of crash-involvement: adolescent/young adult drivers and serious traffic offenders. In organising a review of the relevant psychosocial, judgement and decision-making predictors of traffic safety, we hope to create a more comprehensive blueprint for intervention content and delivery. However, cognitive and psychosocial constructs alone cannot complete the blueprint. This review aims to contribute to this literature by delineating cognitive, behavioural, environmental and physiological characteristics influencing driving behaviour in a conceptual framework emerging from this review.

The specific aims of this review include:

- identifying predictor and intervention research relating to psychosocial, judgement, and decision-making factors and driving behaviour through the use of a variety of databases and search strategies;
- organising a relational database for the literature review;
- cataloguing and critiquing studies based on their methodological and substantive components;
- developing a conceptual framework for the literature review;
- creating a better understanding of the weight of research evidence supporting the conceptual framework; and
- discussing directions for future research and future traffic safety programming.

This review supports the Primary Report (Strecher *et al*., 2006), entitled *Intervention Modalities to Address Relevant Psychosocial Predictors of Driving Behaviour Among Novice Drivers*. The Primary Report examines the relevant psychosocial factors found in traffic safety but also in other health behaviour areas. The Primary Report then examines specific intervention modalities that have or have not worked and makes recommendations for intervention modalities that are likely to address the most relevant psychosocial predictors.

2 LITERATURE SEARCH METHODS

Prior to conducting this review, the research team identified a list of inclusive search terms for studies that would be added to the Department of Transportation (DfT) database. These terms came from ideas generated during team meetings, suggestions from the DfT Scientific Advisory Board, and feedback from the University of Michigan's Transportation Research Institute (UM-TRI) librarians. To maximise the search, each term was assessed individually or in conjunction with other terms using Boolean expressions (e.g. AND, OR, BUT). Table 2.1 displays a complete list of the terms used during the literature search. Search terms are divided into behaviour or outcome relative to driving activity, population or theoretical approach.

Table 2.1: Full list of keywords by category used during the literature search

Behaviours and outcomes		Population	Theories
Driving	Health communication	Driver	Theory of Reasoned Action (TRA)
Driving safety	Car	Adolescent	Theory of Planned Behaviour (TPB)
Traffic injury	Automobile	Teen	Health Belief Model (HBM)
Reckless driving	Wrecks	Teenager	Social Cognitive Theory (SCT)
Diversion	Collision	Youth	Social Learning Theory (LT)
Drinking and driving	Crash	Young adult	Problem Behaviour Theory (PBT)
Seat-belt use	Injury	Offender	Transtheoretical Model (TTM)
Drug use	Traffic	Recurrent offender	Precaution-Adoption Model (PAPM)
Risk	Accident	Recidivist	Social Norm Theory (SNT)
Stress	Distraction		Decision Making Theory (DMT)
Sensation seeking	Road injury		Sensation Seeking Model
Personal control	Substance use		Risk Homoeostasis Theory (RHT)
Skill	Behaviour		Self-control Theory (ST)
Driver behaviour			Risk Compensation Theory (RCT)
Intoxication			Deterrence Theory (DT)
Driver education			Knowledge-Attitudes-Practice (KAP)

The research team approached the review process from two directions:

(a) an inductive systematic collection of all potentially relevant articles found through computerised searches; and

(b) a deductive top-down review of theory-relevant publications.

The literature search included iterative searches of MEDLINE, Pub Med, PsycInfo, Transportation Database (Silver Platter WebSpirs 5.0) and the Cochrane Library. In addition, retrieved articles' bibliographies were examined for any additional relevant studies. To maximise the search, the research team placed no initial restrictions on publication year, population or explicit mention of psychosocial factors associated with traffic safety. Any peer-reviewed journal publication written in English and related to traffic safety, related traffic behaviours or potential predictors of these behaviours in the social science, public health, medicine, criminology, injury

prevention, transportation and urban planning fields was eligible for inclusion. The research team initially identified 39,286 citations using the generated list of keywords. Citations were published in over 1,900 journal titles between January 1950 and August 2005.

To narrow the search, the research team focused on the approximately 9,000 studies published between January 1950 and August 2005 involving two salient at-risk groups in the traffic safety literature: adolescent/young adult drivers and traffic offenders whose offence was of a serious nature. Where relevant, we also included studies of children. From the citation abstracts, the research team further excluded studies not written in English, detailing medical procedures, targeting other populations and/or lacking mention of any psychosocial variable related to traffic safety. After filtering all non-relevant citations, the research team identified 625 relevant studies and proceeded to sort them as predictor ($n = 239$) or intervention ($n = 386$) studies.

To ensure that only the most relevant studies were included in the review, two members of the research team re-read each abstract and excluded any studies failing to clearly suggest psychosocial constructs and/or behaviours relevant to traffic safety. Furthermore, studies exploring outcomes such as pedestrian behaviour and/or two-wheeled driving were excluded if they did not also study car driving outcomes. Reviewers' agreement to keep or discard an entry was 96%. Reviewers discussed inconsistencies in research team meetings until reaching an agreement to keep or discard these studies. The research team retained 409 studies for the review.

2.1 Traffic safety database

The research team created a relational database of articles for rapid cataloguing and retrieval using FileMaker Pro (FMP, version 8.0). In addition to being a cross-platform application, FileMaker Pro can be searched quickly to find records across specific criteria. The database facilitated the review by collecting consistent information from each study. The database is divided into three sections: reference, theory, and methodology. Each sub-area is discussed below.

2.1.1 Reference

This section included an annotated bibliography of each study reviewed. Information on the study's citation (e.g. author, year, title, journal, volume and issue, and page number) is presented, along with the age group (e.g. child, adolescents or adults), study type (e.g. predictor or intervention) categories and abstract. Reviewers selected the relevant fields of the study (e.g. public health, urban planning, sociology, criminology, psychology, substance use, transportation, injury prevention).

2.1.2 Theory

This section included information relevant to the assessment of psychosocial constructs in the traffic safety literature. The information consisted of the theories and constructs alluded to in the research study, and the operationalisation of psychosocial factors such as knowledge, beliefs and attitudes, skills capabilities, driving behaviours and study outcomes.

The first area of the theory section required reviewers to select one or more theories, and record the constructs examined in the study. In selecting theories, reviewers selected from a list of theories including the:

- Health Belief Model;
- Theory of Reasoned Action/Theory of Planned Behaviour;
- Social Cognitive Theory;
- Transtheoretical Model;
- Elaboration Likelihood Model;
- Sensation seeking;
- Problem Behaviour Theory;
- Self-determination Theory;
- Social Comparison Theory;
- Attribution Theory;
- Decision-making Theory;
- Deterrence Theory;
- Risk Homoeostasis Theory;
- Transactional Model of Stress and Coping; and
- Community Organizing Framework.

Reviewers had the option to select more than one theory and to include any other theory of interest mentioned. We provide a brief description of these theories in Table 2.2.

Once the reviewers identified a study's theory/theories, the specific psychosocial construct(s) were recorded. Reviewers were knowledgeable in all the psychosocial theories aforementioned, and thus were able to identify the components of a theory explored in a study even when not specifically mentioned.

In the second area of the theory section, reviewers categorised a study's independent variables as knowledge-based, beliefs or attitudes, skills or capabilities, or

Table 2.2: **Summary table for theories**	
Theory name	**Description**
Health Belief Model (HBM)	HBM suggests that the likelihood of behaviour change is influenced by (1) the belief that adoption of a behaviour will prevent an outcome and (2) the desire to avoid the outcome.
Theory of Reasoned Action (TRA)/Planned Behaviour (TPB)	TRA and TPB suggest that the likelihood of behaviour change depends on the individual's intention to change the behaviour. While intentions are predicted by individual and normative attitudes in TRA, TPB includes perceived behavioural control to acknowledge power imbalances in a person's decision-making.
Social Cognitive Theory (SCT)	SCT suggests that behaviour change depends on the dynamic interaction of people's personal characteristics (e.g. cognitions and personality), the type of behaviour, and the environmental influences contextualising it.
Transtheoretical Model (TTM)	TTM suggests that behaviour change occurs over six stages of progress, including: precontemplation, contemplation, preparation, action, maintenance, and termination.
Elaboration Likelihood Model (ELM)	ELM emphasises that attitudinal change occurs through two distinct cognitive routes. The central route requires that the message presented to change people's attitudes is thematically-relevant and engages people in high-cognitive thought processes. The peripheral route changes people's attitudes through simple associational processes that involve low-cognitive thought process.
Sensation seeking (SS)	SS proposes that people seek new sensations and experiences, usually through physical arousal. Accumulation of these sensations and experiences requires people to be willing to take social and physical risks.
Problem Behaviour Theory (PBT)	PBT suggests that high-risk behaviours occur to satisfy a person's proneness to deviance. Proneness to deviance occurs through the interaction of personal characteristics (e.g. personality), the behaviour and the environmental influences contextualising it.
Self-determination Theory (SDT)	SDT suggests that individuals seek to fulfil their needs through self-motivation. Self-motivation may vary according to personal well-being, social functioning and socio-physical environmental characteristics.
Social Comparison Theory (SoCo)	SoCo suggests that individuals learn and change their attitudes and behaviours by comparing themselves with similar others.
Attribution Theory (AT)	AT suggests that individuals create explanations for their behaviour by assigning a cause and effect relationship to factors outside of their control (external attribution) or within themselves (internal attribution).
Decision-making Theory (DMT)	DMT suggests that a person makes decisions by setting goals, developing and ranking the approaches to achieve that goal, and then selecting the highest ranked approach.
Deterrence Theory (DT)	DT suggests that individuals will engage in deviant behaviours if they do not fear the repercussions of punishment or consequences.
Risk Homoeostasis Theory (RHT)	RHT suggests that individuals will engage in more deviant driving behaviours to the extent they feel they have greater control and safety in the road.
Transactional Model of Stress and Coping (TMSC)	TMSC suggests that individuals cope with stress by first appraising the stressor and then evaluating the availability of social and cultural resources at their disposal.
Community Organizing (COrg)	COrg suggests that people may change their environment and social conditions by organising, mobilising, and advocating for social and environmental changes in their communities.

behaviours related to traffic safety. Knowledge was defined as any construct or operationalised variable referring to a fact related to driving or an associated behaviour. For example, if a study assessed whether participants have been educated on how to avoid swerving in the snow, then the reviewer wrote under 'Knowledge': 'Steps to Prevent Fishtailing in the Snow'. 'Beliefs and attitudes were defined as any construct or operationalised variable referring to expectancies and the respective evaluation of these expectancies. For example, if a study assessed the participant's perceived susceptibility of swerving in the snow, and the accompanying severity of serious injury from swerving, the reviewer wrote under 'Beliefs/Attitudes': 'Perceived Susceptibility and Severity (swerving while driving in the snow)'. Skills or capabilities were defined as any construct or operationalised variable referring to an individual's ability to perform a behaviour. For example, if a study assessed the extent to which individuals feel confident in avoiding swerves while driving in the snow, the reviewer wrote under 'Skills/Capabilities': 'Self-efficacy (avoid swerving when driving in snow)'. Related behaviours referred to any action, safe or unsafe, associated with driving behaviours (e.g. using a seat belt, speeding, drinking and driving, receiving a driving citation) and were measured in a study as a predictor of the dependent variable(s).

Finally, reviewers also noted each study's dependent variable(s). While the other theory boxes were specific to different psychosocial domains, the 'Dependent Variable' category included any construct or operationalised variable associated with driving and measured in the study as an outcome. For example, a study could consider 'collisions' as the dependent variable, whereas in another study 'collision' could have been included in the 'Behaviour' box because the dependent variable was 'death on impact'.

2.1.3 Methodology

The methodology section was subdivided into three sections. The first area included administrative information regarding who reviewed the study and whether the study was flagged for group discussion.

The second area ascertained information on the research design, including:

- study design;
- sampling design and sample size;
- prevention type;
- study population characteristics (e.g. age range, gender, population of interest); and
- study location.

There were four study design options:

- cross-sectional predictor study;
- cross-sectional experimental study;
- longitudinal predictor study; and
- longitudinal experiment study.

Most studies fit this heuristic, but additional designs could be added. Four sample designs were provided for the reviewer:

- convenience sample;
- stratified sample;
- simple random sample; and
- stratified random sample.

Again, while most studies fit this heuristic, additional sample designs could be added.

Reviewers selected one or more of three prevention types: primary, secondary and tertiary prevention. Primary prevention refers to any activity that prevents a negative outcome before it occurs (e.g. seat-belt use). Secondary prevention includes activities undertaken by people who are at risk (e.g. not driving after drinking). Tertiary prevention refers to activities undertaken by people who have experienced a negative outcome (e.g. attending an alcohol-rehabilitation clinic to decrease the punishments imposed by a judge after being sentenced due to drunk driving).

After detailing the age range and gender of study participants, reviewers selected the populations of interest of the study. There are four population of interests:

- child (less or equal than 12 years old);
- adolescent (13–19 years old);
- young adult (20–26 years old); or
- serious offender (any age).

Finally, reviewers assessed whether the study had taken place in an urban, suburban, rural or laboratory setting.

The final area included information on the study's analysis, including whether a quantitative and/or qualitative approach was used, the type of analysis performed, relevant notes about a study, and the study's primary psychosocial results. After deciding whether a study was qualitative and/or quantitative, reviewers noted a study's analytical approach. The analytical approach referred to statistical or

qualitative methods used to reach a study's conclusions. For example, a quantitative study may have used correlations, t-tests, ANOVAs (ANalysis Of VAriance), MANOVAs (Multivariate ANalysis Of VAriance), regressions, path analysis, among others to test differences between participants. On the other hand, a qualitative study may have used thematic coding, content analysis, grounded theory or other approaches to analyze in-depth interviews or focus groups.

In the 'Primary results' box, the reviewers summarised study findings related to psychosocial factors and traffic safety. The database allowed more than one study to be critiqued if more than one study was detailed in the text. After summarising the results, reviewers included any additional information, comments or concerns about the study in the 'Notes' section.

2.2 Literature review process

The research team conducted data entry and review between October and November 2005. Reviewers could access all studies in their full text through an online repository at the University of Michigan. Using the FileMaker system and the online repository, the review team sorted the 409 studies into three thematic categories. These categories represent the primary domains of social cognitive models of behaviour and behaviour change.

- **Psychosocial, judgement and decision-making factors** – this category included psychosocial constructs commonly used in the decision-making and health education literature, such as risk perception, attitudes, self-efficacy, benefits and barriers, decision-making processes, among others.
- **Behaviour and personality characteristics** – this category included individual characteristics related to driving behaviour (e.g. personality, emotional states, sleep deprivation, thrill seeking) or other behaviours that influence driving (e.g. substance use).
- **Automobile and environment characteristics** – this category included studies detailing how automobile characteristics (e.g. presence/absence of buttons, anti-lock braking system (ABS)), mobile phones and other potential distracters, and passengers might affect relevant psychosocial factors and/or driving behaviour. This category also included road characteristics (e.g. road lighting, absence/presence of speed signs, cameras, weather conditions) and any interventions based on the use of control policies or laws (e.g. driving training laws, interlock ignitions, road calming schemes).

During the review process, the research team appraised 377 of the 409 studies. The research team classified 32 studies as missing because their full text was unavailable for acquisition through electronic databases, inter-library loans or local university libraries prior to the end of the reviewing deadline. Of the remaining 377 studies, 127 did not measure psychosocial variables, though this was suggested in the

abstract. A total of 250 studies were therefore reviewed for this report (see Appendix 1 for the review summary table). Of these studies, 21 were reviews, 9 were meta-analyses and 19 were commentaries. The remaining 201 studies included 84 experimental studies and 118 predictor studies. Some reports contained both experimental and predictor studies. Twenty studies were relevant to children, 176 studies were relevant to adolescents, 171 studies were relevant to young adults, and 43 studies were relevant to adult serious traffic safety offenders. Some reports contained more than one population group or included a representative sample of the general population.

2.3 Reviewer training and quality control procedures

In an effort to ensure consistency in the review process, the research team selected two studies for the reviewers to read and enter into the database. Once reviewers individually appraised the studies and became familiar with the database, the research team met to clarify any doubts about the database or the study review process. In addition, the research team created a Reviewer Guide to help reviewers address any foreseeable questions and/or concerns. The research team updated the Reviewer Guide as new questions/concerns regarding the review process arose (see Appendix 2).

To assess reviewers' consistency, the research teams randomly assigned more than one reviewer to comment on 15 studies in the database. Using 'Quality of Theory' and 'Quality of Methodology' indices, the research team found high inter-rater reliability across reviewers. The agreement ratio in reviewer scores for these two indices was 87% for Quality of Theory (13 agreements, 2 disagreements) and 93% for Quality of Methodology (14 agreements, 1 disagreement).

3 PSYCHOSOCIAL FACTORS INFLUENCING SAFE DRIVING BEHAVIOUR

In this review, we have placed the psychosocial, judgement and decision-making constructs examined into a conceptual framework of driving behaviour. This framework is not intended to supersede current models of driving behaviour; it is being used for the purpose of organising psychosocial constructs for review and discussion. Although most of the constructs have been examined in the traffic safety literature, we are suggesting a number of refinements to constructs, as well as pathways for consideration in future research.

The conceptual framework incorporates elements of Fuller's Task-Capability Interface (TCI) model (Fuller, 2005), Wilde's Homeostasis Theory (Wilde *et al.*, 2002), Deery's model of crash risk perception (Deery, 1999), Bandura's concept of reciprocal determinism within his Social Learning Theory (Bandura, 1978), Fishbein and Ajzen's Theory of Reasoned Action (Fishbein and Ajzen, 1975), Weinstein's Protection Motivation Theory (Weinstein, 1988) and Rosenstock's Health Belief Model (Rosenstock, 1974). The conceptual model also includes a physiological perspective related to separate influences of neuroendocrine and pre-frontal cortical activity on psychosocial, judgement and decision-making constructs. The framework is examined for both adolescent/young adult drivers and for serious offenders.

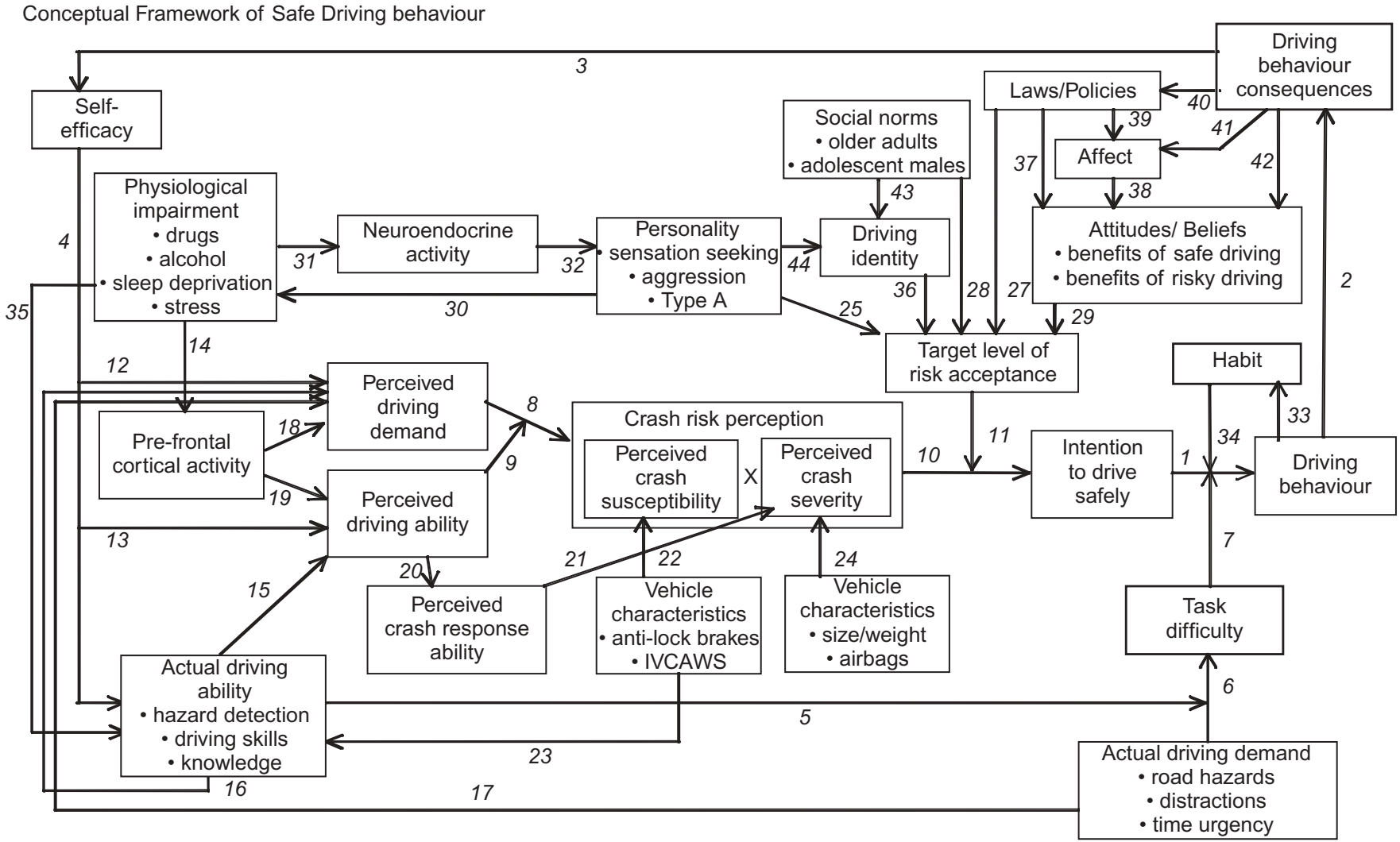
The conceptual framework identifies hypothesised pathways between constructs with a number. The core elements of the model are highlighted with double borders. Note that the conceptual framework identifies a number of moderator relationships which are identified through statistical interactions when a moderator variable affects the direction or strength of the relationship between an independent and dependent variable. We believe there are a number of important moderator relationships worth testing; these relationships often identify specific targets for intervention.

3.1 Driving behaviour – behavioural intention relationship

The outcome of this model is driving behaviour. This construct, however, clearly comprises many different behaviours and clusters of behaviours. We have attempted to make this conceptual framework (Figure 3.1) relevant to a spectrum of driving behaviours, though there will likely be unspecified constructs and relationships depending on the specific driving behaviour in question.

A key issue in the conceptual framework is whether every driver who intends to drive safely is actually able to do so. If this were the case, there would be no need to include behavioural intention in the model. We believe that this is not the case – that

Figure 3.1: Conceptual framework of safe driving behaviour



the difficulty of the driving task inhibits perfect correlation between intention and behaviour. This relationship is central to the Theory of Reasoned Action (Fishbein and Ajzen, 1975) though not well-studied in the traffic safety literature. The utility of this conceptual separation is two-fold:

(1) it focuses consideration on intentional predictors, understanding that intention does not always predict actual behaviour; and

(2) it also focuses attention on factors that get in the way of intention, such as habits or task difficulty (which will be discussed later).

For this reason, **path 1** is included: the relationship between intention to drive safely and driving behaviour.

3.2 Reciprocal determinism of behaviour, consequences and self-efficacy

The border of this conceptual framework represents the reciprocal determinism of driving behaviour (Bandura, 1978), which accumulates with driving behaviour consequences (**path *2***). These consequences, both positive and negative, are interpreted by the driver to create expectations of self-efficacy (**path 3**): confidence in his or her ability to drive safely (Bandura, 1978). Self-efficacy is central to Bandura's Social Learning Theory (SCT) and is one the strongest predictors of health-related behaviours; it is also a frequent target of behaviour change intervention (Bandura, 1997; Strecher *et al.*, 1986). Self-efficacy of safe driving behaviour is not well studied. The relationships of this construct in safe driving are generally more complex than those found in most other health-related behaviours. We see two very different roles of self-efficacy in driving behaviour. On one hand, successful driving experiences are likely to lead to enhancements in self-efficacy, which, in turn, motivates even stronger performance in driving, hazard detection and driving knowledge acquisition (**path 4**). On the other hand, enhanced efficacy expectations may also lead to overconfidence in ascertaining the demands of the driving task (**path 12**) and in driving ability (**path 13**). In other words, with respect to safe driving behaviour, high levels of self-efficacy may save your life or kill you. We return to the role of perceived driving demand and perceived driving ability later in this review.

Legree and colleagues (2003) divide driving knowledge into two categories that are related to crash factors: declarative (or factual knowledge) and procedural (knowledge related to executing driving actions and requiring practice). The traffic safety research literature strongly suggests that increasing knowledge, declarative and procedural, through educational programmes or mass media communications plays an important role but, by itself, is not sufficient to bring about behaviour change (Nichols, 1994). School-based educational programs generally produce an immediate gain in attitude and knowledge (Nichols, 1994), but whether changes in

knowledge and attitudes translate into behaviour change remains an open issue (Mann *et al.*, 1986; McKnight and McPherson, 1986). Nevertheless, as Nichols notes, knowledge can act as an important catalyst for change by raising awareness and shifting attitudes on risks and benefits of given behaviours (Nichols, 1994).

Knowledge and increased awareness of traffic safety issues and laws are key elements in bringing about policy change, which can, in turn, bring about behaviour change (Nichols, 1994; DeJong and Atkin, 1995; Levy *et al.*, 1989). There are many examples of this in the literature, for instance:

- understanding of the importance of proper child restraint (Simpson *et al.*, 2002);
- vehicle safety features, such as size and weight (Rivara *et al.*, 1998);
- traffic safety measures in local communities (Ytterstad, 2003);
- head restraint adjustment (Fockler *et al.*, 1998);
- awareness of the effect of alcohol-related trauma on people's lives (Grant *et al.*, 1995); and
- perceptions of social norms, such as the overestimation of peer reckless driving (Gerrard *et al.*, 1996).

McKnight and McPherson's (1986) research demonstrated that supplementary self-study materials can enhance knowledge while a skills-based peer-intervention is implemented. Knowledge interventions can also focus on the demands of driving when impaired, particularly the degree of driving impairment resulting from particular blood alcohol concentration (BAC) levels and the number of drinks within a given amount of time (Basch *et al.*, 1989; Baum, 2000; Martens *et al.*, 1991). Knowledge gains also have enduring effects in comparison with other educational outcomes (Martinez *et al.*, 1996; McKnight and McPherson, 1986).

Vehicle characteristics can also enhance driving ability. For example, an in-vehicle collision avoidance warning system (IVCAWS) can alert a driver of the risk of collision with another vehicle when approached within a certain distance. Such a feature could be a useful training tool since drivers often overestimate headway (Ben-Yaacov *et al.*, 2002; Fairclough *et al.*, 1997).

3.3 Task-capability interface

Actual driving ability is viewed as a moderator of the actual driving demand-task difficulty relationship (**paths 5** and **6**). The interaction of ability and demand expresses itself as task difficulty, the difficulty of driving the automobile in a safe manner. This relationship is central to Fuller's Task-Capability Interface (TCI) model, a general theory of driver behaviour (Fuller, 2005). Note that in this path we are not focusing on **perceptions** of driving capability and demand, but how they actually exist.

