31 Driver Distraction Injury Prevention Countermeasures—Part 2: Education and Training

Michael A. Regan, John D. Lee, and Kristie L. Young

CONTENTS

31.1 Introduction 560
31.2 The Goals for the Driver Education Matrix 561
31.3 The Goals for Driver Education Matrix, Other Conceptual Frameworks, and Driver Distraction 564
31.4 Hierarchy of Competencies Needed to Educate and Train Drivers to Manage Distraction 566
31.4.1 Cells 1 to 3—Vehicle Maneuvering 566
31.4.1.1 Cell 1 (Vehicle Maneuvering—Knowledge and Skills) 566
31.4.1.2 Cell 2 (Vehicle Maneuvering—Risk Awareness) 567
31.4.1.3 Cell 3 (Vehicle Maneuvering—Self-Evaluation) 568
31.4.2 Cells 4 to 6—Mastery of Traffic Situations 568
31.4.2.1 Cell 4 (Mastering Traffic—Knowledge and Skills) 568
31.4.2.2 Cell 5 (Mastering Traffic—Risk Awareness) 570
31.4.2.3 Cell 6 (Mastering Traffic—Self-Evaluation) 570
31.4.3 Cells 7 to 9—Goals and Context of Driving 571
31.4.3.1 Cell 7 (Driving Goals and Context—Knowledge and Skills) 571
31.4.3.2 Cell 8 (Driving Goals and Context—Risk Awareness) 572
31.4.3.3 Cell 9 (Driving Goals and Context—Self-Evaluation) 573
31.4.4 Cells 10 to 12—Goals for Life and Skills for Living 573
31.4.4.1 Cell 10 (Life Goals and Skills—Knowledge and Skills) 573
31.4.4.2 Cell 11 (Life Goals and Skills—Risk Awareness) 573
31.4.4.3 Cell 12 (Life Goals and Skills—Self-Evaluation) 574

31.5 Summary and Conclusions 574
Acknowledgments 576
References 577

31.1 INTRODUCTION

In the previous chapter, options for countermeasure development were presented to prevent and mitigate the effects of driver distraction in the areas of data collection, legislation and enforcement, vehicle fleet management and driver licensing. In this chapter, options are presented for countermeasure development in the areas of driver education and training.

Distraction, as an issue, has been largely neglected in the design of driver education and training programs. The number of educational initiatives is limited and few have existed long enough to be evaluated.[1] Mayhew and Simpson[2] note the paucity of research data that exists on the level of public awareness and understanding of distraction. The data that do exist (e.g., Refs 3–7) seem to suggest that, as a whole, the driving public has little understanding of what activities are distracting, of the relative risks associated with different sources of distraction, of the impact of distraction on performance and the mechanisms that mediate its effects, and of the need to self-regulate in response to distractions other than the mobile phone. Also, there is a perception that the risk of being apprehended for violating distraction laws is low. Although there is some limited evidence, reviewed in this book, that the ability to combine competing tasks can be improved with practice, distraction as an issue has also been largely neglected in the design of driver training programs. The authors are unaware of any specific reference to distraction in the driver training literature, and there is only scant reference to distraction as an issue in training-related licensing materials issued by road authorities to learner and probationary drivers.

Driver education and training programs need to address, as a core competency, the ability of drivers to safely manage distraction. The terms "driver training" and "driver education" are poorly defined in the road safety literature. They are often used interchangeably to describe the same programs or initiatives. In attempting to separate the two, Senserrick and Haworth[8] distinguish between driver training, which focuses on the development of a specific set of skills, and driver education, which refers to the more "... contemplative and value-based instruction of knowledge and attitudes relating to safe driving behavior" and covers a broader range of topics than training, over a longer time period (p. 5). They view driver training, therefore, as a component of the broader field of driver education. Others have come to a similar conclusion (e.g., Refs 9 and 10). For the purposes of the present chapter, this would seem a reasonable distinction, although, as noted by Senserrick and Haworth,[8] it is often difficult in practice to distinguish between the two. Education programs may include some training, and training programs do not necessarily take place in isolation from driver education.

It may be artificial, and even counterproductive, to attempt to separate these two areas of countermeasure development. This is exemplified by the Goals for Driver Education (GDE) matrix,[11] which derives from the earlier work of Keskinen, 1996,

cited in Ref. 12, and illustrates how inextricably intertwined are the various elements of driver education and training. The cells in the matrix (reproduced in Table 31.1) have been used previously to define detailed competencies that are needed to be a safe driver, that can be addressed through driver education and training.[9,13] The matrix is described in the following section and provides a useful conceptual framework for determining and structuring options for countermeasure development to prevent and mitigate the effects of distraction.

Data on the effectiveness of driver training and education in reducing crashes and crash risk is equivocal, which may be bound up in problems of definition and other methodological issues that are beyond the scope of this chapter to discuss. Recent reviews of literature on the evaluation of driver education and training initiatives yield little or no evidence that either improve safety,[2,8,9,14] although there is evidence that well-designed and evaluated training programs which target specific skills critical for safe driving are effective in improving those skills (e.g., Refs 15 and 16).

Driving is a multitask activity performed at different levels of control.[17] At the strategic level, tasks include journey planning, selection of transport mode, and route choice, at a timescale of minutes to weeks. At the tactical level, tasks include adhering to traffic rules, giving way to other road users, and overtaking. The timescale at this level of control is seconds to minutes. At the operational level, tasks include lateral and longitudinal control of the vehicle, at a timescale of milliseconds to seconds. In Chapter 4, distraction was described as a breakdown in multilevel control in activities critical for safe driving and competing activities at one or more of these levels. In this chapter we assume that the ability to maintain multilevel control of driving and competing tasks requires knowledge and skills that can be acquired through education and training. In the sections that follow, options are presented for countermeasure development to support educational and training initiatives.