Task demands include the actual hazards of the road as well as distractions, such as mobile phones and other passengers in the automobile. In Fuller's TCI model (Fuller, 2005), a target level of task difficulty is developed from the interaction of driving ability and the demands of the driving experience. For example, research by Bjornskau and Fosser (cited in Jorgensen and Pedersen, 2002) suggested that increased road lighting led to a **decrease** in driver concentration, and Mahalel and Szternfeld (1986) argued that drivers may have more accidents while performing simple driving tasks than complex ones.

Kim and Bishu (2004) concluded that normal and hazardous traffic situations demanded the exercise of different driving skills and dimensions: normal traffic requires search, speed and direction, while hazardous traffic requires the identification and response to possible high-risk circumstances.

Completing the reciprocal nature of this person–environment interaction, we believe that task difficulty moderates the likelihood that behavioural intention will result in actual driver behaviour. For example, an individual who intends to drive safely, but finds the particular driving task exceptionally difficult (a function of the driving demand–ability interaction) will not necessarily drive safely. When task difficulty is low, the intention–behaviour relationship will be strong. This relationship is similar to the intention–behaviour perceived behavioural control relationships of the Theory of Planned Behaviour (Ajzen, 1985).

3.4 Crash risk perception

What predicts intention to drive safely? We suggest that the primary pathway involves an interaction between the driver's perception of his or her crash risk and a targeted threshold of risk acceptance. In this case, crash risk perception will predict safe driving intention (**path 10**) when the driver has a high threshold of risk acceptance (e.g. unwilling to take risks) (**path 11**).

Risk perception is a central construct in a number of theoretical models of health-related behaviours, including the Health Belief Model (Rosenstock, 1974) and the Protection Motivation Theory (Weinstein, 1988). It is also a component of other models of human behaviour, including the Theory of Planned Behaviour and Social Cognitive Theory. We agree with Fuller (2005) that the perception of crash risk and task difficulty are separate but co-varying constructs.

As we discuss in this review, risk perceptions of driving have been studied extensively in the traffic safety literature. While there is general acceptance of the importance of risk perception in driving behaviour, some have argued that, for adolescents still developing self-regulatory capabilities, risk-based models are irrelevant (e.g., Steinberg, 2004). While we agree that risk perception may not be well developed in adolescents, we believe that the role of this construct is still important. Also dismissing the centrality of risk perception is Fuller (2005), who

argues that the perception of task difficulty is a more relevant construct. As described later in this section, we believe that this will be an area for future research.

Perception of risk is often studied in terms of the biases individuals have of their perceived versus actual risk. An optimistic perception or bias of risk is present when an individual considers his or her risk to be lower than their actual risk. At a population level, across a broad range of health issues, the average person perceives him or herself to be less at risk than the average person (Weinstein, 1987; 1984; Kulik and Mahler, 1987). This optimism has been related to both poor health behaviours and reduced likelihood in changing these behaviours (Skinner *et al.*, 1998; Kreuter *et al.*, 1995; Strecher *et al.*, 1995). Deery (1999) points out that optimistic perceptions of driving risk have been identified in Australia (Cairney, 1982; Job, 1990), Brazil (Sivak *et al.*, 1989a), Britain (Groeger and Brown, 1989), Canada (Matthews and Moran, 1986), Finland (Naatanen and Summala, 1974), France (Delhomme, 1991), Germany (Sivak *et al.*, 1989b), New Zealand (McCormick *et al.*, 1986), Spain (Sivak *et al.*, 1989b), Sweden (Svenson, 1981) and the United States (Svenson *et al.*, 1985).

In a recent national survey of US drivers, 74% of respondents rated their own overall driving skills as better or much better than those of the average driver, and only 1% of drivers perceived their skills to be worse than average (Williams, 2003). Moreover, most people report driving slower than the average driver (Walton and Bathurst, 1998). Deery (1999) suggests that this perceived crash risk is, in part, the result of perceived driving ability (DeJoy, 1989; Delhomme, 1991): **path 9** in our conceptual framework. In a recent study, Harre and colleagues (2005) found that the perception of superior driving ability was correlated with crash-risk optimism.

Young drivers perceived their personal crash risk to be significantly lower than that of their peers (Finn and Bragg, 1986). This optimistic bias is particularly high among young males, where the highest crash rates exist among all age-gender categories (e.g. DeJoy, 1989). Moreover, compared with young women, young men perceive their driving ability, as reflected by their reflexes, judgement and skill, to be higher than their peers (Harre *et al.*, 2005).

It has been long assumed that adolescent perceptions of risk are different from those of adults, that adolescents are more likely to have an unrealistic optimism of the consequences of risky behaviours. A number of studies demonstrate that younger, novice drivers view their risk from a crash as lower than that of more experienced, older drivers (Arnett, 2002; Deery, 1999). As Arnett (2002), however, points out, no study has yet examined differences in optimistic bias between adolescent and emerging adult drivers. Given the significantly higher crash rates among novice, adolescent drivers, these studies are warranted.

As stated previously, an enhanced perception of driving ability, and subsequent crash risk perception, may be the result of previous experiences (e.g. speeding)

where negative outcomes (e.g. automobile crash) did not occur (Weinstein, 1989). Young males are more likely to push 'the envelope' of driving speed with their higher threshold of risk-taking (Clarke *et al.*, 2005). While this type of driving results in more crashes (Clarke *et al.*, 2005), more often it does not for the individual driver. These experiences could be interpreted in a manner that would lead to greater self-efficacy, leading to an enhanced perception of driving ability (**path 13**). Farrow and Brissing (1990) found that male adolescents had higher perceived driving skills in risky situations and that driving enhanced their self-efficacy. Supporting this hypothesis is a study by Moe (1986), as reported in Gregersen (1996), finding that young males who were found to drive faster had higher perceptions of their driving ability than those who drove more slowly.

Driving-related self-efficacy, and even some types of risky driving, however, may not have only negative consequences. Higher self-efficacy, as a result of pushing the driver performance envelope, may also result in enhancements in actual driving ability. We could find no research in this area, possibly due to the concern that enhanced self-efficacy may also result in an inflated perception of driving ability and lead to detrimental effects. In our conceptual framework, however, we are positing that self-efficacy enhances actual driving ability (**path 4**) and that this ability influences both perceptions of driving ability (**path 15**) and driving demand (**path 16**).

Deery (1999) emphasises that perceived driving ability alone does not explain perception of driving risk; rather, it is the interface between driving ability and the perceived hazards of the driving environment. Deery (1999) refers to perceived hazards as both the ability to identify hazards while also perceiving its potential. This interface between the demands of the driving environment and the person's capabilities is also central to Fuller's Task-Capability Interface (TDI) model (Fuller, 2005) and results in a perception of task difficulty.

In our conceptual framework we make a distinction between perceived and actual driving demand. Perception of driving demand interacts with the perceived ability to create a crash risk perception (**paths 8** and **9**). Similar to our hypothesised relationship between actual driving demand and actual driving ability, we believe that perceived driving ability moderates the relationship between perceived driving demand and crash risk perception. In other words, the relationship between perceived driving demand and crash risk perception would be strong only when perceived driving ability was in accordance with, or lower than, actual driving ability.

Similar to its influence on perceived driving ability, driving behaviour consequences, mediated by self-efficacy expectations, is thought to influence perceived driving demand (**path 12**). For example, previous positive driving performances lead to higher driving-related self-efficacy, which, in turn, may lead to a lower perception of

driving demand than the actual demand conditions merit. We also suggest that actual driving demands influence perceived driving demands (**path 17**).

In our conceptual framework, physiological impairment, including alcohol or drug intoxication, sleep deprivation or stress, diminishes pre-frontal cortical activity (**path 14**), which is likely to have an effect on both perceptions of driving demand (**path 18**) and driving ability (**path 19**).

Driving under the influence of alcohol is often referred to as 'drink-driving,' while 'drug-driving' refers to driving while under the influence of drugs. While alcohol intake is commonly measured by one's blood alcohol concentration (BAC), drug consumption is often measured via self-report (creating potential methodological limitations). Drink- and drug-driving may also be inferred by the nature of the crash or be predicted by perceived environmental, personality and behavioural factors (Klepp *et al.*, 1991). Drink-driving is associated with young age and less concern with obeying traffic laws (Laapotti *et al.*, 2003).

The negative effects of alcohol on driving are apparent throughout the world (Rush, 1998). Alcohol reduces attention to driving, hazard detection abilities, response to hazards and crash risk perception (Banks *et al.*, 2004; Deery and Love, 1996; Martens *et al.*, 1991). Individual attitudes toward, and beliefs about, drink- and drug-driving differ. For example, some evidence suggests that drink-driving is perceived as a normative practice among adolescents and young adults, leading to a false sense of assurance (Basch *et al.*, 1989). Baum (2000) found that drink-driver offenders, when compared with a matched community sample, were more likely to believe that the risks of drink-driving were overrated and that people more commonly drink and drive.

Drug-drivers have a lower perceived susceptibility of accident involvement when taking stimulants than non-drug-drivers (Albery *et al.*, 2000). Drugs commonly used by drug-drivers include cannabis, heroin, amphetamines and cocaine (Darke *et al.*, 2004). Furthermore, although drug-driving may be equally dangerous, most drug-drivers perceive drink-driving to be most dangerous, given the belief that alcohol is the most dangerous substance to use while driving (Darke *et al.*, 2004).

When under the influence of stress, one's driving is often negatively affected, leading to an elevated at-fault crash propensity (Legree *et al.*, 2003). Driving ability, and thus driver safety, may be negatively affected due to either on- or off-road stressful situations. For example, a driver challenged by current environmental factors (e.g. a distracting mobile phone conversation) may cause driver stress due to increased driver workload, and thus lead to an increased crash risk (Rakauskas *et al.*, 2004). Similarly, drivers dealing with life events off the road (e.g. marital separation or divorce, hospitalisation of a partner, or a child leaving home) have an increased collision risk (Lagarde *et al.*, 2004a). Such tendencies are aligned with the data that show angry driving is associated with higher crash rates (Wells-Parker *et al.*, 2002).

Despite the existence of situations in which drivers tend to exhibit more stress and are thus more prone to crashing, the effects of stress on a driver are affected by the way the driver reacts to stress and the external road environment (Mathews *et al.*, 1998). High anger drivers who both recognised and did not recognise their angry driving tendencies, for example, have been found more to be likely than low anger drivers to exhibit more trait anxiety and anger, as well as being less able to control such anger (Deffenbacher *et al.*, 2003). A limitation of this work is the lack of consistency within the literature regarding the definitions and understanding of constructs such as driver stress, anger and anxiety. Driving-related fear, for example, is often defined in terms of phobia and anxiety (Taylor *et al.*, 2002). Further, while anxiety expectancy is a common concern for those fearful of driving, it may be related to a lack of confidence in one's driving ability (Taylor *et al.*, 2000a). In fact, even a general dislike of driving has been associated with poorer driving skills and more mood disturbances than those who do not dislike driving (Matthews *et al.*, 1998), which may further exacerbate driving dangers and difficulties.

Pre-frontal cortical regions are not fully developed until early adulthood (Steinberg, 2004). Steinberg suggests that this region influences self-regulatory functioning, which would include adolescents' and young adults' judgement and decision-making processes, including perceptions of driving demand (**path 18**) and driving ability (**path 19**).

Finally, it is important to reconsider the conceptualisation of risk perception with respect to driving behaviour. The Health Belief Model (Rosenstock, 1974; Strecher and Rosenstock, 1997) specifies risk perception as a combination of perceived susceptibility to the deleterious outcome and perceived severity of the outcome. An individual, for example, may perceive their flu risk to be high but the severity of flu to be low. On the other hand, they may perceive their HIV risk to be low but the severity to be high (Rosenstock *et al.*, 1994). The perceived risk of getting in an automobile crash focuses on susceptibility but not severity.

Perceptions of control over a situation influences risk perception (Zakay and Dil, 1984). Perceptions of driving ability are likely to influence perceptions of control in a crash situation (**path 20**). Zuckerman and colleagues (2004) found that unrealistic beliefs of control (control over an uncontrollable situation) was related to high-risk sexual behaviour. Similarly, we believe that unrealistic beliefs of control during a crash (what we have termed the 'perceived crash response ability') would be related to perceptions of crash risk severity. For example, during the event of a crash, the individual might believe that, in many cases, they could engage in behaviours that would minimise the severity of the crash (e.g. locking arms to brace for impact, falling the right way in the car) (**path 21**).

The particular equipment or characteristics of the automobile, such as the size or weight of the automobile or presence of airbags, may also influence perceived crash severity (**path 24**). Note that automobile equipment that influences perceived

severity (e.g. airbags, size and weight of the automobile) is different from equipment that influences perceived susceptibility (e.g. anti-lock brakes): **path 21**. Even though certain vehicle characteristics have been found to improve driving ability (**path 23**), they may also reduce perceived crash risk susceptibility. Future research should distinguish causal influences of different vehicle characteristics on perceived susceptibility and severity.

3.5 Risk homeostasis

In our conceptual framework, crash risk perception predicts intention to drive safely (**path 10**). We believe that the strength of this relationship is moderated by the driver's acceptable level of risk (**path 11**). For example, a person may perceive a high crash risk, but will not intend to adjust his or her driving behaviour due to a high level of risk acceptance. As Turner and McClure (2004) state, 'Potentially, people with a "high" risk acceptance may perceive risk differently and therefore engage in more risky driving/riding behaviours that lead to a crash resulting in injury. A "high" risk acceptance itself is neither a sufficient nor necessary cause for an injury outcome but it is a part of the causal relationship' (p. 388). This interaction is very similar to the central relationship of Wilde's homeostasis theory, which views an individual's driving decisions as a function of the target level of risk and perceived level of risk. We employed the term 'target level of risk' to maintain consistency with the homeostasis theory, though it is also similar to Deery's concept of 'risk threshold' (Deery, 1999).

Risk taking among adolescents has been examined from cognitive, psychosocial and neurobiological perspectives. Social influences, including the normative perceptions and collective behaviour of others, are likely predictors of the target level of risk acceptance (**path 28**); they are direct predictors of behavioural intention in both the Theory of Reasoned Action (Fishbein and Ajzen, 1978) and the Theory of Planned Behaviour (Ajzen, 1985). The collective behaviour of other drivers on the road significantly influences driver behaviour (Zaidel, 1992).

Our conceptual framework also suggests that the target level of risk acceptance is influenced by relatively stable attitudes and beliefs (**path 29**). Attitude is a central construct of the Theory of Reasoned Action and the Theory of Planned Behaviour, and is the product of an individual's beliefs and the evaluative assessment of the belief. While not always the case (e.g. Assum, 1997; Kennedy *et al.*, 1997), a large body of research supports the influence of attitudes on safe driving behaviour. Moreover, attitudes are associated with drink-driving behaviours in adolescents (Augustyn and Simons-Morton, 1995) and adult traffic offenders (Baum, 2000). Drink-drivers differ from the general community in their attitudes regarding strategies for avoiding the drink-driving behaviour, risk perception, acceptability of drink-driving, likelihood of getting caught drink-driving, prevalence of drink-driving and the necessity of punitive measures (Baum, 2000).

Seat-belt use is also influenced by attitudes (Martinez *et al.*, 1996). In one study, beliefs that safety belts are uncomfortable or a waste of time, an underestimation of danger of not wearing a seat belt, and other risky behaviours, explained half of the variance in the lack of seat-belt use (Chliaoutakis *et al.*, 2000). Gerrard and colleagues (1996) found that reckless driving in youths was highly influenced by attitudes towards safety and health, and Gibbons and Gerrard (1995) concluded that positive or negative perceptions of 'prototypes' of people who engage in reckless driving significantly affected youth engagement in the behaviour. Whether subjects considered reckless driving to be cool, immature, careless or unattractive was correlated with their own behaviour. A similar result was also found for red light running behaviour (Porter and Berry, 2001).

Ulleberg and Rundmo (2002) identified 11 dimensions of risk-taking attitudes associated with self-reported driving behaviour and crash frequency, including safe driving, speeding, riding with an unsafe driver, concern for others, violation of traffic rules, accident causality and crash risk. These attitudes were associated with both self-reported driving behaviour and crash frequency. A study of US adult drivers (Williams, 2003) found that a concern for others' safety, negative outcomes of unsafe driving, and increased insurance costs and fines were the strongest motivating factors for safe driving behaviour.

It has been widely documented that traffic safety attitudes vary by age and sex. Younger age drivers tend to be associated with more negative attitudes toward traffic safety (Seo and Torabi, 2004), while females tend to exhibit more positive traffic safety attitudes than do males (Laapotti *et al.*, 2003; Parker *et al.*, 1992; Taubman and Findler, 2003).

Consistent with our conceptual framework, Brown and Cotton (2003) found that attitudes regarding the acceptability of speeding were contingent on the perceived risk of the circumstances, including the familiarity of roads, belief in an ability to handle speed safely, absence of others on the road, strength of belief that speeding is dangerous, and the time of day (also see Parker *et al.*, 1992). Additionally, sensitivity to punishment is associated with behavioural intention and traffic violation (Castella and Perez, 2004; Voas *et al.*, 2002a).

An area just beginning to receive attention in driver safety research is perceived **benefits of unsafe driving**. A recent study by McKenna and Horswill (2006), combined with evidence from Lawton and colleagues (manuscript in preparation), suggests that positive beliefs regarding unsafe driving are associated with driving behaviour. These beliefs are likely to evolve from more frequent, immediate feedback provided by fast driving and positive outcomes (e.g. getting to the destination faster, exhilaration) and the lack of negative outcomes (e.g. a crash, a traffic fine). While not a focus of traditional models, such as the Health Belief Model, there is a strong body of research supporting the role of positive

expectancies for alcohol, drug and sexual risk-taking behaviours (e.g. Goldberg *et al.*, 2002; Katz *et al.*, 2000; Fromme *et al.*, 1999).

Recent evidence from Lawton and colleagues (manuscript in preparation) also suggests that affective beliefs (e.g. fast driving evokes worry, guilt, anxiety, enjoyment) (**path 38**) predict driving speed to a greater extent than do instrumental beliefs (e.g. fast driving is harmful, safe, timely). A second study in the area of smoking (also by Lawton et al. and being prepared in the same manuscript) confirms the importance of emotions on behaviour.

Sensation-seeking and other personality traits have received significant attention in driver safety research (**path 25**). Sensation-seeking, defined as 'the need for varied, novel, and complex sensations and experience, and the willingness to take physical and social risks for the sake of such experience' (Zuckerman, 1979), has often been measured using the proxy of vehicular speed. Speeding behaviour may fall under the category of sensation-seeking since such risk-taking and reckless behaviours are frequently executed for the excitement they may bring to the driver. In fact, sensation-seeking strongly predicts preferred driving speed (Sümer, 2003).

The Manchester driver behaviour questionnaire has been used to measure sensation-seeking as a component of one's driving behaviour or style (Bianchi and Summala, 2004). Similarly, the Reckless Behaviour Questionnaire has been used to attain sensation-seeking information (Wagner, 2001). 'Smart cars' have also been used to collect speeding data, as these cars may be programmed to record vehicle speed (Boyce and Geller, 2002). In addition to measures related to speeding, the sensation-seeking trait has been correlated with blood platelet MAO activity levels (Eensoo *et al.*, 2005) and measured by the Zuckerman's Sensation-Seeking Scale (Jonah, 1997).

Similar to the association between risk behaviours and alcohol use (Leigh, 1999), the positive relationship between sensation-seeking and risky driving behaviours is well-established, tending to be stronger in men than women (Wagner, 2001; Jonah, 1997) and to weaken with age (Jonah, 1997). Still, most non-fatal crashes caused by adolescents appear to result from failing to pay attention to, and search the environment for, hazards, rather than from the driver's excessive speed or thrill-seeking (McKnight and McKnight, 2003). Further, although the literature shows significant indirect effects of sensation-seeking on traffic collisions through risky driving behaviours, the direct effects of sensation-seeking on traffic collisions have not been shown (Stead *et al.*, 2005).

People with similar sensation-seeking personality types also tend to exhibit unsafe sex practices, use alcohol and drugs (**path 30**), and engage in violence (Caspi *et al.*, 1997). The most compelling evidence for personality factors associated with unsafe driving behaviours comes from Caspi *et al.* (1997), who examined temperament and personality traits in a birth cohort of over 1,000 individuals through the age of 21. High aggression (e.g. frightening and causing discomfort for others) and low control

(e.g. reflective, cautious, careful, rational), harm avoidance, traditionalism (endorses high moral standards) and social closeness scores at age 18 were predictive of dangerous driving habits (drink-driving behaviour, seat-belt use). These traits were predicted, in general, by an uncontrolled temperament (e.g. irritable, impulsive, difficulty sitting still, rough and uncontrolled in their behaviour, labile in their emotional responses) **measured at age three**. Moreover, at least half of the variation in similar personality traits are a result of genetic factors (Bouchard, 1994; Tellegen *et al.*, 1988).

While neither personality nor heredity traits are not targets for change (unlike attitudes or skills), they can be used in segmenting audiences for health communications messages (Caspi *et al.*, 1997). To our knowledge this type of segmentation has not been previously pursued. More research is also needed to understand how specific sensation-seeking characteristics affect driving behaviour. For example, it is of interest to determine how well Sensation-Seeking Scale (SSS) scores predict traffic collisions, which may be possible through tracking driving records and determining threshold SSS scores (Jonah, 1997).

It will be important to better understand the physiological determinants of personality characteristics. Changes in reward sensitivity, novelty and sensation-seeking occur early in adolescence (Steinberg, 2004). An increased need for the type of stimulation provided by risk taking is possibly due to developmental changes in neuroendocrine activity (**path 32**). In animal models, the development of the limbic system during adolescence may, in part, account for changes in reward-seeking behaviour (Spear, 2000).

This limbic-controlled process is probably naturally selected, as animals must gain competence through taking risks (e.g. baby birds jumping from their nests). Steinberg (2004) posits that the temporal gap in physiological development between puberty-triggered limbic activity and slower-maturing pre-frontal cortical development forms a ‘window of vulnerability’ where the propensity to accept risk is high and self-regulatory processing is low. Steinberg (2004) speculates that the most vulnerable adolescents might be those maturing earliest but developing self-regulatory functions latest. This could presumably be tested in traffic safety research examining the onset of puberty, risk acceptance, perceived risk and driving behaviour.

Finally, we posit a relationship between physiological impairment, neuroendocrine activity (**path 31**) and personality traits (**path 32**) (Weijers *et al.*, 2001). It has been demonstrated that drugs and alcohol-induced intoxication can reduce risk-taking thresholds (Lane *et al.*, 2005; 2004), which is probably mediated through alterations in individual state variables. Physiological impairment is therefore seen as a potentially inhibiting self-regulatory functioning (governing crash risk perceptions) and/or exciting neuroendocrine activity (governing target level of risk acceptance).

Research data are very clear that laws and policies (**paths 37 and 39**) have a significant influence on our driving behaviours, mediated by the level of risk drivers accept (e.g. Voas and Hause, 1987; Voas *et al.,* 1997b). Moreover, recidivism rates for driving under the influence (DUI) offences are clearly lowered as a result of legal sanctions (Nochajski and Stasiewicz, 2006; Woodall *et al.*, 2004). While this review is not focused on the specific influence of laws and policies, it is important to identify their prominent role in driving behaviour.

Finally, the identity an adolescent is developing is likely to be influenced by social norms (**path 33**) and by their personality (**path 34**). For many individuals, driving is simply a utilitarian endeavour; for others, driving is a personally relevant activity. Ego involvement in a particular behaviour could influence chronic dispositions toward the behaviour (West, 2006) and the response to messages attempting to influence the behaviour (Freeman *et al.*, 2001).

Stronger identification as a smoker predicts both lower intentions to quit (Falomir and Invermizzi, 1999) and poorer cessation outcomes (Shadel and Mermelstein, 1996). A recent study of Irish adolescents (Stewart-Knox *et al.*, 2005) found smoking uptake often to be driven by a desire to conform to the norms of a peer group as opposed to being through direct persuasion.

As West (2006) states, identity is a set of mental representations we have of ourselves as we both **are** and we **could be**. Markus and Nurius (1986) call these future states our 'possible selves' – what we 'would like to become . . . could become . . . or afraid of becoming' (p. 954). Freeman and colleagues (2001) operationalised the possible selves construct for future smoking identity by asking smokers to rate the likelihood of smoking one month, one year, 10 years and 20 years from now, and also with respect to specific life events, such as graduating from college, living with a romantic partner, having a full-time job and having children. When smokers were then shown a series of anti-smoking videos, those with the strongest future identities (possible selves) as smokers were most likely to resist the messages of the videos. These smokers, however, were less resistant to videos focusing on the immediate impact of smoking (such as addiction). Together, these data point to the importance of measuring both current and future ego involvement with driving, and in tailoring safe driving messages to these specific identities.

3.6 Habit

Yates (1993) points out that, in many instances, unsafe driving behaviour may occur when no semblance of risk taking is made. Yates uses the example of a person getting into a car who, with no consideration of risk acceptance, fails to use the seat belt. Routines that become habituated with driving experience (**path 43**) may have very little to do with the other processes presented in the conceptual framework. Regardless of whether a person intends or does not intend to drive in a safe manner,

habitual processes, similar to thoughtlessly lighting a cigarette, supersede cognitive processing (**path 44**).

A large body of research in other behavioural areas now supports the comments by Yates: that the relationship between intention and behaviour are not as strong among behaviours that largely habitual, such as seat-belt use or cigarette smoking (Webb and Sheeran, 2006; Wood *et al.*, 2002; Ouelette and Wood, 1998). A review of research found that among behaviours conducted frequently and in stable contexts, past behaviour was the strongest predictor of future behaviour, whereas among less frequent behaviours conducted in unstable contexts, intention was the stronger predictor of future behaviour.

4 INTERVENTION APPROACHES

While this review specifically addresses traffic safety programme development, existing interventions administered to both adolescent and young adult drivers and to serious traffic offenders provide insight into active psychosocial predictors. Our conceptual framework, and the research evidence supporting it, suggest directions for screening and intervention.

4.1 Adolescents and young adults

For decades, a key aspect of driver safety programmes has been the focus on risk perception. General mass media and educational approaches to adjusting risk perception (inducing a more accurate perception of one's crash risk) have not had a strong impact. A reason for this lack of effect may be that novice drivers with an optimistic bias of their crash risk are less likely to relate to risk-based communications. Walton and McKeown (2001) found that drivers who believe they drive slower than others tended to ignore an anti-speeding media campaign. Harre and colleagues (2005) found that college students exposed to a series of messages depicting the horrific results of a crash developed heightened perceptions of driving ability relative to their peers. The authors suggest that, rather than having their risk perception affected by the message, subjects attributed the cause of the crash outcome to poor driving ability.

This compensatory adjustment in cognition in order to maintain current behaviour is consistent with the perceived driver-ability crash-risk perception of our conceptual framework; the driver 'looks for evidence of distinction between the self and the image and facilitates this process (or search) by derogating the image' (Gibbons and Gerrard, 1995, p. 506). The derogation, in this case, relates to perceived driving ability: lowering the ability of the image while raising the ability of the self.

An experiment by Gregersen (1996) suggests that skill-based instruction alone might overly-enhance perceived driving ability. In this study subjects using a 'Skid Car' designed to simulate a car on an icy road were assigned to either:

(a) skills-based instruction focusing on braking and avoidance manoeuvring; or

(b) an 'insight' condition that left the subject without specific instruction.

One week following training, subjects in the skills condition estimated their driving skill to be higher than the insight group, while no difference was found in their actual skill.

These results elucidate the complex role of self-efficacy enhancement in driver safety training. Unlike other health-related practices, such as smoking cessation, dietary changes or physical activity, where self-efficacy enhancement appears to

have strong positive effects (Bandura, 1997), efficacy enhancement in driving may result in overconfidence, motivating unsafe driving without the requisite skills. The results of the Harre *et al.* (2005) study suggest that adding dramatic crash outcome messages to driver training will do little to mollify this overestimation. We agree with Fuller's (2005) recommendation that enhancing driver awareness of the demands of driving may yield positive results.

Numerous studies have found that driver education and enhancement courses in the manoeuvring and handling of vehicles have little or no effect on traffic outcomes and can actually be counterproductive (Gregersen, 1996; Ker *et al.*, 2005, 2003; Mayhew and Simpson, 2002). There is, however, evidence that when the right skills are targeted and applied appropriately, it is possible to improve individual driving safety and reduce crashes. Such skills include understanding traffic situations, building self-efficacy in defensive driving and hazard perception, and increasing experience through the distance driven (Cartensen, 2002). Katila and colleagues (2004) further argue that the crux of the issue is which skills the driver prioritises as important. As discussed previously, we believe that these skills include the detection, recognition and response to traffic hazards (Deery, 1999), and the impact of physiological impairment (e.g. alcohol, drugs, stress) and distractions on objective hazard detection as well as the perceived ability to detect hazards.

Behavioural capability as a driver relates not just to the actual skills used in driving but also to the skills in declining to drive and recognising times when it is inappropriate to drive, such as after alcohol consumption or substance use. As Augustyn and Morton (1995) note, the most effective school-based interventions have involved teaching kids how to cope with social pressures and life skills. This finding was corroborated by Shope and colleagues (2001a) in school curriculum experience.

Additionally, such training extends to behavioural capability in encouraging others to engage in safer driving behaviours, such as convincing friends not to drive after alcohol and substance use (McKnight and McPherson, 1986) or parents guiding and monitoring their children's driving progress and learning experience more closely (Simons-Morton *et al.*, 2005).

Graduated driver's licensing is predicated on the rationale that important driving and judgement skills should be acquired in a stepwise manner with more sophisticated skills building upon the more basic (McKnight and Peck, 2003; Mayhew *et al.*, 1998; Waller, 2003). Mayhew and colleagues (1998) also recommend that age and human development stages be taken into account in driver training to address issues including perceptual skill deficiencies, such as overconfidence, and developmental issues, including assertiveness and impatience. This recommendation is in close alignment with our conceptual model, suggesting that neuroendocrine and pre-frontal cortical development will influence driver behaviour from adolescence through young adulthood (Steinberg, 2004).

Since, when attempting to drink-drive, one's significant other is suggested to be the person with the most potential to successfully intervene (Kennedy *et al.*, 1997), effort may be well-spent creating programmes that encourage partners to keep their loved ones safe. Since less effort has seemed to focus on drug-driving, this may be another priority area for research and intervention. Finally, as college students who report being substance users are more likely than reported non-users to engage in risky driving behaviours that may lead to collision and injury, including being more likely to ride with a drink-driver while not wearing a seat belt (Everett *et al.*, 1999), interventions may be successful by jointly targeting substance use and risky driving.

Considering the risks associated with driving under the influence of stress, it is important to note the effectiveness of coping strategies, as stressed drivers that are able to successfully implement coping strategies may avoid collisions or otherwise remain safe. Incorporating explicit coping strategies in traffic safety advertisements, for example, has been found to lead to a greater internalisation of the safety message, although it is uncertain whether this approach increases driver safety (Tay and Watson, 2002). Therefore, not only is more work needed towards defining and understanding the concepts relevant to the topic of driver stress, additional research is needed to understand and improve the efficacy of methods aimed at reducing and coping with driver stress.

4.2 Adult serious offenders

Evidence is beginning to mount regarding the best ways to target serious offenders. In a study of over 16,000 multiple traffic offenders, McKnight and Tippetts (1997) found that identifying and intervening on unlawful driving behaviour through the participation of the court system or the licence-issuing agency resulted in greater reductions in driving violations and crashes more than teaching safe driving behaviours. The authors point out, however, that even the more effective court-issued recidivism prevention programming could not come close to equalling the effects of having your licence suspended by the licence-issuing agency.

While it is clear that a large proportion of DUI offenders with a suspended licence report continuing to drive (Ross and Gonzales, 1988), licence suspension programming appears to be more effective than any known psychosocial intervention among serious traffic offenders (Nochajski and Stasiewicz, 2006). Voas and colleagues (1997b) found that impounding and/or immobilising vehicles used by serious offenders significantly reduced recidivism rates before and after offenders reclaimed their vehicles. Consistent with standard tenets of behaviour modification approaches, Nochajski and Stasiewicz (2006) found that the most effective criminal justice models of deterrence, including jail time, suspended or revoked licence, or heavy fines, are most effective when the conviction is made soon after the offence and when punishment is applied quickly and consistently. When these intervention conditions can be met, criminal justice models may be particularly appropriate for serious offenders and recidivists.

Both self-efficacy and motivation to refrain from drink-driving vary a great deal among repeat offenders (Freeman *et al.*, 2005), with the majority of first-time offenders typically being highly motivated and confident in their ability to change (Wells-Parker *et al.*, 2000, 1998). Jones (1997) found that advisory letters to drivers exhibiting early signs of risky pattern driving were effective in preventing re-involvement in accidents and major violations over a 24-month period.

Broadening the scope of intervention to include moderate offenders should have a greater impact on traffic safety. DeJong and Hingson (1998) point out that fewer than 5% of alcohol-related traffic fatalities would be prevented if every driver who had been arrested the prior year for DUI could be kept off the road. Woodall and colleagues (2004) point out that this finding reflects the 'prevention paradox', relevant to numerous health issues concerned with the prevention of disease, including obesity, blood pressure and cholesterol control (Rose, 1992). Rather than focusing most attention on a small number of high-problem offenders, greater focus on making changes among a larger number of moderate problem cases would shift the normal distribution of drink-driving downwards.

Cognitive behavioural therapy (CBT) programmes fit this public health intervention model well. CBT focuses on the observation of high-risk situations and the development of coping and avoidance strategies for those situations. The relatively minimal requirements for therapist contact, combined with the practical recommendations of CBT and the ability to individualise to specific needs and situations, have made it a treatment of choice for a broad range of behavioural medicine issues, including anxiety disorder, post-traumatic stress disorder, anger, chronic pain, bulimia nervosa, smoking cessation, stress management, physical activity and migraine management (Butler *et al.*, 2006; Ghaderi, 2006; Herning *et al.*, 2005). CBT interventions for drink-driving (Nochajski and Stasiewicz, 2006; Donovan *et al.*, 1990a, 1990b) and for aggression management in driving (Galovski *et al.*, 2003; Galovski and Blanchard, 2002) have demonstrated positive effects.

Another approach to rehabilitation forces a confrontation with individuals affected by an impaired driver. While inherently interesting, victim impact panels (VIP), requiring the serious offender to listen to individuals affected by a serious driving offence, have not generally proven effective (Nochajski and Stasiewicz, 2006; Wheeler *et al.*, 2004).

5 CONCLUSIONS AND RECOMMENDATIONS

On the basis of this review, we make the following recommendations for future psychosocial, judgement and decision-making research of driver behaviour:

1. Develop greater consistency in construct nomenclature, specification and operationalisation. Other research areas have benefited from consistent naming conventions, standardised conceptualisation of constructs and consistent operationalisation of measures. While such consistency with other studies is clearly not possible in many research situations (e.g. when new constructs are being examined and when a long battery of questions measuring a construct is not feasible), we saw numerous instances where concept naming, specification and measurement was clearly 'home grown'.
2. Further examine the reciprocal nature of driving behaviour, resulting consequences, cognitive processing and subsequent behaviour. Bandura's groundbreaking Social Cognitive Theory elucidates a feedback loop between behaviour and cognition. Homeostatic models of driving behaviour (i.e. Fuller's Task-Capability Interface (TCI) model (Fuller, 2005) and Wilde's Homeostatic Theory (Wilde *et al*., 2002)) also specify relevant cognitive-behavioural feedback loops. The role of previous driving consequences should be examined more carefully, particularly as it relates to subsequent self-efficacy and actual and perceived driving ability.
3. Further examine the homeostatic processes involved in driver ability, the demands of the driving task and task difficulty. Examine inconsistencies between actual ability and demands, perceived ability and demands, and driving behaviour.
4. Further examine the predictors of risk acceptance thresholds, including personality, attitude, social norms, time urgency and legal/policy constructs.
5. Examine the interaction between perceived driving ability and perceived driving demands on crash risk perception.
6. Examine the interaction between crash risk perception, the target level of risk acceptance and intention to drive safely.
7. Examine the interaction between intention to drive safely, task difficulty and driving behaviour.
8. Further examine the physiological influences of neurological development and impairment to both neuroendocrine and pre-frontal cortical activities. Also examine the influence of these activities on individual state variables, perceived demands and perceived driving ability.
9. Consider the use of constructs specified in other models of health-related behaviour, particularly the distinction between perceptions of susceptibility and

severity in overall crash risk perception and the distinction between behavioural intention and actual behaviour.

10. Consider greater specification in the analyses of moderating and mediating relationships between constructs. Most studies reviewed used simple bivariate or multivariate predictor analyses. We recommend developing hypothesised models of constructs and mechanisms, then testing these models using structural equation modelling techniques. Moderator analysis of interventions could determine strategies that work for some drivers but not for others. These analyses could potentially lead to effective treatment matching strategies.

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APPENDIX 1

Table of studies

Authors	Year	Theory	Country	Population	*n*	Results
Albery *et al.*	2000	TRA/TPB	UK	Adolescent Young adult	210	*Outcomes: Accident involvement (impaired or non-impaired), perceived skill, perceived accident likelihood.* Drugged driving is common among drug users, whether or not they are in treatment or severely dependent. Drug-using drivers had lower perceived accident involvement and higher perceived skill when taking stimulants than non drug-drivers.
Assum	1997	TRA/TPB HBM SCT	Norway	Adolescent Young adult	7,425	*Outcomes: Accident risk.* Drivers whose attitudes complied with traffic rules reported lower accidents and speeding, higher consideration for other road users, and higher self-perception of being a good driver. No association was found between drinking and driving and traffic compliance attitudes.
Barkley *et al.*	2002	PBT Task-interface DMT	USA	Adolescent Young adult	105	Severity of Attention Deficit and Hyperactivity Disorder (ADHD) symptoms alone may be the most powerful evidence available for driving risk. Overall, after extensive analysis of the many potentially confounding or interactive factors, such as substance use, comorbidities and intelligence, group differences appear to be attributable to ADHD uniquely. Compared to community controls, the ADHD group received more than twice the number of driving citations, particularly for speeding, had more licence suspensions/ revocations, more vehicular crashes as driver, being at fault in more such crashes, and having more severe crashes as reflected in dollar damage. Self-report and Department of Motor Vehicles (DMV) coincided with few exceptions. Driver inattentiveness was cited most frequently by both groups as the reason for their first two crashes. The ADHD group had the same knowledge in perception skills, traffic risk situations and driving procedures. General driving knowledge – laws, rules – was significantly lower.

Authors	Year	Theory	Country	Population	*n*	Results
Basch *et al.*	1989	SCT TRA/TPB SS	USA and Canada	Adolescent Young adult	316	*Outcomes: Drink and drive decision-making.* Participants reported a lack of knowledge about the effects of alcohol on driving and a lack of skill in making decisions whether to drink and drive. There was evidence that drinking and driving was viewed as a normative practice, with increased frequency of drinking and driving suggesting a greater false sense of assurance. Respondents were also willing to accept risks of driving after drinking, or deny those risks. Focus group participants mentioned the social benefits of drinking and driving, such as fun and peer acceptance.
Baum	2000	TRA/TPB SCT HBM	Australia	Serious offender Young adult Adolescent	298	*Outcomes: Knowledge of safe BAC levels, attitudes toward drink-driving and avoiding drink-driving.* Although knowledge is similar, drink-driving offenders do not hold the same attitudes as other community members. Offenders are less likely than the general community to agree with strategies for avoiding drink-driving, especially abstaining from driving after having too much to drink by leaving one's car behind and keeping track of the number of drinks consumed to stay under BAC limits. Furthermore, offenders were more likely to agree that the risks of driving are overrated, that they can drive after drinking, they would get picked up if they drove after drinking, and that everybody drinks and drives once in awhile. Offenders were less likely to agree that society needs harsher sanctions for drink-driving.
Beck *et al.*	2001	PBT	USA	Adolescent	424 teen/ parent pairs	*Outcomes: Driving violations and risky driving.* Parental supervision through the enforcement of rules and supervised access to a car was associated with a decreased frequency of driving infractions and risky driving among new drivers.

Authors	Year	Theory	Country	Population	*n*	Results
Bianchi and Summala	2004	SCT TRA/TPB SS PBT	Brazil	Adolescent Young adult	123	*Outcomes: Driving violations (ordinary or aggressive), errors, lapses, accidents, tickets and mileage.* The authors showed that the more parents have traditional traffic violations, the more likely they are to occur in their children when they learn to drive. However, this transference does not occur for aggressive violations. These results support previous work that family connectedness relates to fewer aggressive driving violations in children.
Bingham and Shope	2004	PBT	USA	Adolescent Young adult	2,085	*Outcomes: Risky driving*. Participants were assigned to one of five risky driving groups based on self-reported measures (gender, drug-driving, high-risk driving and drink-driving). Risky driving between high- and low-risk driver groups was evident by 10th grade and through the 12th grade. These differences were most salient for drink-drivers, high-risk drinking drivers, and drug-drivers.
Brown and Cotton	2003	TRA/TPB HBM SCT TTM	Australia	Adolescent Young adult	800	*Outcomes: Speeding risk beliefs, risk estimates, speeding*. Participants' beliefs about speeding risks was directly associated with speeding behaviour. Furthermore, participants' risk estimates mediated the association between speeding risk beliefs and speeding behaviour. Females reported higher agreement to the risks of speeding than their male counterparts
Calisir and Lehto	2002	TRA/TPB HBM DMT	USA	Young adult Adolescent	25	*Outcomes: Safely belt use.* Drivers' seat-belt use decision-making is influenced by demographic factors such as age, gender and grade point average (GPA). Seat-belt use decision-making was not associated with perceived risk, usefulness or consistency of safety belt use in accidents. Furthermore, drivers do not continuously assess risk and benefits about seat-belt use; rather it is a habit-based behaviour.

Authors	Year	Theory	Country	Population	*n*	Results
Caspi *et al.*	1997	SS PBT	New Zealand	Child Adolescent Young adult	1,037	*Outcomes: Health risk behaviour (dangerous driving habits).* Participants with similar sensation-seeking personality types clustered across health-risk behaviours, such as dangerous driving habits, unsafe sex practices, alcohol use and violent behaviour.
Castella and Perez	2004	TRA/TPB Gray's Model	Spain	Young adult Adolescent	792	*Outcomes: Infringement of traffic rules, attitudes toward infringement on traffic rules.* Attitude was positively associated with infringement of traffic rules behaviour. Those who perceived less danger in driving infringements showed greater likelihood of being fined and breaking laws. Men were more likely to respond to reward and women were more likely to respond to punishment. Sensitivity to reward attitudes were stronger than sensitivity to punishment attitudes in predicting driving behaviour.
Caudill *et al.*	2000	HBM TRA/TPB	USA	Young adult Serious offender	472	
Chaudhary and Northrup	2004a	HBM TRA/TPB AT	USA	Adolescent Young adult	9,088	*Outcomes: Seat-belt use.* Respondents scoring high on perceived effectiveness of belts were more likely to answer that they always use seat belts than those with less fatalistic attitudes. Interaction effects were found for perceived effectiveness of belts and perceived risk of getting a ticket. People who believe in the effectiveness of seat belts are less likely to be influenced by the fear of getting a ticket, than those who believe seat belts are less useful.

Authors	Year	Theory	Country	Population	*n*	Results
Chen *et al.*	2001	TRA/TPB	USA	Adolescent	1,181	*Outcomes: Road user death rates.* Increased compliance with passenger restrictions could hypothetically increase the estimates of lives saved.
Chliaoutakis *et al.*	2000	SCT TRA/TPB HBM	Greece	Young adult Adolescent	200	*Outcomes: Seat-belt use.* Experience driving was not strongly associated with seat-belt use. Motivation to wear a seat belt was varied by different environments, social norming and imitation, self-protection, fear, experience, socioeconomic status, and perceived legality of driving behaviours. Lack of seat-belt use was predicted by risky behaviour, underestimation of danger, belief that seat belts are a waste of time, and physical discomfort. Seat-belt use was related to imitation, self-protection and legality factors.
Clark *et al.*	2005	TRA HBM	UK	Young adult	3,437	*Outcomes: Reasons behind accident.* Accident records of drivers ages 17–25 were reviewed to determine whether accidents were caused by voluntary risk-taking, skill failure, or a combination of the two. Although skill deficit was partially responsible for some accidents, a fair amount were due only to voluntary risk taking. Accidents involving drivers with performance cars indicated that, even though the drivers had somewhat greater skills, they had especially high risk-taking behaviour. Accidents during darkness were due less to visibility and more to increased recreational driving and related behaviour.
Darke *et al.*	2004	HBM	Australia	Serious offenders Young adult Adolescent	300	*Outcomes: Drug driving perceptions.* Alcohol use was perceived to be the most dangerous substance while driving. Drivers recently detained for drug-driving perceived their behaviour to be less dangerous than non drug-driving. Drug-drivers also perceived themselves as being less likely to be detained for drug-driving than non drug-drivers.

Authors	Year	Theory	Country	Population	*n*	Results
De Blaeij and Van Vuuren	2003	Prospect Theory	The Netherlands	Young adult	17	*Outcomes: Accident-related injury risk perception, valuation of traffic safety.* Valuation of losses follows a concave shape. Furthermore, participants' losses are perceived to be due to the desired outcome of their driving behaviours rather than on the probability of a negative outcome (i.e. their risk).
DeJoy	1989	TRA/TPB HBM	USA	Young adult Adolescent	106	*Outcomes: Perceived traffic accident risk.* Participants were much more optimistic when they perceived a traffic event as controllable. Optimism was associated with greater ability to mentally picture the type of person who would be involved, but was not associated with event seriousness. In general, subjects attached considerably greater importance to human error in causing accidents than to either technical problems (with vehicle or road design) or chance (bad luck or fate). Subjects who assigned greater importance to human factors in accident causation also rated themselves as more skilful. Optimism and the importance assigned to human error both increased with driving experience. Finally, females assigned greater importance to technical factors than did males.
Delhomme	1991	SCT TRA/TPB AT SoCo	France	Adolescent Young adult	454	*Outcomes: Perceived driving ability, perceived driving law adherence.* Subjects considered themselves to be better than average drivers based on their self-reported ability. Perception of driving ability did not differ by age or sex, involvement in an accident, degree of responsibility in an accident, accident type, or whether they had been penalised for an offence in the past three years. Individuals evaluated themselves as being more cautious and having better reflexes than other drivers in general. Furthermore, subjects who believe their abilities are superior to the average driver are less likely to think that crashes are caused by external, uncontrollable factors.

Authors	Year	Theory	Country	Population	*n*	Results
Eensoo *et al.*	2005	SS PBT SCT	Estonia	Serious offender Adolescent Young adult	414	*Outcomes: Drunk-driving behaviour.* Drunk-driving is associated with behavioural, biological and personality based risk factors. The frequency and recentness of alcohol use, seat-belt use, smoking behaviour, paying for parking, impulsive behaviour, platelet MAO activity and age were all significant predictors of drunk-driving behaviour. Drunk drivers were unaware of how long to wait after drinking before getting behind the wheel. Drunk drivers were more likely to exhibit impulsive behaviour than the control group (non-drunk drivers).
Elliott *et al.*	2003	TRA/TPB	UK	Young adult Adolescent	598	*Outcomes: Intention to speed, speeding behaviour.* TPB explained speeding behaviour well as shown in this study. Drivers' attitudes, subjective norms and perceptions of control are positively associated with intention to comply with speed limits. Intention to comply is then positively associated with speeding behaviour. Intention to comply and perceived behavioural control are the strongest predictors of speeding behaviour, followed by demographics. Prior behaviour moderated the relationship between the perceived control and intention as well as the relationship between perceived control and behaviour.
Evans and Norman	2003	TRA/TPB	UK	Child Adolescent	1833	*Outcome: Road-crossing intention.* Theory of Planned Behaviour was able to explain 25% of the variance in road-crossing intentions, controlling for age and gender, with perceived behavioural control emerging as the strongest predictor. Identifying oneself as a safe pedestrian and anticipated affect were also strong correlates.

Authors	Year	Theory	Country	Population	*n*	Results
Everett *et al.*	1999	SCT TRA/TPB	USA	Young adult Adolescent	2,847	*Outcomes: Seat-belt use, drink driving, riding in a car with a drink driver.* Substance-using college students are more likely than non-users to not wear a seat belt, drink drive or be a passenger of a drink driver. Smokers, episodic heavy drinkers, marijuana users and users of illegal drugs in combination with alcohol are more likely to drive after drinking alcohol, are more likely to ride with a driver who had been drinking alcohol, and are less likely to wear a safety belt. For drinkers and drug users, as the frequency of substance use increases, so does the likelihood of drink driving, riding with a drink driver while decreasing the likelihood of wearing a seat belt.
Ey *et al.*	2000	HBM	USA	Adolescent Child Young adult	135	*Outcomes: Perceived crash risk susceptibility.* Caucasian adolescents were significantly more likely to report vulnerability to car accidents than African-American adolescents. Girls rated themselves as much more vulnerable to injury by motor vehicle accident than boys.
Fergusson *et al.*	2003	PBT	New Zealand	Adolescent Young adult Serious offender	907	*Outcomes: Risky driving behaviours, traffic accidents.* Ninety per cent of drivers performed some sort of risky driving behaviour. Frequency of risky driving was associated with being male, abusing alcohol and marijuana, partaking in violent behaviours, and affiliated with substance using and delinquent peers. Risky driving frequency was associated to traffic accident risk.
Finn and Bragg	1986	TRA HBM	USA	Young adults	93	*Outcomes: Perceived risk (general, specific, danger rating).* Overall, young drivers perceived less risk than older drivers. All drivers saw young drivers as being at greatest risk. However, young drivers saw their own risk as lower than that of other young male drivers, while older drivers saw their risk as comparable to their peers. Compared to older drivers, younger drivers did not perceive driving as more dangerous (as measured by perceived accident and fatality rates and the perceived danger level of certain driving situations).

Authors	Year	Theory	Country	Population	*n*	Results
Fockler and Cooper	1990	TRA/TPB SCT HBM	Canada	Young adult Adolescent	408	*Outcomes: Vehicle safety measure use (seat belts, helmets, daytime running lights).* Over 11% of interviewed drivers stated that they did not consider themselves a regular safety-belt user even though 30% of them were observed not using safety belts at the time of the survey. Safety belt non-users were more likely to be driving vehicles over 10 years old, used their headlights during the daytime less frequently, and had more average recorded traffic violations per year during the five years prior to the survey than did observed seat-belt users. Reasons for not wearing seat belts included discomfort, a matter of personal choice, and travel in short distances. Suspected police checks were the most frequently stated motivation for wearing a seat belt according to irregular seat-belt wearers.
Foss	1989	HBM ELM	USA	Child	45,000	*Outcomes: Seat-belt use.* A mass media educational campaign in a community found that the use of restraints varied widely. Seat-belt use rose in response to ads and publicity of programme. Children of ages 2–4 were least likely to be restrained and the most difficult to reach with programmatic effort. Among school-age children, front-seat restraint use responded moderately to publicity. The intervention did not have an effect among adults.
Gerrard *et al.*	1996	SCT SoCo	USA	Adolescent	477	*Outcomes: Perceived vulnerability, health and safety concerns, reckless driving (and drinking, smoking) prevalence, perception of peers' reckless driving prevalence.* Increases in reckless driving over time were accompanied by increased perceptions of risk, increased prevalence estimates, and decreases in reported influence of concerns about health and safety. Decreased risk behaviours were associated with an increase in health and safety concerns and a decrease in perceptions of risk. Furthermore, these drivers were the only showing a tendency to decrease their estimates of the prevalence of reckless driving, in spite of the significant increase in actual reckless driving. With the exception of the no-risk group, all adolescents clearly overestimated the prevalence of reckless driving among their peers.

Authors	Year	Theory	Country	Population	*n*	Results
Gibbons and Gerrard	1995	TRA/TPB SoCo	USA	Young adult	628	*Outcomes: Driving behaviour, social comparison, prototype perception, self-perception.* For reckless driving, participants engaging in the behaviour had more favourable images of the prototype than did those who were not engaging in it. Consistent with their behaviour, men had a more favourable impression of the typical reckless driver than did women. Finally, participants whose driving behaviour stayed at the same level (i.e. no risk or same risk) reported no change in normative perception. Prototypes predicted actual behaviour most for people who tended to make social comparisons between themselves and others. Self-perception did not vary as a function of risk behaviour.
Goszczynska and Roslan	1989	TRA/TPB	Poland	Adolescent Young adult	300	*Outcomes: Self-estimate of driving ability, comparison with other drivers' abilities.* Polish drivers had high self-estimates and rated themselves highly in relation to others, but their estimates of others were close to the average. Findings of both studies suggest that increase in driving skill through experience may lead to riskier driving. The study results also suggest that American drivers overestimate their skills much more than Swedish or Polish drivers.
Gotthoffer	2001	HBM TRA/TPB	USA	Adolescent Young adult Serious offender	349	*Outcomes: Drink-driving rationalisation, fear of drink-driving outcomes, and receptivity to public service announcements (PSAs).* Females were more likely to respond to localised PSAs than males and reported increased fears of drinking consequences drinking more than males. In addition, students over age 21 rationalised their behaviour more than underage students, reported fewer fears about the consequences of drinking and disagreed more often with PSAs than their younger counterparts. Students who drink and drive sometimes have higher rationalised behaviour and lower fear of consequences to drink-driving than those who rarely or never drink and drive. Those who sometimes ride with intoxicated drivers were more likely to rationalise their behaviour.

Authors	Year	Theory	Country	Population	*n*	Results
Groeger and Brown	1989	SoCo	UK	Young adults	54	*Outcomes: Self-rated driving skill and safety ratings of other drivers.* Surveys indicated that drivers overrated their driving ability, and there was no difference in self-rated skill and safety across age groups. However, the authors claim the results are artefactual because the rating scales encourage subjects to respond in ways that are favourable with peers, rather than accurately. The variable analogue scale in which drivers compared themselves to other drivers was seen as more reliable. Young drivers rated themselves more favourably in situations that required a quick response. Young males described their own driving as less smooth and more reckless than other drivers. Males of all ages claimed to drive more impulsively than females.
Guppy and Adams-Guppy	1995	HBM TRA/TPB	International – UK, Greece, Spain, Belgium, Sweden, Australia, Zimbabwe, South Africa	Adolescent Young adult	600	*Outcomes: Drink-driving behaviour, perceived risk, perceived safe consumption rates.* Driving after drinking remains a common feature of driver behaviour in a number of countries. Driving over the legal limit was reported by one-third of the sample, although there were some significant differences in behaviours between countries. Strongest predictors of reported drink-driving were the perceived difference between safe and legal consumption limits and reported restraint on drinking the night before driving. Moral attachment appeared to play a role in predicting offender status. There was a correlation between the belief that one's driving is impaired at or below the legal limit and agreement with the perceived importance of alcohol intoxication as an accident risk factor.

Authors	Year	Theory	Country	Population	*n*	Results
Harre *et al.*	2000	TRA/TPB SCT HBM	New Zealand	Adolescent	277	*Outcomes: Driving behaviours*. Drinking and driving attitudes were found to differ by gender and age. Males were found to be more likely to have positive attitudes toward drinking and driving, intending to be the future passenger of a drinking driver, considered driving in 100 km zones safe, reported more unsafe driving behaviours and reported fewer consequences to reckless driving behaviours. Older participants reported greater instances of being the passenger of a drunk driver, greater back-seat belt use, greater belief that driving in 100 km zone is safe, decreased driving behaviour knowledge, and listing fewer consequences to reckless driving. No association was found between driving experience and risky driving attitudes.
Hilakivi *et al.*	1989	PBT	Finland	Young adult	916	*Outcomes: Auto accidents.* Impulsivity and adventurousness, naiveté and excessive trustfulness, and poor self-control predicted subsequent motor vehicle accidents. However, naiveté and excessive trustfulness and poor self-control were predictive only when participants were at-fault for accidents. Driving experience predicted safer driving at follow-up.
Horberry *et al.*	2004	HBM SCT	Australia	Young adult Adolescent	6720	*Outcomes: Driving speed.* Driving speed was predictive by age, gender, time of day, and type of vehicle. Drivers in the age 55 and over category were slower than younger age categories and were over-represented in the study population of slow drivers. Females drove significantly more slowly than males, but females were not significantly over-represented in the population of slow drivers. Driving speeds typically slowed gradually as the day progressed, and people drove more slowly on weekdays than on weekends. Vehicles over 10 years old were driven significantly faster than vehicles less than 10 years old. A community survey showed that slow driving is thought to sometimes cause accidents.

Authors	Year	Theory	Country	Population	*n*	Results
Horswill and Coster	2002	TRA/TPB HBM SCT	UK	Young adult Adolescent	569	*Outcomes: Vehicle performance, driver risk taking.* A bi-directional relationship was found between risk-taking behaviour and vehicle performance. Respondents who drove faster preferred higher-performance cars and higher-performance cars caused drivers to drive faster. The more power a vehicle possessed, the more risks reported by the drivers. Finally, older drivers drove more powerful cars.
Iversen and Rundmo	2004	HBM TRA/TPB	Norway	Young adult Adolescent	2,614	*Outcomes: Risk behaviour, accident and near-accident involvement.* Three dimensions of attitude explained 50% of the total variance of risk behaviour: 1. Attitude toward rule violations and speeding. 2. Attitude toward drinking and driving. 3. Attitude toward careless driving of others. Attitude towards rule violations and speeding was the strongest of the three predictors. Risk behaviour had an effect on involvement in near accidents and accidents. Women, older respondents and those who had a licence for a long time were more likely to report positive attitudes towards traffic safety. Men, younger respondents and those holding a licence for a short time were more likely to report 'non-ideal' behaviour. The relationship between attitudes and risk behaviour was not due to correlation between background variables and attitudes. Attitudes were still strongly predictive when gender, age and number of years holding a licence were taken into account.
Jonah *et al.*	1999	TRA/TPB HBM SCT	Canada	Young adult Adolescent	1,545	*Outcomes: Police officers' attitudes and behaviours toward the enforcement of drink-driving laws.* Canadian police officers gave the following barriers to formally charging DWI offenders: lengthy time to process each charge and time required for court appearances. When officers did give DWI charges, it was usually a result of the driver bringing her or himself to the attention of the officer through driving behaviour or a collision, and infrequently because of a DWI enforcement campaign. Although studies have shown that seat belt non-users tend to be DWI offenders, police officers do not use the lack of seat belt use as an indicator that a driver might be intoxicated. Due to the difficulty in convicting DWI offenders, officers reported using discretion in giving DWI charges. Most officers did not know the percentage of fatally injured drivers that were legally impaired.

Authors	Year	Theory	Country	Population	*n*	Results
Jorgensen and Wentzel-Larsen	1999	HBM SCT	Norway	General population	100	*Outcomes: Safety and cost benefits of warning sign installation.* For drivers with correct risk formation, only 62% of curves should be marked for optimal safety and cost reduction. According to the simulation, when appropriate signs are installed, there is little benefit to overall safety and accident-related costs are not greatly reduced.
Junger *et al.*	2001	PBT Social Control Theory	Netherlands	Serious offender General population	1,531	*Outcomes: Criminal behaviour, risky traffic behaviour.* Accidents recorded in the police registration system were examined, and the at-fault drivers were identified in a separate national database of criminal offenders. The sample drawn from the accident registry contained a high number of individuals involved in criminal activity, and strong relationships were revealed between traffic crimes and other criminal offences. Risky traffic behaviour was also connected to criminal activity. Results suggest consistency of self-control problems for the same individuals across different situations and the existence of traits that drive behaviour.
Karlaftis *et al.*	2003	AT DT Social Control Theory HBM	UK, Austria, Belgium, Finland, France, Germany, Hungary, Netherlands, Sweden, Switzerland, Greece, Portugal, Spain, Italy, Ireland, Slovakia, Slovenia, Czech Republic, and Poland	Young adult Serious offender Adolescent	17,425	*Outcomes: Self-assessed driving behaviour.* Most drivers reported that their driving was less dangerous than other drivers, followed by those drivers who reported their driving to be as dangerous as others' driving. Female drivers considered themselves less dangerous than their male counterparts, as did individuals with increased years of driving experience, older age, greater annual distance travelled, and higher education. Furthermore, higher income leads to higher beliefs of being dangerous. Northern European drivers consider themselves more dangerous than Eastern European drivers, and Southern Europeans consider themselves less dangerous than their Eastern European counterparts.

Authors	Year	Theory	Country	Population	*n*	Results
Karlberg *et al.*	1998	PBT	Sweden	Young adult	135	*Outcomes: Auto accidents, near accidents.* After adjusting for age, annual mileage and experience driving in urban settings, male Type A drivers reported a greater number of near-accidents due to time pressures while driving. This relationship did not hold for female Type A drivers. No association was found between accidents and Type A scores, or between hostility and vehicle accident risk.
Kennedy *et al.*	1997	TRA/TPB SCT HBM Social Control Theory	USA	Serious offender Young adult	100	*Outcomes: Drink-driving interventions.* Participants reported whether someone had intervened in their drink-driving behaviour at least once. Most participants reported that their significant other would be the best person to intervene when participants drink and drive. Significant predictors of successful interventions included: whether the drinker had 5–10 or 10 or more drinks per occasion; having a previous drink-driving accident; and drink-driving recently when they felt they should not have. Attitudes toward impaired drinking, drinking locations, planning ahead not to drink and drive, and use of a designated driver were not significant predictors of previous drink-driving interventions.
Kim and Bishu	2004	SCT	USA	Adolescent	42	*Outcomes: Hazardous driving component skills, normal driving component skills.* Driving component skills in normal situations were not relevant to driving component skills in hazardous situations.
Klepp *et al.*	1991	PBT	USA	Adolescent	1,482	*Outcomes: Drink-driving behaviour.* Perceived environmental, personality and behavioural factors predicted self-reported drink-driving. Psychosocial risk factor score was successful in predicting drink-driving behaviour or the discontinuation of drink-driving, after adjusting for sex, age and baseline alcohol consumption. Increases in baseline drink-driving psychosocial risk scores were accompanied by heavier involvement in drink-driving at follow-up.

Authors	Year	Theory	Country	Population	*n*	Results
Kontogiannis *et al.*	2002	TRA/TPB SCT	Greece	Adolescent Young adult	1,425	*Outcomes: Aberrant driving behaviour, accident involvement.* Cognitive and attitudinal characteristics in Greek drivers suggest distinctions between errors and violations. Errors could be changed through driver trainings, however violations should be decreased by targeting drivers' attitudes and social norms. Driving experience, gender and highway code violations were the best predictors of accident involvement.
Laapotti *et al.*	2003	TRA/TPB KAP SCT	Finland	Adolescent Young adult	12,149	*Outcomes: Traffic behaviours, attitudes toward traffic regulations.* Compared to drivers in 1978, drivers in a 2001 survey reported lower attitudes toward obeying the law. Specifically, lower attitudes were most likely among male drivers and those driving longer distances. Traffic accidents among respondents in the 2001 survey were associated with greater distance travelled, lower attitudes toward obeying traffic laws, being male, and reporting low driving skill. Furthermore, participants in the 2001 survey had more offences if they had driven longer distances, reported lower attitudes toward obeying laws, were male, and had lower educational attainment. Drink-driving was associated with younger participants, driving longer distances and reporting lower attitudes toward obeying driving laws.
Lagarde *et al.*	2004a	AT TMSC	France	Adult	13,915	*Outcomes: Serious traffic accident risk.* Stressors due to recent divorce/separation were associated with an increased risk of driver-at-fault serious traffic injury.
Lagarde *et al.*	2004b	TRA/TPB	France	Adult	13,852	*Outcomes: Risk-taking driving behaviours, serious road traffic accidents, ticket fixing.* Strong associations were found between ticket fixing and driving at high speeds, driving after drinking too much, and risky use of mobile phone use while driving. Participants with more negative attitudes towards complying with the law were more likely to have had a serious road traffic accident in the past 11 years.

Authors	Year	Theory	Country	Population	*n*	Results
Lalloo *et al.*	2003	AT	England	Child Adolescent	5,913	*Outcomes: Major accidents involving a moving vehicle (e.g. bicycle, motor vehicle).* Hyperactivity was found to be a risk factor for major accidents after controlling for demographic, family and socio-economic factors. Children scoring high for hyperactivity were three times more likely to have had a major accident involving a moving vehicle than other children, again after adjusting for the demographic, family and socio-economic factors.
Lam	2002	SCT HBM	Australia	Young adult Adolescent	414,136	*Outcomes: Car crash injury or fatality.* Distractions from inside the vehicle were found to be a significant contributor to injurious crashes. Relative risks of injurious crashes from inside-vehicle distraction increased as age increased. Drivers in the 25–29-year-old age group had the highest rate of mobile phone-related injurious crashes, while those in the 40–49-year-old age group were least susceptible to any type of distraction.
Legree *et al.*	2003	SDT DMT SCT KAP	USA	Adolescent Young adult	551	*Outcomes: Driver at-fault crash rate.* Participants with less knowledge of safe speed reported greater likelihood of crashes. Emotional distractions (i.e. passenger distraction or experiencing a life event) increased crash likelihood. Furthermore, individuals who can more accurately appraise the level of risk associated with a range of driving hazards are involved in fewer accidents and are less likely to be at fault when in a crash. After adjusting for weather conditions and age, heightened stress was predictive of driver at-fault status. Road condition and passengers disturbing the driver, insufficient sleep the night before and medicine/drug use were predictive of the internal state of the driver.

Authors	Year	Theory	Country	Population	*n*	Results
Mathews and Moran	1986	HBM Social Control Theory	Canada	Young adult	46	*Outcomes: Perception of driving risk, confidence in driving ability.* Young drivers' ratings of accident likelihood were double those of older drivers. They viewed themselves as much less likely than their peers and equally likely as older adults to get into an accident. Older drivers did not have a difference between their own risk and the risk of their peers. Younger drivers rated their driving ability as comparable to older drivers but better than their peers. Older drivers rated their abilities as similar to their own age group but better than younger drivers. Overall, high estimates of ability were correlated with low estimates of risk. Since young drivers view their own abilities as equal to those of older drivers, they perceive their risk as being equal to that of older drivers.
Meadows *et al.*	1998	PBT	UK	Adolescent Young adult Serious offender	100	*Outcomes: Accident involvement, driving violations.* Propensity to commit driving violations and extreme social deviance predicts accident involvement in this sample. However, the relationship between extreme social deviance and accident involvement is partly mediated by a tendency to commit driving violations. Serious driving offenders are found to have higher extreme social deviance scores than those under remand for non-driving related offences.
Miller *et al.*	2004	HBM	New Zealand	Adolescent Young adult Serious offender	Not applic-able	*Outcomes: Serious and fatal injury crashes, cost of implementing compulsory breath tests.* A cost-benefit ratio used to evaluate the effectiveness of a compulsory breath test in New Zealand compares three approaches. Authors conclude that compulsory breath test is dramatically effective but costly. Authors recommend implementation of compulsory breath tests in conjunction with broader community-centred efforts to reduce drink-driving. While community-centred efforts are not obvious, increased law enforcement visibility seems to enhance effectiveness.

Authors	Year	Theory	Country	Population	*n*	Results
Nabi *et al.*	2005	PBT	France	Adolescent Young adult	11,965	*Outcomes: Serious crash involvement, risky driving behaviour.* The study explores the relationship between Type A behaviour, risky driving behaviours, and serious crash involvement. A strong association between Type A behaviour patterns and serious road traffic accident risks is found, even after adjusting for risky driving behaviours. Furthermore, Type A drivers are more likely to engage in risky driving behaviours such as speeding or using a mobile phone while driving at high speeds.
Nelson	1996	TRA/TPB	USA	Adolescent Young adult	50	*Outcomes: Validity of self-reported seat-belt use.* Safety belt use varies between states, with self-reported use ranging from 2% to 5% higher than observed estimated use. Validity of self-reported seat-belt use is lower in southern states and in states with the lowest levels of observed use, suggesting a stronger influence of social desirability in areas where injury prevention behaviour is less prevalent.
Noland	1995	TRC HBM	USA	Young adult Adolescent	506	*Outcomes: Probability of choosing a certain mode of transportation.* Behavioural responses to the perceived risk of specific mode of transportation are explored. Results show that as perceived risk increases for a certain transportation mode, the probability of using the mode decreases. Mass transit and walking are viewed as the safest modes of transportation. Nonetheless, people do not always choose the safest mode, indicating that factors such as time of travel have an impact on choice. Other results reveal that shifts between modal choices have variable effects on commuting traffic fatalities.

Authors	Year	Theory	Country	Population	*n*	Results
Norris	1997	TRA/TPB	USA	Adolescent Young adult	640	*Outcomes: Behavioural attitudes regarding driving safety, perceived behavioural control over driving outcomes.* Attitudes and behaviours relating to driving safety are explored. A fairly strong correlation is found between attitudes and driving behaviours. Drivers report high perceived behavioural control over their safety in surviving a car accident.
Norris *et al.*	2000	PBT	USA	Young adult Adolescent	500	*Outcomes: Car crash rate.* A prospective examination is conducted to measure risk factors for motor vehicle accidents. Results suggest environmental and personal characteristics affect driving behaviours and outcomes. Over 35% of participants experienced a minor accident over the four year study period, while 9% were involved in a serious (injury-producing) accident. Significant predictors of future car accidents include drivers who live in a large city, are of a young age, have high levels of hostility in combination with poor self-esteem, have high job stress, prior accident history, and a general tendency to disregard traffic rules. In addition, seat-belt use is found to be a protective factor in reducing accident severity.
Parada *et al.*	2001	TRA/TPB	USA	Adolescent Young adult	612	*Outcomes: Validity of self-reported seat-belt use.* The validity of self-reported seat-belt use is evaluated among a low belt use population. Overall, 75% report always using seat belts although only 61.5% are observed wearing seat belts. Results suggest that the over-reporting of seat-belt use in low seat-belt use populations may be greater than expected.

Authors	Year	Theory	Country	Population	*n*	Results
Parker *et al.*	1992	SCT TRA/TPB HBM	UK	Adolescent Young adult	881	*Outcomes: Intention to commit driving violations.* The determinants of intention to commit driving violations are explored using the Theory of Planned Behaviour. Participants report negative attitudes towards all four violations (drink-driving, speeding, close-following, dangerous overtaking). Speeding is regarded less negatively than the other three. Corresponding to the negative attitudes, participants report a weak intention to commit the violations. Other results indicate that participants would find it relatively easy to not drink and drive or close-follow, but more difficult to resist speeding and dangerous overtaking behaviours. Analysis of age differences reveal that younger drivers hold significantly stronger beliefs about the consequences of committing violations compared to older drivers. In addition, they do not perceive the consequences to be as negative as do the older drivers. Following that trend, young drivers report the weakest normative beliefs, meaning others have less expectations of them regarding traffic violations compared to older drivers. Another significant difference in age is found with the intention to commit driving violations, with older drivers reporting strong intentions to not commit violations and young drivers finding it difficult to refrain from committing violations. Males view driving violations less negatively than females, and therefore have weaker intentions to avoid committing a violation. Males also report having less behavioural control over driving violations, especially drink-driving behaviour. Driver beliefs regarding specific violations reveal less concern over speeding at night than during the day. However the opposite is true for the other violations when passengers are present, with drivers having more concern about committing violations at night. When participants are compared on accident history, accident-free drivers believe significant others are less likely to expect them to commit the violations than participants with an accident history.

Authors	Year	Theory	Country	Population	*n*	Results
Parker *et al.*	1995	PBT	UK	Adolescent Young adult	1,373	*Outcomes: Accident involvement.* The study examines the link between driving behaviour and involvement in different types of traffic accidents. An association is found between driving violations and accidents in general, including involvement in active and passive accidents. Specifically, drivers that commit violations are more likely to be involved in loss-of-control accidents and passive right-of way violations. The only significant relationship found among driving errors is an association with active accidents. Further results show that driving lapses are not associated with any specific type of accident. Low thoroughness of decision making is associated with active accidents overall, specifically rear-end collisions and right-of-way violations. Although high driving speed is associated with involvement in active accidents and right-of-way violations, researchers are questioned by the lack of association between speeding behaviour and other specific accident types.
Passman *et al.*	2001	HBM	USA	Young adult Adolescent	136	*Outcomes: Post-crash seat-belt use.* The effect of motor vehicle trauma on seat-belt use is explored. Accident trauma appears to have a significant effect, as the number of participants that report always wearing a seat belt increases from a pre-crash level of 50% to 85% afterward. An increase or maintenance of previous use is also reported among nearly all participants in the absence of any additional intervention (e.g. education). The people most likely to increase seat-belt use following crash involvement are participants who report never wearing seat belts before the crash. With relation to injury severity, those in the intermediate category experience the largest increase in frequency of seat-belt use following the crash. While males experience a larger increase in frequency of seat-belt use compared to females, they still have a lower post-crash use rate. Participants report the main reasons for not wearing a seat belt are the taking of short trips, forgetfulness and belt discomfort.

Authors	Year	Theory	Country	Population	*n*	Results
Petridou	1998	TRA/TPB	Greece	Adolescent Young adult	1,400	*Outcomes: Seat-belt use.* The use of seat belts is examined in the Athens metropolitan area. Only 24% of front-seat occupants use seat belts, while rear-seat belts are used by 4% of passengers when the belts are available. Higher seat-belt use is found among older passengers and females. Unfortunately the seat-belt use rate is lower for people travelling at night, noted as a time when the crash rate is higher.
Porter and Berry	2001	TRA/TPB	USA	Young adult Adolescent	880	*Outcomes: Red-light running rate, perceived consequences of running a red light.* The study examines the prevalence, predictors and perceived consequences of red-light running. Nearly 20% of survey respondents report running a red light in the previous 10 signalised intersections. Reasons given for speeding through a red light include wanting to save time or being in a rush. Those who slow down report a concern for safety. As expected, the presence of passengers, especially children, is found to reduce the tendency of running a red light. The only demographic variable that predicts red-light running is age, with young drivers significantly more likely than older drivers to report the behaviour. Frustration does not have the same increase in likelihood of running red lights as in other behaviours, such as weaving, tailgating and speeding. The most common reason for frustration is discourtesy of other drivers. Nearly 99% of drivers believe red light running to be dangerous, but most do not believe people will usually be caught by the police. Red-light runners tend to think it is less of a problem. The most common strategies suggested by respondents to address red-light running are legal initiatives such as stricter enforcement and greater consequences, or more education.

Authors	Year	Theory	Country	Population	*n*	Results
Poysti *et al.*	2005	SCT TRA/TPB	Finland	Young adult Adolescent	834	*Outcomes: Driver mobile phone use, driving hazards experienced while using phone.* Factors contributing to driver mobile-phone use and hazards experienced while using it are explored. Drivers who are young, male and drive more often are the most likely to use a mobile phone while driving. Furthermore, drivers who have high perceived skill level and are less motivated by safety concerns are prone to use a mobile phone while driving. Another contributing factor to driver mobile phone use is occupation type, with managers or executives more likely than small business owners or retirees to use a phone while driving. A similar trend is found with hazardous experiences while using a phone, as executive-like occupations are associated with greater hazard risk. Others at risk for experiencing hazards are younger drivers and those who use a mobile phone more than 15 minutes a day.
Preusser *et al.*	1991	HBM PBT	USA	Adolescent Young adult	4,534	*Outcomes: Seat-belt use, driving behaviour, perception of seat-belt use law and enforcement.* Respondents least likely to use seat-belts are males with less formal education, lower household income and proclivity to taking other health risks. Furthermore, those drivers who are less likely to use a seat belt are most likely to be involved in injury crashes and have more traffic convictions as well as drive older vehicles. Attitudes and beliefs for the less compliant group include the belief that unbelted drivers are not likely to get a ticket. Notwithstanding, drivers from both groups agree that points assessed against drivers' licence for non-compliance with belt laws will improve behaviours regarding belt actions (i.e. get them to buckle up every time). It is noted by authors that changes in penalties will be futile without an associated increase in enforcement.

Authors	Year	Theory	Country	Population	*n*	Results
Preusser *et al.*	1998	PBT DM	USA	Adolescent Young adult	273, 054	*Outcomes: Fatal crash involvement.* The association between passenger presence and teenage fatal crash involvement is examined. The risk of being involved in a fatal crash is much higher for teenage drivers when passengers are present in the vehicle, especially when there are one or more teenage passengers. Along those same lines, adolescent drivers have the highest proportion of fatal crashes with one or more passengers present. Adjusting for miles driven, the fatal crash rate among teenage drivers is three times greater at night than during the day. Passenger presence is found to be a protective factor for at-fault fatal crashes for drivers over the age of 30, while it has the opposite effect for drivers under the age of 24.
Rajalin	1994	HBM	Finland	Adolescent Young adult Serious offender	1,391	*Outcomes: Number of traffic offences, risky driving behaviour.* Traffic data sets are analysed to explore the relationship between risky driving behaviour and fatal accident involvement. Distance driven or age of driver could not explain the significantly higher number of offences committed by both fatal accident drivers and risky drivers compared to drivers in the control group. Other results show that younger age and greater distance driven increases the probability of fatal accidents. Culpable fatal accident drivers have significantly more traffic offences than non-culpable drivers, with both having significantly more offences than drivers in the control group. In contrast to all other groups, the offence rate for those cited for risky driving did not decrease with age.

Authors	Year	Theory	Country	Population	*n*	Results
Rajalin and Summala	1997	HBM Avoidance Learning Models	Finland	Adolescent Young adult	498	*Outcomes: Pre/post crash quality and quantity of driving, perceived effects of accident on driving behaviour.* The effects of being involved in a fatal crash on driving behaviour are examined in the study. Nearly half of the participants involved in car crashes report decreasing their amount of driving after the accident. Higher crash severity is associated with a greater decrease in the amount of driving after the crash. A slight increase in traffic offences is found among car drivers, while a decrease is found among heavy-vehicle drivers in proportion with mileage driven after the crash. Most drivers report the effects of the accident on general safe driving behaviour to be short lived, with the exception of a higher awareness of situations closely related to the crash. While many car drivers return to their normal driving style, heavy-vehicle drivers report a more permanent change in driving behaviour as a result of the collision.
Redelmeier and Tibshirani	1997	SCT	Canada	Young adult Adolescent	699	*Outcomes: Crash rate* The association between driver mobile phone use and motor vehicle collisions is examined. Results show the risk of a collision when using a mobile phone is four times higher than the risk when a mobile phone is not being used. Younger drivers are at a somewhat higher relative risk when using a mobile phone than older drivers, although this trend is not significant. Subjects with many years of experience in using a mobile phone still have a significant increase in risk. The highest relative risk is found among subjects who have not graduated from high school. Telephones that allow the hands to be free did not appear to be safer than hand-held phones. The increase in risk appears to be greatest for calls made near the time of the collision. About 39% of the subjects used their phone at least once to contact emergency services immediately after the collision.

Authors	Year	Theory	Country	Population	*n*	Results
Ritzel *et al.*	2001b	TRA/TPB	USA	Adolescent	634	*Outcomes: Alcohol use, perception of peer alcohol use, subjective norm of alcohol use, drink-driving behaviour.* The study examines alcohol and drink-driving behaviours and attitudes of high school juniors and seniors. Half of the students sampled did not participate in binge drinking. Less than 73% believe that the average high school student drinks once a week or less, although 72% believe that college students drink more than three times a week. Subjective norm varies according to the amount of drinking: 53% of participants report peers would not care if they consume one or two drinks and 43% felt this is true if they binge drank once. Over 75% of the participants believe that binge drinking held moderate or great risk for driving whereas 72% felt that the consumption of two or less drinks creates slight or no risk for driving.
Rivara *et al.*	1998	TRA/TPB DMT	USA	Adolescent	313	*Outcomes: Parental attitudes regarding choosing a vehicle for their teenager.* Ranked factors influencing parents' decision to purchase a vehicle for their teenager are insurance cost, price, repair record, gas mileage, anti-lock brakes, airbags, other safety features, and size of vehicle. Over two-thirds of parents state their teenager would drive an existing family vehicle, while nearly 30% plan to purchase another vehicle. Respondents value less important safety features involved in crash fatalities, such as anti-lock brakes, compared to size and weight, according to the literature. Authors suggest informing parents about vehicle-crash worthiness through driver education programmes.
Roeper and Voas	1998	PBT	USA	Adolescent Young adult Serious offender	>30,000	*Outcomes: Drink-driving behaviour, injury crash rate, alcohol use.* The ability of roadside surveys to evaluate drink-driving interventions designed to reduce alcohol-related crashes is examined in the study. Differing estimates are found for roadside surveys as a measure of alcohol consumption by drivers and prevalence of crashes as represented by night-time and weekend motor vehicle injury crashes. Roadside surveys are offered as an efficient means of evaluating drinking and driving intervention effectiveness in relation to temporal variation in injury crash levels and amount of alcohol consumption. This is particularly true if the survey data collects BAC data directly or through self-reported means.

Authors	Year	Theory	Country	Population	*n*	Results
Rothe and Elgert	2003	AT SDT TRA/TPB	Canada	Adolescent Young adult	82	*Outcomes: Driver attitudes and beliefs regarding driving, traffic safety and law enforcement, perceived driving behavioural control.* The focus group study explores driver attitudes and beliefs that may contribute to driving outcomes. Over half of participants focused on determinism as an important determinant of driving outcomes. Three versions emerged: religious, humanistic and universal. Many participants believe that traffic situations are out of drivers' control.
Rothe and Elgert	2005	TRA/TPB SCT HBM RHT SS DT	Canada	Adolescent Young adult	212	*Outcomes: Driver attitudes and beliefs regarding driving, traffic safety laws and enforcement.* A focus group study is conducted to examine rural driving behaviour. Authors note three main thematic categories for the beliefs, attitudes, and perceived barriers and benefits to driving. These are summarised by three categories: traffic laws, priorities, safety, and law, and law enforcement. Rural drivers do not necessarily associate traffic laws with safety, and they see enforcement as a form of control or punishment. Therefore priorities and time commitments can be justification for violating traffic laws.
Rueda-Domingo *et al.*	2004	SCT	Spain	Adolescent Young adult	307,742	*Outcomes: Crash rate.* Researchers examined the influence of passenger presence on the risk of collision. Results suggest that drivers are less likely to cause car collisions that result in personal injuries or death when they are accompanied by passengers, regardless of driver or passenger characteristics. Nonetheless, certain situations increase the protective effect against collisions. The strongest protective effect is exerted by female passengers on male drivers. The protective effect is higher for drivers aged more than 45 years and lower for drivers younger than age 24. For passengers aged 4–15, a protective effect is observed only when the driver is male and younger than 55 years old. For passengers aged 16–24, male passengers show a protective effect on both male and female drivers aged more than 35 years.

Authors	Year	Theory	Country	Population	*n*	Results
Sabel *et al.*	2004	HBM TRA/TPB PBT	USA	Adolescent	2,955	*Outcomes: Drink-driving behaviour.* The association between adolescent drink-driving behaviour and self-reported risk and protective factors is examined in the study. Students over 16 years old are more than twice as likely to report driving after drinking and one-third less likely to report riding with a drinking driver, compared with younger students. Males are more likely than females to report driving after drinking. Support from parents, schools and communities are each associated with a reduced likelihood of driving after drinking. In addition, greater quantity and frequency of drinking, lack of seat-belt use, cigarette smoking and illegal drug use are all associated with driving after drinking and riding with a drinking driver.
Salzberg and Moffat	2004	COrg	USA	Child Adolescent Young adult	402	*Outcomes: Seat-belt use rate, crash fatalities.* Washington state promotes seat-belt use with a series of legislations and community programmes (primary enforcement seat-belt law enacted, safety belt enforcement is made a core mission of police enforcement, and participated in the national Memorial Day Click It or Ticket programme). Following these events, there is a dramatic increase in seat-belt use across Washington state starting in 2001. Seat-belt use peaked at 95% in 2003. Motor vehicle fatalities decreased by 13% during the same timeframe.
Sarkar and Andreas	2004	HBM TRA/TPB SCT PBT	USA	Adolescent	2,710	*Outcomes: Engagement and exposure to risky driving behaviour.* Adolescent participants report driving while drunk (17%), drag racing (20.9%), driving recklessly (27.2%) and taking illegal drugs while driving (17.8%). Males report greater driving ability and significantly less perceived danger of risky driving behaviours than females. Those who are in a vehicle with a drunk driver are more likely to have been exposed to drag racing, reckless driving and riding with a driver under the influence of drugs. Participants who report exposure to drunk driving also have a significantly higher level of exposure to what they consider speeding than did those who did not report such exposure. These participants are also less likely to rate drink-driving as a risky behaviour than did those who have not been exposed to it.

Authors	Year	Theory	Country	Population	*n*	Results
Schootman *et al.*	1993	TRA/TPB SS PBT HBM SCT	USA	Adolescent Child	2,250	*Outcomes: Seat-belt usage, helmet usage, drink and drug driving behaviour.* The study examines demographic variables in relation to safety behaviours among teenagers. Students report higher seat-belt use in the front seat, while females are more likely than males to wear a belt in the back seat. Females are also more likely than males to wear moped helmets. Front seat-belt use is significantly less among students in rural versus urban schools. Both seat-belt and helmet use decrease dramatically with age, while drink and drug driving behaviour increase with age. Even after controlling for age, an association between possession of a driver's licence and safety behaviours is not found.
Sellstrom *et al.*	2000	HBM AT	Sweden	Child Young adult	870	*Outcomes: Perceived risk of child injury.* Predictors of maternal risk perception of child injury are examined in the study. Maternal risk perception is associated to causal attribution. The more she attributes risk to the child, the more she perceives risk of injury to the child. Other factors that predict risk perception in select models having less significance include perceived benefits, perceived barriers, attribution to chance, parents, and environment norms of the father, and age, education and birth order.
Seo and Torabi	2004	HBM SCT TRA/TPB	USA	Young adult Adolescent	1,185	*Outcomes: Near and actual crash rate.* The study examines the nature of driver mobile phone use among college students and the impact on both near-crash and actual crash rates. Female students are more likely than male students to use a mobile phone while driving. Sixty-four per cent of drivers report experiencing accidents or near accidents; 21% of those report that the accidents or near-accidents involve at least one driver using a mobile phone. While 74% report that driver mobile phone use increases the risk of an accident, only 6% of respondents are in favour of banning all types of mobile phone use while driving. Attitudes against talking while driving by students who seldom or never did it increase as years of driving experience increase. Attitudes among all other respondents are moderate to moderately high when they have less than one year of driving experience.

Authors	Year	Theory	Country	Population	*n*	Results
Simpson *et al.*	2002	HBM TTM TRA/TPB	USA	Child Young adult	111	*Outcomes: Seat belt and booster seat use.* Parents who use seat belts to restrain their children perceive less risk of child-related injury, are less aware of child passenger safety issues, and are less proactive in seeking child passenger safety information compared with parents who use booster seats to restrain their children. Whereas negotiability is not an option among parents who use booster seats, it is an alternative among parents who use seat belts for their children. Parents of children using booster seats demonstrate a greater overall awareness of the issues in child passenger safety, child passenger safety laws, best practices for child restraint, and the risks associated with the premature use of seat belts. Barriers to booster seat use include: lack of knowledge, gaps in child passenger safety and seat belt laws, situational influences (e.g. extra passengers in vehicle, lack of availability of the booster seat), attitudes about booster seat (e.g. difficulty installing and using, uncomfortable), child behaviour (resistance), inconvenience and cost.
Sivak *et al.*	1989a	HBM	USA, Germany, Brazil, Spain	Young adult	320	*Outcomes: Risk perception.* Young, middle-aged and older people from the US, Germany, Brazil and Spain viewed traffic scenes and assessed the risk. Subjects from the US had the lowest risk ratings, and those from Spain had the highest. The younger drivers in all countries had lower risk ratings than middle-aged or older drivers.
Sivak *et al.*	1989b	SCT HBM	USA, Germany, Spain	Young adult	180	*Outcomes: Probability of attempt, probability of success, minimum clearance (all with regard to intersection crossings).* Young, middle-aged and older subjects from three countries participated in a computer-simulated activity involving intersection crossings in order to assess their risk-taking behaviour. Drivers in the US, the youngest drivers and male drivers attempted the most crossings in the allotted time period. Germans had the highest probability of success, but there was no significant effect for age or sex for probability of success. US drivers and males had the smallest minimum clearance; there was no age effect for this category.

Authors	Year	Theory	Country	Population	*n*	Results
Smart and Stoduto	1997	TRA/TPB SCT PBT	Canada	Young adult Adolescent	1,184	*Outcomes: Substance abuse and drink-driving intervening behaviour.* The study analyses the frequency and propensity of drug and alcohol intervening behaviour between adolescents. About a third of students report intervening in illegal drug use, drinking, and drinking and driving. Half of students report intervening on smoking. Interveners are more likely to be older, spend fewer nights at home and more nights working, less likely to use cannabis but have more friends who use cannabis or illegal drugs, more exposure to school drug education, and more disapproving attitudes regarding drug use. No association between intervening and self-esteem or grades in school is found.
Snow and Wells-Parker	2001	PBT	USA	Serious offender	778	*Outcomes: Drinking behaviour, drinking location.* Authors evaluate relationships between substance abuse diagnoses, driving convictions and risk-taking dispositions among injured drivers in trauma centres. Findings point to differences between drinking frequency and quantity and locations. Drivers with severe alcohol problems are more likely to drink in a moving vehicle than are those with less severe drinking problems. Furthermore, results suggest people with severe drinking problems are more likely to drink in multiple locations and be at increased risk for a motor vehicle crash.
Steenbergen *et al.*	2001	TRA/TPB	USA	Adolescent	840	*Outcomes: Perceptions of graduated licensing programme.* Kentucky's graduated driving licensing (GDL) programme is evaluated. Many participants are unaware of important GDL provisions, especially the night-time driving restriction. Driver education instructors and teenage drivers report that young drivers are not getting enough driving experience before obtaining their licence. Other issues with the GDL programme stated by participants include difficulties with provision enforcement and the penalties of traffic violations being an ineffective deterrent.

Authors	Year	Theory	Country	Population	*n*	Results
Stevenson and Palamara	2001a	TRA/TPB SS	Australia	Adolescent	1,796	*Outcomes: Crash rate, time until first crash.* Driving behaviours and crash rates of rural and urban youth drivers are examined in the study. The crash rate for urban drivers is slightly higher than the rate for rural drivers. Other results reveal no significant difference in the time to first crash between urban and rural drivers in the first year of driving. Risk taking and frequency of driving before obtaining a learner's permit are significantly associated with a crash in the first 12 months of driving.
Stevenson *et al.*	2001b	HBM TRA/TPB SCT SS	Australia	Adolescent	1,277	*Outcomes: Crash rate, time until first crash.* Incidence of motor vehicle crashes along with the effect of driver and behavioural factors is examined. Drivers who report driving weekly or daily prior to receiving their learning driving plates are at greater risk for a crash in the first 12 months after licensure when compared to those who never drove prior to their licensure. Highly overconfident drivers are twice as likely to have a crash in the first year when compared to low and moderately confident drivers.
Stiles and Grieshop	1999	HBM	USA	Young adult Adolescent	126	*Outcomes: Driving history, perceived driving skill, seat-belt use, child car-seat use, traffic law knowledge.* The driving behaviours and traffic law knowledge of Hispanic migrant workers are examined in the study. Many participants report learning to drive between the ages of 8–14 (20% of the sample). Initial driving age is influenced by where one learned to drive (USA or Mexico). Those between ages 8 and 17 are more likely to have a valid licence than unlicensed drivers who began at the age of 18 or over. Possessing a licence is associated with better driving skills and knowledge. Violators are predominantly licensed in Mexico.

Authors	Year	Theory	Country	Population	*n*	Results
Sümer	2003	SS PBT	Turkey	Young adult	295	*Outcomes: Number of accidents, aberrant driving behaviour, alcohol use.* Personality and behavioural predictors of traffic accidents are explored using a contextual model. Results show personality factors indirectly predict accident involvement through mediation of risky driving behaviour. Psychological symptoms predict aberrant driving behaviour, which in turn are a strong predictor of accident involvement. Other results illustrate that attitudes and beliefs regarding drink driving are a stronger predictor of the behaviour than the amount of alcohol use.
Svenson	1981	Social Control Theory	USA, Sweden	Young adult	161	*Outcomes: Self-rated skill and safety compared to other drivers.* Eighty-eight per cent of the US group and 77% of the Swedish group believed themselves to be safer than the median driver. Ninety-three per cent of the US group and 69% of the Swedish group believed themselves to be more skilful than the average driver.
Taylor and Deane	1999	Theory of Fear SCT HBM	New Zealand	Adolescent Young adult	190	*Outcomes: Driver fear severity, acquisition of driving related fears.* The fear acquisition pathways for a community sample who report driving-related fears are described and Rachman's theory of fear acquisition is tested. Rachman's hypothesis that direct conditioning pathways would lead to more severe fear than indirect and the hypothesis that respondents would have higher levels of physiological than cognitive anxiety correlates for directly-conditioned fears are both unsupported. However, consistent with the third hypothesis, significantly higher proportions of respondents who have been involved in a motor vehicle accident ascribe their fear to the direct pathway compared to those who have not been involved in a motor vehicle accident.

Authors	Year	Theory	Country	Population	*n*	Results
Taylor *et al.*	2000a	HBM	New Zealand	Adolescent Young adult	190	*Outcomes: Driving related fear and anxiety.* The characteristics of driving fears are analysed among participants who have been in a motor vehicle accident and those who have not. Fear severity did not significantly differ between the accident victims and those from the media-recruited control group. There are high levels of driving anxiety among the control group, suggesting the fearful driving population to be broader than originally expected. Participants report high levels of anxiety when driving with someone who criticised their driving and when driving alone.
Taylor and Deane	2000b	SCT	New Zealand	Adolescent Young adult	85	*Outcomes: Driving related fear.* The study examines the characteristics of fearful drivers and whether a difference exists between participants who have been in a crash and those who have not. Results show that both groups rank fear of accident, loss of control of the car and injury as the highest concerns. However, there is no significant difference in fear severity between the groups. Distinct categories of fear are experienced by the participants, one characterised by danger expectancies and the other based on anxiety expectancies and unpleasant driving situations. Although anxiety expectancy is common in both groups, fearful drivers are more concerned about being involved in a crash.
Taylor *et al.*	2002	RHT	Australia	Adolescent Young adult	17,023	*Outcomes: Driver mobile phone use.* An observational study is conducted to determine the amount of driver mobile phone use in Melbourne. During 36 hours of observation, 315 of 17,023 drivers screened (~2%) are observed using mobile phones. There is no difference in driver phone use between young and middle-aged drivers, or between males and females. However, the rate among older drivers is significantly less than other age groups. Mobile phone use is significantly greater for drivers in the evening, while no difference is found in the rates between the morning and afternoon.

Authors	Year	Theory	Country	Population	*n*	Results
Turner and McClure	2003	PBT SS HBM	Australia	Adolescent Young adult Serious offender	977	*Outcomes: Crash risk.* Males are twice as likely to have reported at least one crash as a driver compared to females, and nearly three times as likely to have reported two or more crashes. Drivers aged 17–29 are also twice as likely to have reported at least one crash when compared to those aged over 50 years. Inclusion of risk-taking behaviours suggests males or 17–29-year-olds are more likely to being involved in at least one crash. Authors conclude that an increased risk of a crash as a driver can, in part, be explained by the age and gender differential in risk-taking behaviour.
Turner and McClure	2004	PBT SS HBM	Australia	Adolescent Young adult	977	*Outcomes: Serious crash rate.* The study examines the causal relationship between risk-taking behaviour and serious road-crash related injury. Participants in the case group are younger (more in the 17–24 age group), have less educational attainment, lower occupational status, and are more likely to have never been married than those in the control group. Results show that high-risk acceptance is associated with an eight-fold increased risk of having a crash that resulted in serious injury after adjusting for demographics, number of years driving and total distance driven per week. Unlike risk acceptance, thrill seeking behaviour is not associated with being involved in a crash resulting in serious injury.
Ulleberg and Rundmo	2002	Cognitive Dissonance Theory TRA/TPB HBM	Norway	Adolescent Young adult	3,942	*Outcomes: Risk-taking driving behaviour.* The psychometric qualities of a scale intended to measure adolescents' risk-taking attitudes to driving (safe driving, speeding, riding with an unsafe driver, concern for others, violating rules of traffic in general, accident causation, and risk of traffic accidents) are evaluated. Attitude dimensions are significant in predicting self-reported risk behaviour, explaining 50% of the variance in self-reported risk behaviour. Authors suggest that accident frequency is likely to be an inappropriate outcome measure to use with specific measures of attitudes for measuring the attitude-behaviour relationship.

Authors	Year	Theory	Country	Population	*n*	Results
Vingilis *et al.*	1994	TRA/TPB PBT SS	Canada	Young adult Serious offender	106	*Outcomes: Alcohol use, drink driving behaviour, perceived driving skill, driving attitudes* In the study alcohol-positive and alcohol-negative drivers that are seriously injured in a crash are compared on demographics, personality characteristics, driving-related attitudes, prior driving history, lifestyle, substance use, and antecedent driver condition. No driving-related attitude differences are found between the two groups. The most consistently significant difference between groups involved alcohol related variables. The alcohol-positive drivers report more frequent alcohol use and drink driving before the crash in addition to a greater perceived alcohol problem. An examination of driving histories reveals the alcohol-positive group to have significantly fewer graduates of driving schools and more license suspensions compared to the alcohol-negative group.
Vingilis *et al.*	1996	PBT SCT SS	Canada	Young adult Serious offender	149	*Outcomes: Drink-driving behaviour after crash, crash recidivism.* Motor vehicle trauma victims are surveyed in the study to determine the consequences and behaviours following a crash. Results show prior serious injury in a crash did not prevent future drink-driving behaviour. The trauma victims faced re-crash risk in addition to psychosocial problems as a result of the crash. Over one-quarter of the victims report post-traumatic stress symptoms, fear of driving, and fear of cars.
Voas *et al.*	2000	SCT DT	USA	Young adult Serious offender	912,954	*Outcomes: Alcohol-related fatal crash rate.* The study examines the relationship between the passage of alcohol safety legislation and the number of alcohol-related fatal crashes. To do that, the implementation of key alcohol safety laws (administrative licence revocation laws, 0.10 illegal per se laws and 0.08 illegal per se laws) is evaluated. Results reveal that the passage of each law is followed by a decrease in the number of alcohol-related fatal crashes.

Authors	Year	Theory	Country	Population	*n*	Results
Vollrath *et al.*	2002	RHT	Germany	Young adult Adolescent	112,847	*Outcomes: Crash rate, passenger presence, crash characteristics.* The influence of passengers on risk of collision is examined in this study. Results show that passengers exert a protective effect on driving and decrease accident risk. However, this protective effect is reduced in young drivers, and when drivers are presented with more difficult driving tasks, such as driving at night, passing other vehicles or managing intersections. The positive effect is also reduced in slow traffic and when the driver disregards the right of way.
Wagner	2001	SS	USA	Young adult Adolescent	155	*Outcomes: High-risk behaviour.* The study examines the relationship between risk-taking behaviour, substance abuse, sensation seeking, anxiety sensitivity and self-reinforcement. Results reveal that a significant relationship exists between sensation seeking and risk-taking behaviour, including substance abuse, risky sexual behaviour, reckless driving, and theft and vandalism. Anxiety sensitivity is also found to be a significant predictor of substance abuse. Those most likely to engage in reckless driving are participants highest in sensation seeking, with male incidence being greater than for females.
Walton and Bathurst	1998	Social Control Theory	New Zealand	Adolescent Young adult	86	*Outcomes: Perceived driving speed, perceived driving skill, perceived driver safety.* The relationship between the perception of the average driver's speed and perceived driving safety and skill is examined through the Downward Comparison Theory. The findings support this theoretical approach. Driving speeds related to self-enhancement of safety are due to perceptions that others are more dangerous rather than the driver's perceptions of their own speed. Respondents claiming to be safer than the average driver regarded the average driver as driving at exaggerated speeds when compared to those who claimed not to be as safe as the average. Those who claimed to be less safe than average have a more realistic, though still exaggerated, estimate of average driver's speed.

Authors	Year	Theory	Country	Population	*n*	Results
Walton and McKeown	2001	TRA/TPB HBM Social Control Theory	New Zealand	Adolescent Young adult	113	*Outcomes: Perceived driving speed, perceived advertising audience.* The study examines the differences between perceived and actual driving speed of individuals and other drivers. In addition, the ability of public safety messages regarding speeding to reach a target audience is explored. Results show that drivers tend to exaggerate the perceived speed of others. Drivers with a perceived speed bias relative to others are more likely to ignore public safety messages encouraging people not to speed.
Weiss	1996	HBM PAPM	Israel	Adolescent	2,408	*Outcomes: Perceived threat of drink-driving, perceived legality of alcohol use.* The study examines differences in the drinking and driving knowledge of Israeli Jews and Arabs. Five areas in the 'drinking and driving' domain – legal blood alcohol concentration (BAC) limit, minimal number of drinks prohibited by the law before driving, common myths, main effects of alcohol on driving ability and youth vulnerability – are explored. Differences between the Jewish group and the Arab group indicated Jews received the highest score and Moslems the lowest. Possession of a driver's licence or the location of the group in Israel did not have an effect on drinking and driving knowledge. All groups have minimal knowledge of the BAC limit and youth vulnerability to alcohol-related behaviour. Arabs have a greater awareness of youth vulnerability than Jews; however they tended to hold on to common myths regarding alcohol use. Jews have a better understanding of the minimum amount of drinks allowed before becoming legally drunk as well as the main effects of alcohol on driving skills.
Wells-Parker *et al.*	2002	SCT	USA	Adolescent Young adult	1,382	*Outcomes: Crash rate, number of traffic citations received, hazardous driving behaviour.* The study examined the relationship between road rage behaviours and crash experience. Results reveal angry or threatening driving is associated with a higher crash rate in addition to habitual speeding, drunk driving and increased traffic violations. On the other hand, verbal frustration behaviours are not associated with crash involvement, but only to the number of traffic citations received.

Authors	Year	Theory	Country	Population	*n*	Results
Williams	2003	TRA/TPB	USA	Adolescent Young adult	909	*Outcomes: Perceived driving skill, crash avoidance behaviours, motivation for safe driving behaviour, driving hazard perception.* In the survey most drivers perceived their skills as being better than average. Concern for the safety of others in the vehicle is the greatest motivating factor for safe driving behaviour. Other factors include perceived threat of a crash, and increased costs from insurance or fines. Participants believed the greatest threat to their safety was behaviour of other drivers that increased crash risk, such as alcohol impairment or running red lights. Driving defensively or using a seat belt are also important crash avoidance behaviours utilised by safe drivers. Little attention is given to the role of vehicles and vehicle features in crash or injury prevention.
Wittenberg *et al.*	2001	HBM TRA/TPB	USA	Child	28,688	*Outcomes: Passenger seating.* Factors associated with the seating of children in the front seats of vehicles involved in fatal crashes between 1990 and 1998 are evaluated in the study. The proportion of children sitting in the front seat declined from 42% at the start of 1990 to 31% by the end of 1998. The decline is especially true for vehicles carrying only children under the age of six and vehicles with dual air bags. Children most at risk for being placed in the front seat are those travelling alone with the driver. The risk of a child being placed in the front seat is dramatically reduced by the presence of a teenage or adult passenger.
Yanovitzky	2002	HBM Corg	USA	Adolescent Young adult	15,914	*Outcomes: Drink-driving rate.* The study examined mass media information's role on stimulating drink-driving behaviour change indirectly through the policy process. A negligible association between drink-driving related news coverage and decline in behaviour over time is found. News coverage increased the likelihood of individual exposure to health messages and influenced behaviour indirectly by facilitating processes of social and cultural transformation.

Authors	Year	Theory	Country	Population	*n*	Results
Banks *et al.*	2004	SCT HBM TRA/TPB	Australia	Adolescent Young adult	20	*Outcomes: Perceived driving performance, intention to stop driving to avoid accident, microsleeps, braking reaction time, steering deviation, speed variability.* This study examined effects of sleep deprivation alone and in combination with low alcohol consumption (legal BAC levels). Participants substantially underestimated their driving impairment and crash risk in both states. For crash risk, men were less likely to accurately assess crash risk than women when sleep deprived, but the gender effect disappeared when alcohol intake was added.
Barrett *et al.*	2004	HBM TRA/TPB SCT	UK	Young adult	12	*Outcomes: Driving impairment (lane drifting), reported sleepiness, electroencephalographic measures or sleepiness, perceptions of driving performance, reported intention to drive.* Compared to a previous study with men, low, legal BAC levels alone did not impair women's simulated driving performance. Sleepiness and low levels of alcohol consumption combined worsened driving performance among men and women. Nonetheless, women had higher awareness of driving risks from sleepiness (with and without alcohol) across all study conditions.
Ben-Ari *et al.*	2000	Terror Management Theory HBM TRA/TPB	Israel	Young adult	109	*Outcomes: Self-reported intentions to drive recklessly, speed driven in simulator.* This study focused on the effect of threat appeal messages on self-reported intentions to drive recklessly and driving speed in simulator. Contradictory results were found. Threat appeals (film depicted graphic consequences of automobile crash) led to fewer self-reported intentions to drive recklessly, but higher driving speeds in the driving simulator. The threat appeal only had a significant effect on those who reported their driving behaviour to be highly associated with their self-esteem.

Authors	Year	Theory	Country	Population	*n*	Results
Ben-Yaacov *et al.*	2002	SCT	Israel	Young adult	30	*Outcomes: Percentage of time spent in safe or dangerous temporal headway zones, driver speed-related reactions to warnings.* This study examined the change in temporal headway maintenance of drivers with in-vehicle collision avoidance warning systems (IVCAWS). Results showed that drivers do not accurately judge temporal headway. Use of the warning system helped drivers assess appropriate headway during the experiment and six-months later. Furthermore, even when the warning system was manipulated to 'misfire' (i.e. did not beep when it should have or beeped when it should not have), drivers still improved their headway behaviour.
Boyce and Geller	2002	PBT SS	USA	Adolescent Young adult	61	
Carstensen	2002	SCT HBM TRA/TPB	Denmark	Young adult	1	*Outcomes: Number of accidents, accident type, drink-driving, reported driving skill, attitudes.* This study evaluated changes in the Denmark driver education programme through the administration of surveys over a 5.5 year follow-up period. Decreased risk for accidents were found for younger, less experienced and female drivers after changes in the driver education programme. Effects were strongest in the first 18 months of driving, greater adherence to the new driving curriculum, and for non-drink driver participants. Changes in accident risk were mostly due to a decrease in multiple vehicle accidents.

Authors	Year	Theory	Country	Population	*n*	Results
Chaudhary *et al.*	2004b	HBM DT	USA	Young adult Adolescent	26,063	*Outcomes: Frequency of seat-belt use, perceived likelihood of getting a ticket for not wearing seat belt.* This study examined the relationship between perceived risk of getting a ticket (PRT) and seat-belt use. A media and law enforcement campaign was evaluated before, during and after implementation. PRT was found to be higher among those who report consistent seat-belt use than those who do not. Further, PRT and belt use increased after campaign enforcement for all participants, especially for those living in high income, low income and urban areas. Perceived risk did not increase in rural areas. The effect of PRT on seat-belt use was stronger among men, younger individuals had lower PRTs than other age groups, and as age increased so did PRT.
Chen *et al.*	2000	DT HBM TRA/TPB	Canada	Young adult Adolescent	30	*Outcomes: Speed at photo radar deployment sites, number of traffic collisions, injuries and fatalities.* This study evaluated the effect of the implementation of a photo radar programme in which 30 radar cameras were installed at selected traffic sites and was accompanied by a media public education campaign. The cameras in high accident areas were found to substantially decrease driver speed, daytime collisions and ambulance use, while a small generalised effect on traffic speed in non-deployment areas was also observed.
Cooper and Zheng	2002	HBM SCT DMT	Canada	Young adult Adolescent	39	*Outcomes: Accepted between-vehicle gap sizes for turning, estimated oncoming vehicle speed.* This experiment studied the effect of audio distraction on left-turn decision making by measuring perceived acceptable gap size between vehicles, speed of trailing through-vehicle, time taken between decisions, pavement surface condition (wet or dry), and participant age in both distraction and non-distraction conditions. Pavement surface condition was taken into account by drivers only when making decisions in the non-distraction condition. Collision risk was greater in the distraction condition than the non-distraction condition. Furthermore, risk of collision increases in wet pavement conditions and with distraction for all ages, but the increase is notably higher for middle and older age-groups (25–44, 45–70) than for younger age-groups (19–24).

Authors	Year	Theory	Country	Population	*n*	Results
Deery and Love	1996	SCT HBM TRA/TPB	Australia	Young adult Serious offender Adolescent	32	*Outcomes: Hazard perception (response time, level of risk perceived, duration of perceived hazard).* This study examined the effect of a moderate dose of alcohol (0.05% BAC) on traffic hazard perception among DWI offenders, impaired drivers, moderate drink-drivers, and non-drink drivers. Alcohol had an effect on hazard perception and interacted with drink-driving practices. After alcohol consumption, all participants were slower to detect hazards and reacted to them more abruptly. All subjects also perceived less risk in active hazards (those caused by the driver) than in passive hazards (those caused by others). Effects were stronger for DWI offenders, regardless of whether alcohol was consumed, suggesting a difference in driving style. After removing the effect of age, neither hazard was predictive of drink-driving frequency.
Deffenbacher *et al.*	2003	State-Trait Anger Theory TTM PAPM HBM	USA	Adolescent Young adult	153	*Outcomes: Self-perceptions as angry or aggressive drivers, frequency and intensity of anger, aggressive behaviour, risky behaviour, crashes and crash-related outcomes.* This study surveyed high anger drivers who both did and did not believe their driving anger was problematic, as well as low-anger drivers. Drivers scoring high anger scores reported greater frequency and intensity of driving while angry, were more likely to be aggressive, less likely to manage anger in a constructive fashion, reported greater risky driving and experienced more crashes than low anger drivers. High anger drivers who acknowledged or did not acknowledge anger as a problem exhibited similar behaviour, reporting more trait anger and anxiety, but may require different intervention strategies.
Deyoung	1999	SCT HBM	USA	Serious offender	12,724	*Outcomes: DWS/DWU convictions (recidivism), traffic convictions and crashes.* This study examined the effect of a California impoundment law on the driving behaviour of violators of those driving while suspended (DWS) or driving while unlicensed (DWU). Participants in the car-impounded group had lower rates of subsequent DWS and DWU, other traffic convictions and crashes. The decrease in subsequent conviction rates for DWS/DWU and crashes was even greater for repeat offenders than one-time offenders after vehicle impoundment.

Authors	Year	Theory	Country	Population	*n*	Results
Dukic *et al.*	2005	SCT HBM	Sweden	Young adult	8	*Outcomes: Visual time off road, steering wheel deviations, perceived safety of buttons.* This study focused on the effect of vehicle button location and auditory feedback on visual time off the road, steering deviation and perceptions of safety. Generally, as the visual angle between button location and normal line of sight increases, visual time off road increased, yet this did not hold true for the button near the gear shift. Vertically arrayed buttons took more visual time from the road. No significant effect on visual time on the road was found for auditory feedback or for button location or auditory feedback on steering wheel deviation. Authors found a difference in perceived safety by button location, but no clear pattern could be discerned.
Fairclough *et al.*	1997	TRA/TPB SCT HBM	UK	Young adult Adolescent	16	*Outcomes: Headway maintenance, speed maintenance and driver mental workload.* This study examined the effect of the presence of continuous visual and auditory headway feedback on headway distance and following behaviour. The in-vehicle headway system decreased the time subjects spent at low headways (less than 1 second). The effect was greatest among subjects who tended to drive with shorter headways and in situations where drivers followed another vehicle at a constant speed. System effects on headway length were significant for overtaking manoeuvres during off-peak traffic, but not during peak hours. Speed maintenance and driver mental workload were not affected.
Floerchinger-Franks *et al.*	2000	HBM COrg	USA	Child	2,683	*Outcomes: Child seat-belt use, children sitting in rear vehicle seats and child bicycle helmet use.* This study focused on the effects of a health district sponsored contest for elementary schools to develop programmes to improve safety in seat-belt use, rear seating in vehicles and bicycle helmet use among children. There was an increase in seat-belt use and bicycle helmet use among children attending schools that participated in the contest compared with children attending schools that did not participate. Motor vehicle rear seating was not significantly affected.

Authors	Year	Theory	Country	Population	*n*	Results
Fockler *et al.*	1998	SCT HBM TRA/TPB	Canada	Adolescent Young adult	1,974	*Outcomes: Vertical position of head restraint in relation to driver head.* This study examined three modes of education delivery on correcting vehicle head restraint position: in-person instruction, video and a three-dimensional kinetic model. The face-to-face intervention group showed an increase in immediate correct vehicle head-restraint adjustment compared to the control group, while neither the kinetic model group nor video intervention groups made a significant difference. Drivers in vans and pickup trucks were twice as likely to perform correct adjustments compared to drivers in cars. Content and method of attracting attention to different intervention types may have an impact on effectiveness. Attention to the educational intervention varied by gender and age. Drivers over age 50 were less likely to notice the intervention than those in younger groups.
Frick *et al.*	2000	HBM TRA/TPB SCT DMT	Germany	Young adult Adolscent	104	*Outcomes: Perceived traffic accident risk, self-judged driving cognitive performance, decision to drive.* This study focused on the effect of low BAC levels on perceptions of driving risk, cognitive functioning and decision to drive. Drivers with moderate (0.015 BAC) performed better than those who consumed no alcohol and those with a higher BAC of 0.03, and drivers who consumed no alcohol had the worst scores. Receiving negative feedback had a stronger negative effect on perceived cognitive performance than positive feedback, especially for females. Overall, males committed fewer errors than females in the simulated driving risk perception exercise. No significant relationship or interactions were found between intention to drive and alcohol consumption, feedback and gender.

Authors	Year	Theory	Country	Population	*n*	Results
Galovski and Blanchard	2002	CBT PBT SCT TRA/TPB	USA	Serious offender Young adult Adolescent	27	*Outcomes: Aggressive driving symptoms, general psychological distress, trait anger, trait anxiety, and global change in driving behaviour, mood, tension, health and anger.* This study recruited self-referred and court-referred aggressive drivers to test the effects of cognitive behaviour therapy (CBT) intervention on self-reported aggressive driving. CBT was found to be effective in ameliorating reported aggressive driving tendencies with lasting effects in the two-month follow-up. Self-referred and court-referred participants were similar overall, though with self-referred subjects improving more on driving anger and reactions to particular instances of provocation.
Galovski *et al.*	2003	CBT PBT SCT TRA/TPB	USA	Serious offender Young adult Adolescent	43	*Outcomes: Physiological reactivity to aggressive driving scenarios, measured by heart rate, systolic blood pressure, diastolic blood pressure and skin resistance level.* This experiment studied the effectiveness of cognitive and relaxation interventions on the physiological response of aggressive drivers to stressful driving vignettes. While aggressive drivers and non-aggressive controls did not manifest differences in the self-report of reaction to scenarios, systolic blood pressure (SBP) was higher among aggressive drivers for driving stressor scenarios, and higher for controls in non-driving stressor scenarios. Aggressive drivers had lower SBP in response to driving vignettes post-intervention than pre-intervention. Self-referred aggressive driver subjects tended to react with greater emotional response to all scenarios than court-referred aggressive driver participants.

Authors	Year	Theory	Country	Population	*n*	Results
Grant *et al.*	1995	HBM TRA Protection Motivation Theory	Canada	Adolescent	550	*Outcomes: Knowledge of risks and attitude toward drinking and driving.* This study evaluated the effect of the high school IMPACT curriculum on the knowledge of drink-driving risks and attitudes toward drink-driving among students. Most participants felt the hospital-based intervention increased their awareness of the effects of drinking and driving, would help them change their behaviour, and would motivate them to change the behaviour of their friends and family.
Gregersen	1996	TRA/TPB DMT SCT HBM RHT	Sweden	Young adult Adolescent	53	*Outcomes: Self-estimation of driving skill, actual driving skill.* This study assigned driving students to two types of instruction during a special skid car training session, one which focused on improving driving technique and skill and the other that focused on the limits of good driving skill in avoiding accidents. Learner drivers taught to focus on skill improvement overestimated their driving skills whereas those taught to think about limitations overestimated less. There was no difference between groups in actual driving skill.
Hanks *et al.*	1999	HBM	USA	Young adult Adolescent	301	*Outcomes: Dozing incident while driving.* This study used a case-control survey design with college students to investigate the effectiveness of different strategies for combating driving drowsiness. Use of certain coping strategies such as consuming caffeinated beverages, taking walks, stopping for a nap and chewing ice were associated with dozing incidents. On the other hand, strategies such as snacking, opening a window and talking with passengers seemed to have a protective effect.

Authors	Year	Theory	Country	Population	*n*	Results
Harre *et al.*	2005	SCT Social Control Theory HBM	New Zealand	Adolescent Young adult	314 366	*Outcomes: Driving self-enhancement, crash-risk optimism.* This research was comprised of two separate studies that examined crash-risk perception and driving self-enhancement and the effects of media education advertisements on these factors. In Study 1, student subjects were assessed for driving self-enhancement relative to their peers on a range of skill, experience and safety items as well as their crash risk perception. Significant self-enhancement was found in all areas which tended to cluster around themes of 'driving ability' and 'driving caution'. Driving ability, driving caution and luck all significantly predicted crash-risk perception. In Study 2, student subjects were shown advertisements intended to discourage drink-driving. The experimental group viewed an advertisement showing drink-driving ending in a crash, and the control group viewed an advertisement depicting people drinking and simply refraining from driving. The experimental group was found to be significantly more self-enhancing in the area of driving ability, and driving caution was found to predict crash-risk perception. In both studies, trends emerged indicating greater self-enhancement on driving ability among men and on driving caution among women.
Hingson *et al.*	1996	SCT COrg HBM	USA	Young adult Adolescent	11	*Outcomes: Fatal crashes, fatal crashes involving alcohol, young drivers, local roadways and speeding; driver injuries, pedestrian injuries, directly observed seat-belt use and speeding, drink-driving, programme awareness, perceptions of enforcement, traffic citations.* This study evaluated the effectiveness of the Massachusetts Saving Lives Program community campaigns to improve traffic safety. Cities implementing the programme demonstrated a 25% decrease in all fatal crashes compared to the rest of the state over a five-year period, a 42% decline in fatal crashes involving alcohol and 39% decline in fatal crashes involving young drivers. Visible injury rates experienced small declines for the programme communities when compared to state rates. Observed speeding and drink-driving in intervention cities among young people also decreased by 43% and 40% respectively.

Authors	Year	Theory	Country	Population	*n*	Results
Holder *et al.*	2000	HBM SCT COrg DT	USA	Young adult Adolescents	6	*Outcomes: Self-reported alcohol consumption, frequency and quantity of alcohol consumption, reported driving while intoxicated, motor vehicle crashes (night-time, alcohol involvement, daytime), emergency department injuries from violent assault and involving alcohol.* This study compared three communities that implemented campaigns on alcohol-related injury reduction with three control communities. Compared with control sites, intervention communities reported a decrease in DUI crashes, self-reported driving after drinking, night-time injury crashes, and average quantity of alcohol consumed per outing occasion.
Houston and Richardson	2002	SCT HBM	USA	Young adult Adolescent	Not applic-able	*Outcomes: Motor vehicle crash fatalities and injuries.* This study used a time series approach to assess the effect that a change in California from secondary enforcement to primary enforcement had on injuries and fatalities resulting from motor vehicle crashes. The change from secondary to primary seat-belt enforcement did not significantly reduce motor vehicle fatalities. However, primary enforcement did have a positive effect on injuries.
Iancu and Nehama	1993	TRA/TPB SCT	Israel	Young adult Adolescent Serious offender	Not applic-able	A combined plan of action of the Medical Corps in the battle against traffic accidents is described. The plan covers sound medical standards for military driver licensing, disqualification of drivers with medical problems, reporting of problematic drivers (epileptics and others) to the Israeli Ministry of Health, evaluating the driving fitness of drivers involved in traffic accidents, and, finally, an education programme for all Israel Defence Forces soldiers to be delivered by military physicians.

Authors	Year	Theory	Country	Population	*n*	Results
Job	1990	SCT HBM	Australia	Young adult	2,963	*Outcomes: Driving confidence, driving confidence under the influence of alcohol.* Surveys were given before and after the introduction of a random breath testing (RBT) programme. Driving confidence increased with age up to 40 years old and was much higher for males than females. Overconfidence was common, with 53.6% of people believing they were above average drivers. Confidence in the ability to drive under the influence of alcohol was less, but still indicated overconfidence, especially among males. RBT had no significant effect on the two measures of confidence.
Jones	1997	HBM	USA	Serious offender Young adult Adolescent	28,479	*Outcomes: 24-month traffic accident and violation survival without additional moving violations, major violations or accidents.* This study examined the effect of different styles of advisory letters to drivers manifesting early patterns of risky driving on their ability to survive without another moving violation, major violation or accident over a 24-month period. Results suggest that advisory letters in general are effective in reducing future traffic accidents and major violations, but not moving violations. The standard letter overall was slightly more effective than the soft-sell letter. The study found gender and age effects as well. While there was not a statistically significant difference between the accident survival rates of women who received letters and female controls, the letters had a significant effect on men. Younger drivers responded better to the standard letter while drivers over 45 performed better with the soft-sell letter.

Authors	Year	Theory	Country	Population	*n*	Results
Jones	1997	SCT	USA	Young adult	28,479	*Outcomes: Accidents, major violations, moving violations.* As part of Oregon's Driver Improvement programme, advisory letters are sent to drivers who have a pattern of unsafe driving. In this study, some drivers were sent no letter, some were sent the standard letter, and others were sent a soft-sell letter, which used encouraging, low threat, motivational language. Driving records were reviewed before and up to 24 months after the letters were sent. The letters did reduce accidents. The standard letter was more effective for younger drivers, and the soft-sell letter was better for drivers over 45. Both the standard and soft-sell letters effectively reduced major violations for drivers over age 20. Moving violations were not affected by the letters. The letters appeared to have more of an effect on men than women.
Jorgensen and Pedersen	2002	SCT RHT DMT HBM	Norway	Young adult Adolescent	515	*Outcomes: Driving speed, driver concentration (measured by lateral deviation and self-report).* This study presented economic models to explain previously published empirical results on the effects of newly installed road lighting and effects on driver speed and concentration. Data from previous studies indicated that better road lighting increases driving speed, decreases driver concentration, but leads also to fewer traffic accidents than unlit roads. The authors argue that drivers see speed and concentration as 'complementary safety means'. Better lit roads lead to a decrease in concentration and perceived risk of accidents and an increase in driving velocity. It is reasoned that the decrease in concentration and perceived risk is well offset by safety benefits of road lighting.

Authors	Year	Theory	Country	Population	*n*	Results
Katila *et al.*	2004	HBM SCT	Finland	Adolescent Young adult	31,909	*Outcomes: Self-reported accidents in slippery and non-slippery conditions, officially recorded accidents, self-estimation of skills, worry and risk in slippery conditions.* This study evaluated the effects of a change in the Finnish driving curriculum to emphasise anticipatory skills over manoeuvring skills in slippery driving conditions. Results of the evaluation indicate that improved confidence in driving skills in slippery conditions does not translate into increased risk for accidents. Slippery road accident odds remained the same before and after the curriculum change, while there appeared to be a greater self-confidence in slippery driving skills among those trained under the new curriculum. Significant gender and age effects were found in confidence in skills. Males, younger drivers, drivers under the new curriculum, and those with more driving exposure tended to have greater confidence in their skills and less apprehension about driving in slippery road conditions.
Katsikopoulos *et al.*	2000	DMT	USA	Young adult Adolescent	60	*Outcomes: Reported choice to take alternative driving route over main route.* This study described the likelihood of drivers to take an alternate route when given estimates and ranges of travel times for both routes. The effect of added cognitive load was also investigated. With a paper and pencil experiment, results show that in general, drivers try to minimise travel time and prefer narrower ranges of estimates when the alternate route is faster and the driver stands to gain time. As average time and range of travel time estimates for the alternate route increased, the chance of participants taking it decreased. Overall, people had a tendency to opt against the alternative route. An experiment using a driving simulator tested the effect of heavier cognitive loads on decisions to take alternate routes. Range of travel time impacted decisions less in the simulator, but average time was still important. People were less risk-averse when choosing between alternative routes that would certainly take longer than the main route. The authors concluded that a simplification process is undertaken by drivers when cognitive load is higher.

Authors	Year	Theory	Country	Population	*n*	Results
Keall *et al.*	2001	HBM SCT TRA/TPB	New Zealand	Adolescent Young adult	31	*Outcomes: Mean driving speeds, attitudes toward road safety (preferences of driving fast, perceived risk of being caught for speeding), crash injuries.* This study examined the impact of the installation and publicity around hidden speed cameras on average driving speed and attitudes. Pre-trial publicity of speed camera implementation decreased mean speed. During trial period, intervention area speeds remained lower than levels in control areas, and crashes and casualties dropped. The speed effect was greatest in reducing higher speeding patterns. Furthermore, speeds in non-trial areas experienced a decline indicating a potential spill-over impact of hidden cameras. Attitudes toward risky driving improved slightly immediately after the trial, but eventually returned to previous levels. Perceived risk of being caught was similar with the rest of the country by the end of the intervention.
Keall *et al.*	2002	SCT TRA/TPB HBM	Australia	Adolescent Young adult	88	*Outcomes: Mean driving speeds, attitudes toward road safety (preferences of driving fast, perceived risk of being caught for speeding), crash injuries*. This study was a continuation of an examination of the impact of the installation and publicity around hidden speed cameras on average driving speed and attitudes (see Keall *et al.*, 2001). Effects from the first year of observation were maintained in the second year of the study, including overall decreases in average speeds, crashes and casualties in the trial areas. Non-trial areas experienced a spill-over effect as well. Attitudes regarding road safety did not change.

Authors	Year	Theory	Country	Population	*n*	Results
Klitzner *et al.*	1994	SCT TRA/TPB HBM	USA	Adolescent	4	*Outcomes: Motivation to not drink and drive, alcohol knowledge, norms, discussions with parents, alcohol consumption, driving, DWI/riding with an impaired driver.* This study included a process and outcome evaluation for two schools implementing a Students Against Driving Drunk (SADD) programme. There was no detectable effect of the SADD programs on drink-driving outcomes in the treatment schools compared to control schools. There was also no evidence that SADD programmes led to an increase in student alcohol consumption by encouraging planning for alternative transportation options after drinking. The study revealed weak implementation of SADD programme plans and was further limited in confounding historical events occurring in control sites.
Koenig and Wu	1994	TTM TRA/TPB SCT	Canada	Adolescent Young adult	3,625	*Outcomes: Probability of left-turn drivers yielding to pedestrians.* This study examined the effect of a media campaign encouraging drivers to yield to pedestrians when making left-turns. Overall, results suggest both greater short-term and more moderate long-term improvement in yielding behaviour during left-turns.
Kuthy *et al.*	1995	HBM TRA/TPB SCT	USA	Adolescent	274	*Outcomes: Self-reported drinking and driving behaviours.* This study assessed a community outreach programme, ‘After the Party’s Over’, that aimed to reduce drinking and driving among high school students. The intervention decreased self-reported risky driving behaviours immediately following, and one month after, the programme.

Authors	Year	Theory	Country	Population	*n*	Results
Lamble *et al.*	1999	SCT Multiple Resource Theory HBM	Finland	Young adult	19	*Outcomes: Driver detection of deceleration of lead car, brake reaction time, time-to-collision, movement in lane.* This study examined the effect of mobile phone tasks and non-visual cognitive tasks on the response of drivers to deceleration of the car in front of them. Brake reaction time and time to collision increased when dialling numbers on a mobile phone and when performing cognitive tasks. Findings suggest that hands-free mobile-phone use does not eliminate mobile phone safety issues when driving. Lateral lane position deviations were inconclusive.
Land *et al.*	1997	SCT	USA	Child	603	*Outcomes: Safe child transportation* The Missouri Department of Health implemented a programme, called 'Take a Seat, Please!', in which citizens reported motorists who transported children under age four in a way not compliant with the state law. Two years later, a telephone survey and a pre- and post-observation study at child care centres did not show that the intervention had any effect.
Lave and Elias	1994	SCT HBM	USA	Young adult Adolescent	50	*Outcomes: Overall state-wide road fatality rates.* This study compared changes in road vehicle fatality rates between states that adopted a 65 mph speed limit in 1987 and states that kept the 55 mph limit. Findings indicate that fatalities decreased 3.4–5.1% more in states that increased the speed limit than states with the lower limit. Research also suggests that traffic shifted from alternate roads to the higher-speed highways, possibly because police were able to shift their resources from enforcing speed laws to other safety activities.

Authors	Year	Theory	Country	Population	*n*	Results
Lehman and Geller	1990	TRA/TPB SCT HBM	USA	Child Young adult	34	*Outcomes: Observed seat-belt use of parents and children.* This study evaluated the effect of involvement in, and viewing a skit on, the use of safety belts among kindergarten and primary school children and their parents. Among children who presented the skit, belt use doubled among those who used them inconsistently before. Parents viewing the skit also increased and maintained belt use over three months, though use was higher when children were in the car. These results suggest that children can influence adult behaviour.
Lenne *et al.*	1997	SCT HBM	Australia	Young adult	11	*Outcomes: Lateral position, speed, reaction time to secondary task in simulator, subjective alertness, sleepiness and motivation.* This study tested the effect of different times of day on driving performance in a simulator. Poor driving performance and driver alertness was found to vary by time of day. Poorest performance was at the same time as highest alertness, post-lunch. Performance tended to be low at 06:00, 02:00 and 14:00.
Levy *et al.*	1989	SCT	USA	Serious offender Young adult Adolescent	Not applic-able	*Outcomes: Crash rates.* Fall in New Jersey's single-vehicle night-time rates relative to state's all fatality rate and US single-vehicle night-time fatality rate suggests that New Jersey's three driving while intoxicated programmes (Checkpoints, Drinking and Driving task force education, and SOBER) effectively deterred alcohol-involved crashes. When analysed at the county level, the drinking and driving Checkpoint programme decreased single-vehicle night-time crash rate, peaking in the second year and gradually declining. The drink-driving task force educational programme reduced crash rates but the effect declined quickly over time. The SOBER educational programme did not have an effect.

Authors	Year	Theory	Country	Population	*n*	Results
Lindqvist *et al.*	2001	COrg SCT TRA/TPB HBM	Sweden	Young adult Adolescent Child	Not applic-able	*Outcomes: Patterns of traffic injuries presenting to health care units.* This study evaluated an inter-agency community organisation programme that was implemented to increase traffic safety. Injury rates and severity decreased significantly among mopedists and pedestrians. Drops in injuries were greatest among males less than 16 years, and the overall rate of moderate injuries was also reduced. The programme failed to reduce total risk of traffic injury requiring health care, severe injuries or traffic volume. However, intervention may be considered successful in achieving selected safety objectives among children, boys and systemic sources of moderate injury.
Loeb	1993	SCT	USA	Young adult Adolescent Child	Not applic-able	*Outcomes: Driver-involved injury rates from official national accident reports.* This study examined the effect of the enforcement of seat-belt laws in California on injuries. Laws were found to decrease moderate and severe crash injuries. Seat-belt laws also reduced crash fatalities.
Malenfant *et al.*	1996	SCT TRA/TPB	USA	Young adult Adolescent	Not applic-able	*Outcomes: Observed driver and front passenger seat-belt use.* This study evaluated the effects of the installation of signs that provided feedback to drivers on seat-belt use rates in Greensboro and Asheboro, North Carolina. Driver seat-belt use increased in both communities, whereas passenger seat-belt use only increased in one community. Asheboro (change from 75% to 89%) experienced much larger increase than Greensboro (80% to 86%), but no change in belt use occurred at the interstate sites near Greensboro.

Authors	Year	Theory	Country	Population	*n*	Results
Martinez *et al.*	1996	PAPM TRA/TPB	USA	Adolescent	170	*Outcomes: Knowledge, attitudes and self-reported behaviour and intentions around seat-belt use, speeding and drink-driving.* This study evaluated a one-week high school physics unit that focused on the mechanics of vehicle crashes and injuries on knowledge, attitudes and behaviour around driving injury prevention. Results suggest that there was an improvement among students in the treatment school in short-term knowledge and attitudes related to injury prevention, in understanding of the physics of crashes and injury, and in attitudes toward speeding and seat-belt use, particularly with regard to belt use as a passenger. Follow-up data showed a negative trend in attitudes toward seat-belt use, although behaviour effects seemed to have sustained. Some students also began to encourage family members to wear seat belts, inform other passengers in their cars about the importance of seat-belt fit, and some even developed presentations for lower grade science classes.
Matthews *et al.*	1998	TRA/TPB HBM SCT TMSC SS DMT	England	Young adult Adolescent	298	*Outcomes: Objective measures of driving performance on simulator, including speed, lateral position and risky overtaking.* This study examined the effect of different dimensions of stress on driving performance on a laboratory simulator. Habitual dislike of driving was predicted with less risk-taking, poorer control and mood disturbance. Aggressiveness was connected with more overtaking at a higher level of risk. A measure of alertness was positively associated with response time to pedestrian interactions.

Authors	Year	Theory	Country	Population	*n*	Results
McCartt and Geary	2004	HBM SCT DT	USA	Young adult Adolescent	6	*Outcomes: Use of mobile phones while driving.* This study compared mobile-phone use in cars in four intervention and two control communities after the passage of a ban on the behaviour in New York. Use rates declined in intervention cities immediately after the ban which was accompanied by a spate of unpaid publicity. Rates in the control areas did not change. Mobile-phone use rates in treatment areas returned to baseline levels a year later. Authors suggest that a lack of continuing publicity and targeted enforcement of law post-implementation were contributing factors. Use patterns varied among the four communities.
McKnight and McPherson	1986	TRA/TPB SCT	USA	Adolescent	667	*Outcomes: Knowledge of alcohol safety, attitudes toward alcohol, and behaviour in intervening with peers on drinking and driving.* This study evaluated a high-school peer intervention programme for drinking and driving, and used a conventional alcohol safety programme as a comparison. The treatment group saw increases in self-reported intervention behaviour and attained the same knowledge gains as the control group, despite the peer intervention focus. The control group did not experience changes in behaviour. No attitude changes were detected in either group.
McKnight and Tippetts	1997	TRA/TPB SCT	USA	Serious offender	16,793	*Outcomes: Violation and accident rates.* A year after the programmes ended, drivers in recidivism prevention programmes had significantly fewer violations and accidents than those in accident prevention programmes. Drivers who did not participate in either class had the smallest number of violations and accidents because they received a six-month suspension. The authors conclude that suspension is more effective than instruction in preventing violations and accidents in repeat offenders. However, if a course is used, it appears that it would be most successful in preventing violations and accidents if it aims to prevent unlawful driving, rather than primarily teaching and promoting safe driving practices.

Authors	Year	Theory	Country	Population	*n*	Results
Morrison *et al.*	2004	SCT	Scotland	General population	244	*Outcomes: Residents' happiness with area, self-reported physical health, pedestrian activity.* Residents perceived that the traffic calming scheme had improved road safety, traffic and the general environment. Twenty per cent of participants reported walking in the area more, and this was supported by observations. Self-reported physical health scores also increased.
Nilsson	2000	SCT	Sweden	Young adult (ages 20–49)	10	*Outcomes: Time by gap, relative judgement error.* Drivers indicated longer front gaps than rear gaps for adequate, critical and legal gaps. Drivers underestimated gaps and underestimated front gaps more than rear gaps. Acceptance of shorter rear gaps than front gaps may be due to a perceptual bias in distance perception.
Patten *et al.*	2004	SCT	Sweden	Young adult (taxi drivers)	40	*Outcomes: Reaction time, mean speed, stopping distance.* The effects of conversation type (simple versus complex) and telephone mode (hands-free versus handheld) on driving behaviour were evaluated. Participants' reaction times increased significantly when conversing, and reaction times were greater with more complex conversation. However, there was no difference in reaction time for hands-free versus handheld phones. There was a significant effect of telephone modality on mean speed, including significantly lower speeds (than baseline) with the handheld and greater speeds with the hands-free.
Pierce *et al.*	2005	SCT HBM KAP	USA	Child	43	*Outcomes: Booster-seat use, booster-seat knowledge.* An intervention consisted of an educational campaign and a giveaway of booster seats for children in Head Start. The intervention increased parents' and Head Start providers' knowledge of the age requirement of the law and increased providers' knowledge of age and weight requirements of booster seats. The number of children observed riding in a booster seat increased from 6% to 34%, but the post-intervention rate was still low. Perceived barriers for non-compliance included that parents perceived the child to be too big for booster seat and difficulty installing/using a seat.

Authors	Year	Theory	Country	Population	*n*	Results
Preusser *et al.*	1990	SCT	USA	Adolescent	4	*Outcomes: Motor vehicle injuries.* City night curfew ordinances were associated with a 23% reduction in motor vehicle related injuries during curfew hours for 13–17-year-olds as drivers, passengers, pedestrians or bicyclists.
Rakauskas *et al.*	2004	DM SS	USA	Young adult Adolescent	24	*Outcomes: Speed maintenance, lane position maintenance, crash avoidance, mental workload.* The results of this study do not indicate that level of conversation difficulty influences driving performance. Mobile phone conversations negatively affected speed maintenance, a statistically significant, but practically small, amount. Lane position maintenance and crash avoidance were not significantly affected.
Raub *et al.*	2003	PBT	USA	Serious offender	2,937	*Outcomes: DUI arrests.* Recidivism rates of two groups of Illinois drivers who had their driver's licences revoked for alcohol-impaired driving and who received restricted driving permits are compared based on whether they installed an alcohol interlock ignition in their cars. During the first year after having a restricted driving permit, drivers using an alcohol interlock treatment device were 20% as likely as the comparison group to be rearrested for DUI. However, once the device was removed, the treatment group's DUI arrest rates quickly rose back to the level of the comparison group. After three years, the difference in DUI arrests between the two groups was similar.
Reeder *et al.*	1999	HBM SCT	New Zealand	Adolescent Young adult	Not applic-able	*Outcomes: Motorcycle crash hospitalisations.* After the implementation of a graduated licensing programme, motorcycle crash injuries decreased among all age groups. However, the decrease was only statistically significant in the 15–19 year age group, which had a reduction of 22%. Since the number of 15–19-year-olds with motorcycle licences declined during the same period, the crash reduction may have been due to a decreased risk exposure. No changes were found for any other age groups.

Authors	Year	Theory	Country	Population	*n*	Results
Reinfurt *et al.*	1990	SCT HBM DT	USA	Serious offender Young adult Adolescent Child (general public)	72	*Outcomes: Seat-belt use, moderate injuries, serious injuries, fatalities.* The traffic effects of a multi-stage North Carolina Seat Belt Law were examined. Seat-belt use increased from 25% at baseline to 45% during the warning ticket phase. Seat-belt use then reached a peak of 78% upon enforcement and then decreased to 64%. Significant reductions in percentages of moderate and serious injuries occurred at the beginning of both the warning ticket and the enforcement phases. The warning ticket phase led to a 5.4% reduction in serious injuries but no change in fatalities. During the enforcement phase there was an 11.6% reduction in fatalities and a 14.6% reduction in serious or worse injuries.
Retting *et al.*	1999	SCT HBM TRA/TPB	USA	Serious offender Young adult Adolescent (general population)	14	*Outcomes: Red light violation rate, resident awareness, and opinions of red light camera enforcement.* After 3–4 months of red light camera enforcement there were overall reductions in red light violation rates of 40% at camera sites and 50% at non-camera sites. These reductions were statistically significant compared to the control sites. Awareness of the enforcement programme was 69% before the programme began, 84% six weeks into the programme and 85% six months into the programme. Before the cameras were installed, 74% of respondents were in favour of them, and 79% were in favour six weeks and six months after the programme began.
Reyner and Horne	1998a	None	UK	Young adult	16	*Outcomes: Lane drifting, self-reported sleepiness, EEG-measured sleepiness.* Behaviours commonly used to overcome sleepiness while driving were tested. Participants were assigned to take a nap, drink coffee, turn on the radio or use the air conditioner. Radio or air treatment did not have an effect on drifting from the lane. There was a trend for radio to reduce incidents, but a brief nap and/or coffee still had a greater effect than radio. No effect on sleepiness was found for cold air.

Authors	Year	Theory	Country	Population	*n*	Results
Reyner and Horne	1998b	HBM	UK	Young adult	28	*Outcomes: Lane drifting, self-reported sleepiness, EEG-measured sleepiness.* Lane drifting, typifying sleepy driving, was subdivided into minor and major incidents, where the latter was indicative of actually falling asleep. A distinction was made between the subjective perceptions of sleepiness and the likelihood of falling asleep, which drivers reported separately. Increasing sleepiness was closely associated with an increase in the number of incidents. Major incidents were preceded by self-awareness of sleepiness well beforehand and typically, subjects reached the stage of fighting sleep when these incidents happened. While the perceived likelihood of falling asleep was highly correlated with increasing sleepiness, some subjects failed to appreciate that extreme sleepiness is accompanied by a high likelihood of falling asleep.
Rogers and Schoenig	1994	HBM DT	USA	Adolescent Young adult Serious offender (general public)	Not applic-able	*Outcomes: Night-time fatal and injury accidents, single-vehicle night-time fatal injury accidents involving male drivers, and drink-driving fatal injury accidents.* Decreases in alcohol related night-time accidents are associated with 1982 drinking and driving legislative reforms in California. These effects remained after accounting for changes in social milieu regarding drunk driving which developed prior to the intervention. The magnitude of the observed legislative effect is small in relation to the consistent downward trend in alcohol-related accidents that began prior to the intervention itself. Drivers that were influenced by the new legislation may not have been solely influenced by the legislation itself, although its impact is evident.

Authors	Year	Theory	Country	Population	*n*	Results
Ross and Gonzales	1998	SCT	USA	Serious offender	71	*Outcomes: Consequences of licence revocation, driving with a revoked licence.* Drunk-driving offenders were interviewed during their period of licence revocation. Most of the subjects, which were selected at random, were young, male and had problems with alcohol. Most continued to drive even though their licence had been suspended or revoked, but they drove fewer miles and more carefully (to avoid being caught). Driving with a revoked licence was more common among those who were employed and lived farther from work. It was also greater among first offenders and young men. Few were negatively affected vocationally. Most admitted guilt, expressed remorse and supported the anti-drunk-driving movement.
Sadler *et al.*	1991	DT	USA	Serious offender	>8,000	*Outcomes: Non-alcohol-related accidents and convictions, alcohol-related accidents and convictions, fatal or injurious accidents, and late night accidents.* The level of effectiveness of two types of countermeasures to deter impaired driving in California (licence suspension/revocation versus treatment/ rehabilitation) was compared. Treatment was more effective on alcohol-specific outcomes whereas licence suspension was more effective on non-alcoholic and total accidents. Effects of licence actions in reducing rates of non-alcohol-related traffic accidents and convictions were attributed to reduced driving exposure and more cautious driving behaviour. Longer periods of licence action are associated with lower rates of non-alcohol-related accidents and conviction especially for persons under age 36. Short-term licence action may have little specific deterrent effect on traffic accident and convictions. However, relative to alcohol abuse treatment (in lieu of licence action), no-licence action or limited licence action, full-licence action demonstrated greater effectiveness.

Authors	Year	Theory	Country	Population	*n*	Results
Shope *et al.*	1996	SCT TRA/TPB	USA	Adolescent	1,041	*Outcomes: Knowledge, refusal skill ability, frequency and quantity of alcohol use, alcohol misuse and driving after drinking.* An alcohol misuse prevention curriculum for tenth-grade students which focused on social pressures resistance training, immediate effects of alcohol, risks of alcohol misuse and social pressures to misuse alcohol had small effects. The programme was evaluated through twelfth grade in four school districts. The intervention group's knowledge scores were significantly higher than the control group at grades 10 and 12. Refusal skill ability was slightly greater at grade 10 for treatment students compared to control students. Gender by occasion differences were found on alcohol use, alcohol misuse and driving after drinking. Boys' rates increased more than those of girls. Exposure to a sixth-grade, as well as the tenth-grade, programme did not result in better outcomes.
Shope *et al.*	2001a	SCT TRA/TPB	USA	Adolescent	4,635	*Outcomes: Alcohol-related and at-fault, single-vehicle and alcohol-related crashes.* This intervention programme examined the effects on subsequent driving of a high school based alcohol prevention programme. There was a marginal intervention effect for serious offences, but only for the first year of licensure. The effect was strongest for the subgroup of students that had less than one drink per week and those whose parents showed no disapproval of alcohol. There were no treatment effects for crash outcomes.

Authors	Year	Theory	Country	Population	*n*	Results
Shope *et al.*	2001b	HBM	USA	Adolescent	Not applic-able	*Outcomes: Police-reported crashes, fatal injury crashes and non-fatal injury crashes by time of day, single-vehicle and multi-vehicle crashes, and alcohol-related crashes.* The effect of Michigan's graduate driving licensure programme is evaluated. Overall, the rate of 16-year-old drivers (per 1,000 population) involved in crashes declined. After adjusting for population-wide trends, from 1996 to 1999, the overall crash risk for 16-year-olds decreased by 25%, a significant difference. Crash risk decreased significantly from 1996 to 1999 for all subtypes of crashes (reductions ranged from 21–29%), except fatal and alcohol-related crashes. The largest reduction in risk was for night crashes (53%).
Shope and Molnar	2003	HBM	USA	Adolescent	6	*Outcomes: Crash involvement.* Seventeen states implemented GDL programmes between 1996 and 1999, and this article reviewed the effects in six of those states. GDL implementation reduced crashes among teenage drivers in all six states, including different geographic regions and different GDL programmes. The population-adjusted risks of injury/fatal crash involvement of 16-year-old drivers were reduced by 11% in Florida and 24% in Michigan. The population-adjusted risks of any crash involvement was reduced by 25% in Michigan and 27% in Florida. The Florida evaluation was the only one that included a comparison state, and there were significantly greater crash reductions compared to the comparison state.
Shope *et al.*	2003	PBT	USA	Adolescent	4,813	*Outcomes: Serious offences, alcohol-related offences, crashes, and alcohol-related crashes.* This paper examined predictor measures for high-risk driving in the first three years of driving. Friends' support for drinking, susceptibility to peer pressure, tolerance of deviance and alcohol use were associated with all outcomes, especially serious offences, alcohol-related offences and alcohol-related crashes.

Authors	Year	Theory	Country	Population	*n*	Results
Shope and Molnar	2004	DT	USA	Adolescent	89,582	*Outcomes: Number of crashes, non-fatal injury crashes and fatal crashes (by time of day), single- and multi-vehicle crashes, crashes by passenger number.* Michigan's graduated driver licensing programme was evaluated. From 1996 to 2001, crash risk among 16-year-olds was reduced by 29% for all, 44% for fatal, 38% each for non-fatal-injury and fatal-plus-non-fatal-injury, 32% for day, 31% for evening, 59% for night, 32% for single-vehicle, and 28% for multi-vehicle crashes. After adjusting for population-wide changes among drivers 25 and over that might have contributed to the crash reduction among 16-year-olds, there was still a 19% reduction in all crashes.
Simons-Morton *et al.*	2002	TRA/TPB SCT	USA	Young adult Adolescent	420 parent-teen dyads	*Outcomes: Parental limits on teenage driving.* Evaluation of the Checkpoint programme, an intervention designed to promote parental management of teenage driving through the use of staged persuasive communications is presented. Teenagers and parents in the intervention group reported significantly greater limits on teenage driving at licensure and three months post-licensure, compared to the comparison group. In multivariate analyses, baseline driving expectations and intervention were significantly associated with limits at licensure. Limits at licensure were significantly associated with limits at three months post-licensure.
Simons-Morton *et al.*	2003b	SCT TRA/TPB HBM	USA	Adolescent	658 parent-teen dyads	*Outcomes: Parent communication, amounts and limits related to teenage driving.* This study evaluated the persistence of effects of a brief intervention designed to increase parental restrictions on teenage driving privileges. Compared to the control group, the treatment group reported greater communication at months 1, 4 and 9. The treatment group reported more restrictions on the amount of driving at month 1, but there was no difference with the control group at months 4 and 9. The intervention group reported more limits than the control group at month 1, but this difference declined over time.

Authors	Year	Theory	Country	Population	*n*	Results
Simons-Morton *et al.*	2005	TRA/TPB HBM SCT	USA	Adolescent	420	*Outcomes: Parental restriction of high-risk teenage driving conditions.* Checkpoints intervention effects on parent limits on novice teenage driving are explored. Compared to the comparison group, intervention parents and teenagers reported stricter limits on teenage driving at licensure and three months post-licensure, which led to indirect effects at 6 and 12 months post-licensure.
Stead *et al.*	2005	TRA/TPB	Scotland	Young adult Adolescent (ages 17–54)	550	*Outcomes: Predictive ability of TPB for speeding behaviour, recall of advertisements, psychosocial determinants of speeding.* The Scottish Road Safety Campaign implemented a three-year mass media campaign to reduce speeding on Scotland's roads which was explicitly shaped by the Theory of Planned Behaviour's (TPB) three main predictors: Attitude, Subjective Norms and Perceived Behavioural Control. Perceived behavioural control was the most powerful independent variable associated with intention to speed at each survey stage. The TPB was able to predict between 47–53% of the variance in intentions to speed when analysed cross-sectionally. In addition, TPB was able to predict 33% and 40% of the variance in speeding behaviour when analysed cross-sectionally. Over time, the predictors explained 27% of the variance for intention to speed. By the fourth survey, predictors of intention were still attitudes, perceived behavioural control, subjective norms and age (being younger). These predictors explained 22% of the variance of speeding behaviour. Even after accounting for awareness of the campaign, social class and gender were non-significant. The media advertisements led to changes for the attitude construct and its associated affective beliefs, but the advertisements targeting the other TPB constructs did not elicit any change on subjective norms, behavioural control or intention.

Authors	Year	Theory	Country	Population	*n*	Results
Stewart and Conway	2000	COrg TRA/TPB	New Zealand	Young adult Adolescent (general public)	Not applic-able	*Outcomes: Alcohol-related crashes.* A two-and-a-half year pilot community action project aimed at developing strategies to reduce alcohol-use-related crashes that was implemented in a rural police district in New Zealand is discussed. The initial plan to create community committees to mobilise around the issue of drunk driving encountered too many barriers, particularly community members' lack of time and resources to devote to the committees. For this reason, a year into the project the focus shifted to strengthening existing efforts, such as police traffic enforcement and changing the drinking environment. The authors describe anecdotal successes.
Taubman-Ben-Ari and Findler	2003	Terror Management Theory	Israel	Young adult	206	*Outcomes: Intention to drive recklessly, driving speed.* A study, based on Terror Management Theory, examined the effects of mortality salience on young men's and women's behavioural intentions to drive recklessly and behaviour in a simulator. Among those who perceived driving as relevant to their self-esteem, viewing a road trauma film led to fewer self-reported intentions to drive recklessly, but faster driving in a driving simulator (compared to after viewing a neutral film). Those who did not view driving as relevant to self-esteem drove more slowly after seeing the road trauma film.
Tay and Watson	2002	TPB	Australia, New Zealand	General driver population	299	*Outcomes: Fear arousal, response efficacy, self-efficacy, behavioural intentions, self-reported behaviour (driving while fatigued).* The effects of road safety advertisements were assessed. Subjects watched one of two road safety advertisements to discourage driving while fatigued: one included only a threatening message, and the other included a threatening message and coping strategies. There was no difference in fear arousal between the subjects who watched the two advertisements. Those who watched the advertisement with both a threatening message and coping strategies had higher response efficacy, higher self-efficacy, stronger intentions to avoid driving while fatigued, and more self-reported behaviour of avoiding driving while fatigued. The authors state that the results support a low-moderate fear, high-efficacy approach.

Authors	Year	Theory	Country	Population	*n*	Results
Teran-Santos *et al.*	1999	AT	Spain	Serious offender (at least two hospitalisations due to accidents)	254	*Outcomes: Number of traffic accidents.* The results of a case-control study indicated a strong association between sleep apnoea and traffic accidents in unadjusted and adjusted analyses. Apnoea patients had a higher probability of being involved in a traffic accident relative to non-apnoea controls. Further, alcohol consumption had an important modifying effect in apnoea-traffic accident relationship by increasing the strength of the relationship.
Ulmer *et al.*	2000	TRA/TPB	USA	Adolescent	468,949	*Outcomes: Crash rates.* Florida's graduated licensing programme, instituted in July 1996, was evaluated by comparing crash rates before and after implementation of the programme and contrasting rates with Alabama, which does not have a graduate licensing programme. Overall, there was a 9% reduction in the fatal and injury crash involvement in 1997 for 15–17-year-old drivers in Florida, but crash rates did not change significantly for 18-year-olds. There was no difference in crash reductions for males compared with females. However, there was a larger reduction among white than non-white teenagers, and among urban compared to rural teenagers. There were no significant changes in Alabama.
Wells-Parker *et al.*	2000	SCT TTM	USA	Serious offender	670	*Outcomes: Recidivism in drinking and driving violations, stage of change classification and score, self-efficacy.* This study examined the effects of a four-week court-ordered programme for DUI offenders on recidivism, stage of change progress and self-efficacy. Most participants held relatively stable stages of change, with most entering at the action level of change, some in contemplation, and very few in pre-contemplation. Small predictive relationships were found between high action and self-efficacy scores. In general, most participants experienced increase in contemplation and action scores, regardless of recidivist status, indicating the acknowledgement of problems and efforts to change. Those in the contemplation stage tended to have higher recidivism rates, consistent with previous research.

Authors	Year	Theory	Country	Population	*n*	Results
Wheeler *et al.*	2004	SS	USA	Serious offenders	99	*Outcomes: Drinking frequency, drinking intensity, drunk-driving, re-arrests.* First time DWI offenders were assigned to one of two groups: the standard DWI treatment programme which included a victim impact panel (VIP), or the standard DWI treatment programme without the VIP. Two months after the end of the programmes, there was no differential effect of the VIP in terms of drinking frequency or frequency, drunk-driving or re-arrests.

Authors	Year	Theory	Population	Results
Arnett	2002	SCT Social Control Theory TRA/TPB SS HBM	Adolescent Young adult	*Outcomes: Crash risk, crashes.* This study explored the possible developmental factors that may play a central role in explaining why adolescents and emerging adults have dramatically higher rates of vehicle crashes than adults in older age groups. In particular, the literature has not given attention to key developmental changes occurring during these years, but has instead often collapsed the age groups of 16, 17, 18 through 25 years together for analysis. Such factors may include the social influence of friends in driving, optimistic bias, emotionality at these ages, societal expectations for males, and development of sense of social responsibility. In addition, the authors argue that policy and culture may also play a role, as suggested by a comparison between Denmark and the USA where Danish youth obtain drivers licences at an older age, drive cars substantially less, have more access to other forms of transportation, and drink-drive automobiles substantially less than their American counterparts.
Fuller	2005	TRA/TPB DMT SS RHT DT PBT SCT HBM	Adolescent Young adult	*Outcomes: Driving task difficulty* The author argues that drivers attempt to maintain a level of task difficulty when driving. The dynamic interaction between the determinants of driving task demand and driver capability determines task difficulty, a relationship described by the task-capability interface (TCI). Driving capability is formed by biological and acquired factors, however it may be impacted at any given time by human factors such as stress or motivation. Task demand is impacted by factors like the environmental conditions of the road or visibility. Achieving task difficulty homeostasis is proposed as a sub-goal of driving, with speed choice being the mechanism of maintaining task difficulty within selected boundaries.
Hedlund	2000	RHT DMT HBM	Adolescent Young adult	*Outcomes: Risk compensation in response to safety measures.* With regard to individual behaviour change, the author notes that ‘risk compensation predicts that behaviour will change but does not predict how it will change, so we don’t know what to observe’. From a theoretical standpoint, the author presents a personal view of risk compensation which is explained by four factors: (1) visibility, (2) effect, (3) motivation, and (4) control. While each factor is more complex than discussed in the manuscript, the author posits that, taken together, these four factors may serve as a preliminary risk compensation index.

Authors	Year	Theory	Population	Results
Holder	1997		Young adult Adolescent	*Outcomes: Alcohol use.* Author notes the theoretical and empirical support for individual interventions as population-level strategies for reducing alcohol-involved problems. Stronger evidence of a causal relationship between individual interventions and population-level alcohol problems is needed in order to have an impact on alcohol policy.
Janssen and Tenkink	1988	RHT	Adolescent Young adult	*Outcomes: Driver speed choice.* Drivers may behave in such a way as to achieve risk homeostasis. However, a driver's intention is not to achieve risk homeostasis as a purpose on its own. Instead risk homoeostasis must be considered as a by-product of a behaviour used to achieve a reasonable purpose in driving. In that case, engineering measures solely targeting a reduction in risk behaviour may be discounted because of compensating shifts in behaviour.
Leigh	1999	SCT DMT SS HBM PBT	Adolescent Young adult	*Outcomes: Engagement in risk behaviours and associated link to alcohol use.* The complex association between alcohol and risky behaviour has been well studied using population-based, person-based, event-based and experimental methods. Theoretical models explaining the complex relationship can be used to develop both population and individually-based interventions to reduce risks depending on the specific circumstances of the problem.
Mahalel and Szternfeld	1986	SCT Signal Detection theory	Adolescent Young adult	*Outcomes: Change in traffic safety as a result of road safety improvements.* The authors suggest that, in certain cases, simplifying the driving task does not result in an increase in traffic safety. Drivers may have increased confidence or underestimate driving task difficulty as a result of traffic engineering improvements. The road improvements influence driver perception and can result in a decrease in driver attention and driving performance. Environmental demands and driver's optimal performance requires further exploration.

Authors	Year	Theory	Population	Results
Maupin *et al.*	2004	SCT Social-ecological Theory	Adolescent Young adult Child	*Outcomes: Effect of strategies to reduce risk of motor vehicle accident injuries.* Based on a model of risky behaviour, the authors recommend the following to change driving behaviour and reduce risk: Influence individual at point of decision, mobilise communities and coalitions to support individual and systems changes, modify environmental factors to modify behaviours, change laws and public policy, and work towards the elimination of underlying causes.
Mayhew *et al.*	1998	TRA/TPB HBM	Adolescent Young adult	*Outcomes: Driver education programmes.* The authors provide recommendations to improve driver education within graduated licensing systems. First, young drivers should be motivated to use their driving skills. Second, driver education and graduated licensing should be multi-phased. Third, the content and delivery of driver education/training should be reviewed by looking at factors associated with collisions among young drivers. Authors conclude suggesting that, until potential improvements have been tested and shown to add to the safety benefits of graduated licensing, widespread implementation should be discouraged.
Nelson	1997	RHT AT	Adolescent Young adult	*Outcomes: Perception of driver fatigue.* The author discusses the importance of raising awareness of experienced and novice drivers regarding the conditions that may hasten or retard driver fatigue. Some of the commentary was informed and supported by responses from two questionnaires administered by the Alberta Motor Association. There was generally high consensus about the high level of importance respondents believed should be placed on ‘knowledge’ of safety for novice drivers.
Peterson *et al.*	2000	COrg	General driver population	*Outcomes: Community-based injury prevention.* This article reviewed community-based injury prevention programs in Wisconsin that focus on the prevention of home- and transportation-related injuries. Community participation in the design and implementation of these programs are suggested to increase the adoption of safer behaviours at a community level. The assistance of health workers and physicians, and the tailoring of programmes according to the community’s unique characteristics, are suggested to maximise these efforts.

Authors	Year	Theory	Population	Results
Reinfurt	2004	COrg DT	General driver population	*Outcomes: Components of a successful Click It or Ticket programme.* The author reviews the efficacy of the Click It or Ticket programme. Programme components included: a community based coalition, commitments from all levels of government, innovative and integrated use of media including press releases, PSAs, websites, law enforcement, data and results reporting, co-ordinated programmes at the local and state level, and continuous funding.
Ritzel *et al.*	2001a	TRA/TPB	Adolescent Young adult	*Outcomes: Social marketing techniques to reduce drink-driving in high schools and universities.* Authors provide several recommendations for the development of a social norm marketing campaign targeting students in high schools, colleges and universities. The following components to maximise behaviour change are suggested: Informing students about their misconceptions about binge drinking and drink-driving, collecting baseline data to assess change due to the social marketing campaign, developing a message highlighting non-binge norms, ensuring credibility, delivering a message that targets your population, and providing continuous exposure to the message to ensure retention, especially through innovative and different forms of media.
Rush	1998	TRA/TPB SCT	Adolescent	*Outcomes: Mock crash to demonstrate consequences of drink driving.* Author described how to create a mock crash activity for high school students and involve the media. No results for the proposed activity are presented.
Sheridan	2004	Control Theory	General driver population	*Outcomes: Driver distraction and driving behaviour.* The author presents a framework based on the ideas of control theory. The framework uses a control loop to show interactions between driver distraction and driver 'goal setting, sensing, deciding on control response, dynamics of the vehicle, and human body activation'. The framework provides insight into potential research areas, which could lead to a better understanding of driver distraction and driving ability in a variety of situations.

Authors	Year	Theory	Population	Results
Speiglman	1997	DT	Serious offender	*Outcomes: Negative effects of required drunk-driver participation in AA programs.* Author suggests justice system and alcohol services should investigate analytical approaches to accommodating drinking drivers and other coerced referrals without compromising recovery and treatment programmes, which are not adequately designed for this population.
Tonkin	1997	PBT	Adolescent	*Outcomes: Motor vehicle mortality rates in rural areas.* The author notes that although past studies have noted higher motor vehicle accidents fatality rates associated with driving after drinking for adolescents in rural areas, this is not necessarily as meaningful due to potential confounders (such as time spent on the roads, etc.) needing further consideration.
Wilde *et al.*	2002	RHT	General driver population	*Outcomes: Evidence for and against Risk Homeostasis Theory.* Wilde argues that drivers target a level of risk. As new technologies or policies are developed to reduce crashes, drivers readjust their risk/benefit decisions to maintain a particular risk. Interventions which reward drivers for crash-free time periods are suggested to improve driving behaviour. Robertson and Pless concede that risk homeostasis explains occasional changes in driving behaviour based on perceived risk. However, they argue that studies supporting the theory are biased because they focus on traffic-aggregate data and, therefore, are limited to explain the individual driving cognitions, skills and behaviours.
Zaidel	1992	TRA/TPB SCT DT Social Control Theory AT	General driver population	*Outcomes: How driving culture may influence driving behaviour.* Author discussed driving culture and how individual and group dynamics may influence driving behaviour in a positive or negative way. Zaidel uses examples from social psychology, sociology, economics, communication, epidemiology and other disciplines and recommends that traffic behaviour scholars consider concepts developed in other social disciplines.

Authors	Year	Theory	Population	*n*	Results
Augustyn and Simmons-Morten	1995	TRA/TPB SCT Social Inoculation Theory	Adolescent		*Outcomes: Drinking behaviour, impact of alcohol prevention programmes.* Authors review the demographics and aetiology of adolescent drinking behaviour. Adolescents buy alcohol for themselves and their friends and are more likely to drink on weekends during social gatherings away from their home. Heaviest drinkers are more likely to drink illegally in bars and in mixed-sex groups, though boys may drink more in large all-male groups. Adolescents in big cities with large per capita drinking are less likely to drink in a car. Rural adolescents who spend increased time socialising, decreased time at home and receive poor grades in school are more likely to drink. Although substance abuse prevention programmes are not highly effective in reducing precocious alcohol use, programmes with a focus on social influence are most effective, especially when teaching conservative norms.
Blomquist	1986	TRC HBM RHT SCT	Adolescent Young adult		*Outcomes: Seat-belt use behaviour.* Examination of seat-belt studies in light of a utility maximisation model suggests higher costs are associated with lower seat-belt use. Higher value of expected benefits increases probability of seat-belt use.
Deery	1999	HBM SCT	Adolescents, Young adults		*Outcomes: Hazardous driving.* The author conducted a review of literature related to risk and hazard perception skills in novice drivers. The product was a model that explained the primary elements that affect behaviour around traffic hazards. The model includes the following constructs: hazard perception, risk perception, self-assessment of skill, risk acceptance and driving skill. The literature indicated that young drivers' hazard detection was less holistic, quick and efficient than older drivers. There is some evidence of greater risk acceptance among young drivers. Younger drivers also tend to underestimate their risk and overestimate their skill. The author recommends more research on the relative effects of experience and age, and the ways in which the two components contribute to accident involvement.

Authors	Year	Theory	Population	*n*	Results
DeJong and Atkin	1995	TRA/TPB HBM SCT	Adolescent Young adult	137	*Outcomes: Drink-driving behaviour.* Authors review the content of television public service announcements (PSA) involving alcohol-related driving behaviour. Most campaign messages were designed for a general, undifferentiated audience rather than more effectively targeting those at highest risk for drinking and driving. Young people in their teens and early 20s are particularly hard to reach with prevention messages. PSAs targeting adolescents and young adults should feature peers, should not be preachy, and should give greater emphasis to social consequences of drinking and driving. Authors recommend future campaigns target changes in institutional structures, public policies and laws that will contribute to individual behaviour change.
DeJong and Hingson	1998	DT SCT COrg		50	
Jonah	1997	SS	Serious-offenders	40	*Outcomes: Drink-driving, traffic violations and at-fault crashes.* Most studies found evidence to suggest that sensation seeking is positively associated with drinking and driving, especially for those with a history of driving violations. Men had stronger associative effects than women. Moderate evidence suggested that the relationship between sensation seeking and drink-driving is mediated by drivers' perceived risk of crashing. Across most studies testing the effect of sensation seeking on traffic violation and at-fault crashes, separately and combined, high sensation seeking was associated with higher number of traffic violations and collision involvement. These relationships were stronger in men than women and weaken with age.

Authors	Year	Theory	Population	*n*	Results
Klassen *et al.*	2000	TRA/TPB SCT HBM	Adolescent Child	28	*Outcomes: Child and adolescent safety behaviour.* Authors review studies evaluating community based interventions on child and adolescent safety practices. The overall impact of the interventions varies, with results better for promoting bike helmets and child safety restraints. Child pedestrian safety and adolescent alcohol use and vehicle safety is less evident due to poor intervention designs. Characteristics of successful community interventions include a grounding in behavioural theory, integration with the community, and specific tailoring to ethnicity and the socio-economic status of the community.
Li *et al.*	1995	HBM	Adolescent		*Outcomes: Traffic-related injuries and deaths.* The review examines the epidemiology of traffic-related injury among adolescents as well as preventative strategies addressing the problem. Traffic-related injuries are the leading cause of death among adolescents. Males and adolescents living in rural or low income areas are most at risk from suffering a fatal traffic injury. Multiple intervention strategies are needed to reduce traffic-related injury among adolescents, including educational, behavioural and environmental approaches. Legislation combined with community-based education campaigns may be the most effective approach to injury prevention.
Liban *et al.*	1987	HBM	Serious offender Young adult	22	*Outcomes: Effect of drink-driving behaviour interventions.* Authors review drink-driving behaviour interventions implemented and evaluated in Canada. Canadian legal, educational and rehabilitative intervention strategies applied separately and in combination have, for the most part, demonstrated limited and short-term efficaciousness for drinking and driving prevention. Discrepancies exist between the driving public's perceived risk of arrest and actual risk of detection, and contribute to poor outcome of legal countermeasures. Effective interventions addressing alcohol-related crashes must either reduce the quantity and/or frequency of drink-driving or reduce the quantity and frequency of drinks consumed by potential drivers. Interventions failing to address the multiple factors contributing to drink-driving behaviour will be unsuccessful. Additionally, collaboration between the public and private sector should be strived for in order to reduce alcohol-related crashes.

Authors	Year	Theory	Population	*n*	Results
Lund and o'Neill	1986	TRC HBM	Adolescent Young adult		*Outcomes: Perceived risk as a predictor of driving behaviour.* The review discusses the contradictory evidence about the validity of the Theory of Risk Compensation. The authors argue that drivers think more about the task of driving and accomplishing that task as effectively (quickly/safely) as possible, rather than thinking about the risks involved. Therefore, perceived risk may not be the best construct to address in health decision-making. Perceived risk was found to be resistant to change and not very predictive of traffic behaviour.
Mann *et al.*	1986	TRA/TPB SCT HBM	Adolescent	11	*Outcomes: Effect of school-based programmes on drinking and driving behaviour.* The review examines school-based programmes for the prevention of drinking and driving. Most studies showed some effect on knowledge and attitudes of informational and affective programmes. Some effect was found on drinking and driving behaviours. Short-term effects in knowledge and attitudes have been found in the small number of school-based drinking and driving programmes that have been evaluated. Nonetheless, the effect disappears over time. Impact on behaviour has been sparsely studied, while no studies have examined the impact on traffic safety indices. Authors note a need for more well-designed studies to examine the impact of these programmes on traffic safety.
Mayhew and Simpson	2002	SCT	Young adult Adolescent		*Outcomes: Impact of driver education programmes on traffic safety.* The authors suggest there has been little support for the hypothesis that formal driver instruction is an effective safety measure. Traditional programmes fail to properly address the age and experience related factors that increase the risk of collision among young drivers. Driver education programmes should be empirically based and focus on age-related factors that contribute to collisions, including overconfidence and other psychosocial factors that contribute to risky driving behaviour. Authors also acknowledge a need for more research to improve the understanding of the behaviours and crash experience of novice drivers.

Authors	Year	Theory	Population	*n*	Results
McKnight and Peck	2003	TRA/TPB SCT	Adolescent		*Outcomes: Effect of graduated drivers licensing on traffic safety.* The authors reviewed four sources of safer driving related to graduated driver licensing (GDL): extended learning, early intervention, contingent advancement, and multistage instruction. The authors discuss each source and the available evidence as to their effectiveness, and conclude that while the various elements of GDL have demonstrated potential benefit in enhancing the safety of novice drivers, considerable improvement in the nature and enforcement of GDL requirements is needed.
Morrison *et al.*	2003	SCT	General driver population	28	*Outcomes: Crash incidence and traffic-violations.* Programmes including traffic calming and drink-driving legislation decreased crash incidence and traffic violations. Driver improvement and education courses were associated with a greater number of crashes and traffic violations, suggesting they may have deleterious effects.
Nichols	1994	SCT TRA/TPB	Serious offender Young adult Adolescent Child		*Outcomes: Safe driving behaviours.* The author provides a historical overview of the role of education programmes in promoting safe driving behaviours, highlighting the primary role of legislation and the complementary role of education and public information campaigns. Findings suggest that education programmes have been effective in education advocacy groups, which then push for legislation. Neither mass media nor educational campaigns are successful by themselves. They must be combined with legislation and enforcement.

Authors	Year	Theory	Population	*n*	Results
Nochajski and Stasiewicz	2006	DT Social Control Theory Cognitive-Behavioural Model TTM SCT	Serious offender	131	*Outcomes: DUI relapse.* This review focuses on the issue of DUI relapse and recidivism, providing an overview of currently used definitions, theoretical models, characteristics of offenders, and commonly applied interventions. Definitions of DUI relapse range from driving after having consumed any alcohol or drugs, to driving above legal levels of intoxication, to the most frequently used subsequent DUI arrest. Concerns related to using law enforcement records are raised, including underestimation of relapse and wide variation of enforcement and record-keeping over time and between locations. Models of DUI relapse used in criminal justice tend to be based on Deterrence Theory and Social Control Theory. In addictions research Cognitive-Behavioural Theory and the Transtheoretical Model are more commonly used. DUI offenders are highly heterogeneous, however research indicates that repeat offenders are more likely to be male, to continue the behaviour, be poor drivers, have criminal histories, be heavier users of alcohol and drugs, and suffer from mental health issues. Interventions most commonly used are legal sanctions and rehabilitation programmes. Legal sanctions usually either attempt to deter or incapacitate offenders through licence actions, fines, probation or vehicle immobilisation. Deterrence generally is most effective when immediate and certain consequences result and appear to be effective in decreasing DUI recidivism. Rehabilitation can focus on education, treatment, or harm reduction, and whether such interventions are effective is not clear.
Tursz	1997	TRA/TPB HBM	Adolescents Young adults		*Outcomes: Driving-related mortality and morbidity.* Peaks in driving-related mortality and morbidity rates map to countries' initial driving ages. In Europe, crash rates among 20–24-year-olds are much higher than those found in 15–19 years. In the USA, crash rates peak among 16–19-year-olds. Car accidents that are among the principal causes of death in 15–19-year-olds and 20–24-year-olds suggest a recent increase in crashes among female drivers. While rates were low for use of seat belts in this population, there is some evidence to suggest an increase in the use of safety belts with age.

Authors	Year	Theory	Population	*n*	Results
Vernick *et al.*	1999	SCT	Adolescent	9	*Outcomes: Individual and community crash rates.* Review examined whether graduates from driver education courses were less likely to be involved in a crash and whether they were more likely to receive their driver's licence as compared to high schoolers who did not complete driver education. The review also looked for associations between communities with driver education courses and lower community rates of crashes among high school aged drivers. Authors did not find that driver education reduces crashes for graduates or reduces crashes within the community where the course is offered. The authors ask that policy makers reconsider laws, which allow adolescents to receive their licences early if they complete driver education, as there was evidence that driver education courses were associated with higher crash involvement rates for younger drivers.
Voas and Deyoung	2002b	SCT DT	Serious offender		*Outcomes: Limiting illegal driving in suspended licence holders.* Review focused on studies evaluating vehicle action programmes (vehicle plate actions, vehicle impoundment/immobilisation and vehicle forfeiture) that have been implemented to restrict the continued driving practices of convicted drivers following their post-licence suspension. The Authors conclude that all the programmes reviewed showed positive effects, however vehicle impoundment had the strongest evidence and appeared to be the easiest programme to implement in different jurisdictions. Important lessons learned from the application of vehicle sanction programmes are listed.
Waller	2003	SCT DT	Young adult Adolescent		*Outcomes: Graduated driver licensing.* Author discussed the early research that led to graduated driver licensing, some of the educational principles on which it is based, obstacles to its acceptance, and some of the early efforts in the US and elsewhere.
Williams and Wells	2004	DT SCT HBM			*Outcomes: Seat-belt use.* The authors suggest that seat-belt laws and continued, highly publicised, law enforcement have consistently been effective means of increasing seat-belt use. Furthermore, primary seat-belt enforcement laws are more effective than secondary seat-belt enforcement laws.

Authors	Year	Theory	Population	*n*	Results
Bunn *et al.*	2003	SCT	General driver population	12	*Outcomes: Fatal and non-fatal traffic injuries.* Within high-income countries, area calming strategies decreased the number of fatal and non-fatal traffic injuries.
Dinh-Zarr *et al.*	2001	TRA/TPB SCT	General driver population	46	*Outcomes: Seat-belt use, fatal and non-fatal crash-related injuries,* Primary seat-belt use laws were most effective to decrease crash-related injuries and to increase seat-belt use. The effects of these programmes were most notable for women. Although older drivers had higher safety belt use rates overall, the fact that adolescent drivers had a lower use rate at baseline did not keep them from experiencing the same percentage increase in use as other groups. While there was no evidence to suggest increased safety belt use decreased risky driving behaviours, adults who did not use safety belts were also less likely to buckle up children than adults who did report safety belt use.
Ker *et al.*	2003	SCT RHT	Serious offenders	20	*Outcomes: Fatal and non-fatal crashes.* Compared to studies that did not contain a post-licensure driving education programme, post-driving education programmes had no effect on traffic outcomes. Furthermore, there were no differences between types of post-driving education approaches.
Ker *et al.*	2005	SCT	Serious offenders	21	*Outcomes: Fatal and non-fatal injuries and crashes.* Studies included did not support post-licensing driver education programmes as effective in preventing road traffic injuries. Small effects were found for post-licensing driver education programme's efficacy in decreasing crashes.

Authors	Year	Theory	Population	*n*	Results
Masten and Peck	2004	DT PBT	Serious offenders	35	*Outcomes: Crash and traffic violation incidence.* The three most common primary treatment components of the driver improvement programmes were warning letters (30%), group meetings (30%) and individual meetings (15%), but most of the programmes had multiple components (50%). Although the estimated crash effect size combined across all treatments was significant, there were mixed results within each treatment group. Primary prevention programmes explained some of this heterogeneity. Suspension and revocation licence programmes were most likely to lead to reduced crashes, followed by licence extensions and individual meetings, group meetings and letters. Mailed brochures, point reductions and 'other' interventions, such as films and test drives, were ineffective. Programmes started by licensing agencies had a stronger effect than those initiated by courts.
Pilkington and Kinra	2005	SCT	General driver population	14	*Outcomes: Fatal and non-fatal crashes.* All studies reported a protective effect on traffic safety when traffic cameras were installed. However, there was great variation on the effect size of cameras to decrease collisions (5–69%), non-fatal injuries (12–65%) and fatal crashes (17–71%).
Struckman-Johnson *et al.*	1989	TRA/TPB SCT	Serious offenders	59	*Outcomes: Traffic violations and crashes incidences.* Driver improvement strategies decreased violations. However, driver improvement strategies increased the likelihood of crashes. The difference in effect between crashes and violations could not be explained by the delivery of the programme, whether direct or indirect, of driver improvement programmes. Moderate evidence did suggest that individual instruction had better outcomes than group instruction.

Authors	Year	Theory	Population	*n*	Results
Wagenaar *et al.*	1995	DT	Serious offenders	125	*Outcomes: Non-alcohol-related crashes and alcohol-related crashes.* Meta-analysis assessed the quantity and quality of DWI evaluation programmes (administrative licence suspension, implied consent, breath tests, jail sentence, mandatory community service, mandatory licence suspension, limitations on plea bargaining and mandatory fine). All of the DWI control efforts were associated with reductions in drink-driving and traffic crashes. However, authors were unable to calculate effect sizes due to high variation in studies' quality.
Wells-Parker *et al.*	1995	DT	Serious offender	215	*Outcomes: Drink-driving, non-alcohol-related crashes, alcohol-related crashes.* Remediation programmes had better outcomes than no-remediation for drink-driving and alcohol-related crashes. However, the average effect of these programmes was small (8–9%). Variations in effect sizes depended on the programme modality. Multi-component programmes including education, counselling and probation had the strongest effect. Authors conclude that treatment effects are probably underestimated in the literature due to overemphasis on education as a treatment for all offenders and drinking/driving recidivism as the most frequent measure of outcome.

APPENDIX 2

Reviewer guide

Theory section

*1. What do you do if the theory used in the study is **not** in the FileMaker list?*

If a theory deserves consideration, then it should be added to the Theory list. Click on 'Edit' in the pull-down menu and type the name of the theory. Once you pull down the Theory options, the new theory will be available for selection.

2. What do you do if the authors of the manuscript call a variable something different from what it would be called as a psychosocial construct, even though they mean the same thing?

In the 'Constructs' box, type the name of the psychosocial construct. Then, according to the type of construct, type the name used by the study's authors.

For example, an author labelled a variable as 'parental influence on adolescent's driving behaviour', yet their operationalisation refers to an adolescent's motivation to comply with parents' beliefs about driving. As this variable is similar to one of the TRA/TPB's constructs, 'Subjective norm' would be written in the 'Construct' box and then clarified in the 'Attitudes/Beliefs' box (i.e. 'Subjective norm (Parents' influence on adolescent's driving behaviour)').

3. What goes under Knowledge?

Knowledge includes any construct or operationalised variable referring to a fact related to driving or an associated behaviour.

For example, if an article assessed whether participants have been educated on how to avoid fishtailing in the snow, then the reviewer would write something like 'Steps to prevent fishtailing in the snow'.

4. What goes under Beliefs/Attitudes?

Beliefs and Attitudes include any construct or operationalised variable referring to expectancies and the respective evaluation of these expectancies.

For example, if an article assessed participants' susceptibility and its accompanying severity of fishtailing as they are driving in the snow, then the reviewer would write: 'Perceived threat (susceptibility and severity of fishtailing in the snow)'.

5. *What goes under Skills/Capabilities?*

Skills and Capabilities include any construct or operationalised variable referring to an individual's ability to perform a behaviour.

For example, if an article assessed the extent to which individuals feel confident in not fishtailing when they drive in the snow, the reviewer would write: 'Self-efficacy (avoid fishtailing when driving in snow)'.

6. *What goes under Behaviour?*

Behaviours include any action associated with driving and measured in the study.

For example, if participants where queried on whether they place a heavy sand bag in the trunk of their car to reduce the likelihood of fishtailing in the snow, the reviewer would write: 'Places sand bags in trunk'.

7. *What do we write under Driving Outcomes/Dependent Variable?*

While the other boxes are specific to different psychosocial domains, the 'Dependent Variable' box may include any construct or operationalised variable associated with driving and measured in the study as an outcome.

For example, one study may consider 'collisions' as the dependent variable, while 'collision' may be entered in the 'BehaviourBehaviour' box because it predicts 'death on impact' in another study.

8. *Where should sociodemographic factors be written?*

If the article uses the Health Belief Model, sociodemographic factors should be included in the 'Constructs' section. Otherwise, sociodemographic factors should be noted in the 'Notes' of the Methodology section.

9. *How specific should the reviewer be in filling out each of these boxes?*

Once the article has been critiqued, another reader should be able to understand the gist of what/how a construct was measured in that study. Be concise, but provide enough information to give the reader an idea of how a construct was operationalised.

For example, under Beliefs/Attitudes, it would suffice to say: 'Attitude (drinking and driving, seat-belt use, speeding)'.

10. Where do non-psychosocial 'environmental factors' fit?

Non-psychosocial environmental factors (i.e. road type, presence/absence of an ignition lock system) may fit in different boxes. The reviewer must make an educated choice of where to place these environmental factors.

For example, studies assessing 'road type' as a predictor may have different interpretations:

(a) if the authors tested drivers' knowledge of driving in the snow, then Road Type would be under Knowledge;

(b) if the authors tested drivers' beliefs about the risks of driving in the snow, then Road Type would be under Beliefs/Attitudes; or

(c) if the authors tested the drivers' performance across different road types, then Road Type would be under Skills/Capabilities.

More than one box may be filled in these cases.

11. If a study mentions 'driving experience', what category should this construct be written under?

Like 'non-psychosocial environmental factors' (see previous question), 'driving experience' may be placed under Knowledge, Beliefs/Attitudes or Skills/Capabilities. The reviewer must assess how 'driving experience' was conceptualised and measured, and enter it into the database accordingly.

12. What if a journal article has more than one study, where/how should you write the different constructs for each study?

If a journal article has more than one study, divide the constructs per study.

For example, if there are two studies on attitudes towards driving, a reviewer would enter: 'Study 1 – Attitude (speeding, running a red light)', followed by 'Study 2 – Attitude (seat belt)'.

Methodology section

1. *What are the different design options?*

There are four design options:

- cross-sectional observational study;
- cross-sectional experiment study;
- longitudinal observational study; and
- cross-sectional experiment study.

Most studies fit this heuristic; yet, if the need arises, additional designs may be added by typing the design in after clicking on the 'Edit' option.

2. *What is the difference between a predictor study and an experiment?*

The difference between a predictor study and an experiment rests on the presence or absence of a manipulation in the study. If a study measures a set of variables without attempting to cause an effect through the manipulation of a variable, then it is a predictor study (i.e. administering a questionnaire to assess a population's attitudes toward drunk-driving). If a study manipulates a variable to cause an effect, then it is an experiment (i.e. sending a set of targeted newsletters to at-risk youth in order to increase their perceived threat about drunk-driving).

3. *If the article has various groups, what does a reviewer write under sample size?*

If there is more than one group (i.e. a treatment group and a comparison/control group), then type the **total** number of participants in a study in the sample size box. Once this box is filled, write in the 'Notes' how the participants were distributed across groups.

For example, if a study has two groups, a treatment ($n = 15$) and a control group ($n = 20$), the reviewer would add the number of participants in each group and fill that total number in the sample size box ($n = 30$). Then, the reviewer would break down this total by writing: 'Treatment ($n = 15$) and Control ($n = 20$)'.

4. *What are the different sample designs?*

There are four sample designs:

- convenience sample;
- stratified sample;

- simple random sample; and
- stratified random sample.

A **convenience sample** includes participants who were available in the study without being representative of a population through random selection (i.e. college students attending a Psych 101 class). A **stratified sample** includes respondents who participated in a study without being chosen at random from a population and who fulfilled some subgroup criteria (i.e. dividing the sample first by gender, age and/or social class, and then filling the subgroups through a convenience sample design). A **simple random sample** includes respondents who were randomly selected to participate in a study because they represent a particular population (i.e. randomly selecting adolescents living in Detroit for a special driving education programme). A **stratified random sample** includes respondents who were randomly assigned after the different subgroups had been formed (i.e. randomly selecting adolescents living in Detroit for a special driving education programme after dividing the population by whether they lived in urban or suburban households).

Most studies fit this heuristic, yet, if the need arises, additional sample designs may be added by typing the sample design in after clicking on the 'Edit' option.

5. *What are the different prevention types?*

The reviewer may select from one (or more) of three prevention types: primary, secondary and tertiary prevention. **Primary prevention** refers to any activity which prevents a negative outcome before it occurs (i.e. seat-belt use). **Secondary prevention** includes activities undertaken by people perceived to be at-risk and who wish to avoid a negative outcome (i.e. not driving after drinking). **Tertiary prevention** refers to activities undertaken by people who have experienced a negative outcome but wish to improve their outcomes (i.e. attending an alcohol-rehabilitation clinic to decrease the punishments imposed by a judge after being sentenced due to drunk-driving).

6. *What does a reviewer include under population's age range?*

Under age range, a reviewer can include the minimum and maximum ages of participants in a study. For example, in a study of the entire driving population of the United States, a reviewer could type 'Min = 15+ and Max = 100+' or could focus on a particular subgroup 'Min = 14 and Max = 26'.

7. *What ages are covered under each population of interest?*

The reviewer can select one or more population of interests in the database. There are four population of interests: child (less or equal than 12 years old), adolescent

(13–19 years old), young adult (20–26 years old) or serious offender (any age presented).

8. What does 'analytical approach' mean?

Analytical approach (or Data Analysis Strategy) suggests which statistical/qualitative methods were used to reach a study's conclusions. For example, a quantitative study may have used correlations, t-tests, ANOVAs, MANOVAs, regressions, path analysis, among others, to test differences between participants. On the other hand, a qualitative study may have used thematic coding, content analysis, grounded theory, among others, to analyse in-depth interviews or focus groups.

9. What should be included in the 'Notes' box?

The reviewer should include anything worth mentioning about the study (i.e. information about the study population, sociodemographic variables used in the analyses, questions about the study, and/or ideas and feelings about the study). For example, a sentence in the 'Notes' might read 'Interesting procedure to measure attitudes toward driving', 'The intervention activities are well-developed' or 'This article makes no sense due to poor presentation and organisation'.

10. What do you include in the 'Primary Results' box? How much detail?

In the 'Primary Results' box, study findings should be presented, especially as they pertain to psychosocial factors related to driving. The reviewer should use judgement regarding what should be included and excluded; results should be specific enough to be clear yet concisely written. Moreover, the reviewer should note tables/figures of interest. For example, 'Attitudes toward drunk-driving predicted adolescents' intention to drive while drunk after adjusting for sociodemographic variables (see Table 4)'.

11. What if the study details more than one study?

The reviewer may add information regarding more than one study by clicking on the 'New Design' button in the Methodology window. The reviewer may then scroll down to the new Methodology window.

12. How do you fill out the database fields if the article is a meta-analysis?

If the article is a meta-analysis, then the study design and sample design boxes are left empty. The reviewer should be able to write every other field. Under sample size, the reviewer may type the number of articles included in the analyses. Then, type 'Meta-analysis' in the 'Analytical Approach' box.

General questions

1. *What if an article is not relevant to the study?*

If the record does not have any relevance to the current review, the reviewer should 'flag' the article and write 'NOT RELEVANT' in the Notes section. These articles will be removed in the final version of the database.

2. *What if an article does not include information on a particular field?*

If an article does not include information to fill a particular field, the reviewer should type 'MISSING'.

3. *What if the reviewer has questions/doubts/concerns about a particular study?*

The reviewer must 'flag' the article, write down his/her questions, and contact Jose, Rashid, Vic and/or Jean. Once the question is answered, the reviewer should ensure that the others are aware of the answer to ensure consistency across reviewers.

4. *How do you save the FileMaker Pro database?*

Here are some instructions as to how to send the database without breaking it. The database is comprised of two files, Transport and Design. You need both for it to function properly, and because they use the title (Transport knows Design as such and vice versa) they have to have the consistent title:

- Modify database as needed.
- Close database. The database **automatically** saves when you close.
  Rename the enclosing folder with the date and the reviewer's name.
  Compress folder (with databases within). In Windows XP, to compress a folder right click on it. Scroll down the selections until you get to 'send to' – out of the 'send to' menu select the compressed file selection. This will create a .zip file, at the same directory as the directory you are compressing, which is the compressed version of the folder in question.
- Upload the compressed file into the CTOOLS folder with the reviewer name.