31.2 THE GOALS FOR THE DRIVER EDUCATION MATRIX

The GDE model, or matrix (see Table 31.1), was developed to provide a theoretical framework for defining the competencies needed to be a safe driver and the goals of driver education and training.[18] It spans competencies for basic vehicle maneuvering (bottom left corner) all the way through to self-reflection of one's personal lifestyle (upper right corner). The idea is that skills lower in the hierarchy are exercised under the guidance of higher-level goals and motives. This means that, in addition to basic driving skills, driver training and education should take into account drivers' goals connected with driving and with life itself. According to this view, failure or success at higher levels in the hierarchy will affect the demands on skills at lower levels. The model reflects the fact that drivers are individuals and that their problems and skill deficits may lie in different boxes of the matrix[12] (p. 312).

Hernetkoski and Keskinen[13] provide a succinct overview of the matrix. First, they describe the vertical hierarchy. The bottom three levels of the matrix (see Table 31.1) derive from the earlier work of Michon[17] and relate, from bottom to top, to the operational, tactical, and strategic levels of driving control, respectively. The lowest level in the hierarchy, "vehicle maneuvering," relates to knowledge and skills relevant for

TABLE 31.1
Goals of Driver Education Matrix

	Content of Driver Education		
Hierarchical level of behavior (extent of generalization):	**Knowledge and skills the driver has to master**	**Risk-increasing factors the driver must be aware of and be able to avoid**	**Self-evaluation**
Goals for life and skills for living (global)	**10.** Knowledge about/control over how life goals and personal tendencies affect driving behavior: • Lifestyle • Group norms • Motives • Self-control • Personal values • etc.	**11.** Risky tendencies: • Acceptance of risks • Self-enhancement through driving • High level of sensation seeking • Complying to social pressure • Use of alcohol and drugs • Values, attitudes toward society • etc.	**12.** Self-evaluation/awareness of: • Personal skills for impulse control • Risky tendencies • Safety-negative motives • Personal risky motives • etc.
Goals and context of driving (specific trip)	**7.** Knowledge and skills on: • Effect of trip goals on planning • Planning and choosing routes • Evaluation of driving time • Effects of social pressure in car • Evaluation of necessity of trip • etc.	**8.** Risks connected with: • Driver's condition (mood, BAC, etc.) • Purpose of driving • Driving environment (e.g., urban/rural) • Social context and company • Extra motives (competing, etc.) • etc.	**9.** Self-evaluation/awareness of: • Personal planning skills • Typical goals of driving • Typical risky driving motives • etc.

Mastery of traffic situations (specific situation)	**4.** Knowledge and skills on: • Traffic rules • Observation/selection of signals • Anticipation of course or situation • Speed adjustment • Communication • Driving path • Driving order • Distance to others/safety margins	**5.** Risks caused by: • Wrong expectations • Risky driving style (e.g., aggressive) • Unsuitable speed adjustment • Vulnerable road users • Not obeying rules/unpredictable behavior • Information overload • Difficult conditions (e.g., darkness) • Insufficient automatism/skills	**6.** Self-evaluation/awareness of: • Strong and weak points of basic traffic skills • Personal driving style • Personal safety margins • Strong and weak points of skills for hazard situations • Realistic self-evaluation • etc.
Vehicle Maneuvering	**1.** Knowledge and skills on: • Control of direction/position • Tire grip and friction • Vehicle properties • Physical phenomena • etc.	**2.** Risks connected with: • Insufficient automatism/skills • Unsuitable speed adjustment • Difficult conditions, low friction, etc.	**3.** Self-evaluation/awareness of: • Strong and weak points of basic maneuvering skills • Strong and weak points of skills for hazard situation • Realistic self-evaluation

Source: Adapted from Hatakka, M., Keskinen, E., Hernetkoski, K., Gregerson, N. P., and Glad, A., In *Driver Behaviour and Training*, Dorn, L. (Ed.), Ashgate, England, United Kingdom, 2003, p. 313. With permission.

basic vehicle handling such as accelerating, braking, changing gears, steering, and so on. The second lowest level, "mastery of traffic situations," relates to knowledge and skills relevant for adaptation of driver behavior to the behavior of other road users and to the traffic environment. This includes perception and anticipation of the behavior of other road users, making the driver's own behavior predictable to others, and knowledge of and adherence to traffic rules. The third level relates to the "goals and context of driving." At this level, drivers decide for what purpose, where, with whom, with what, and at what time to drive. This level relates to decisions about planning and choosing of the driving route, driver state, and the company of passengers. The highest level in the hierarchy is labeled "goals for life and skills for living." This refers to the motives and goals of the person in a broad sense, and includes personal skills for handling different situations of life in general (Keskinen, 1996, cited in Ref. 13).

The horizontal dimensions of the model, going from left to right, describe the competencies that are needed to be a safe driver. The first column, "knowledge and skills," describes what a good driver needs to know and be able to do at each of the four vertical levels to drive a vehicle safely and cope with traffic. The lower half of the column encompasses competencies that are addressed in traditional driver training programs. The upper half encompasses competencies that are being increasingly addressed in postlicensing training programs.[13] The second column, "risk-increasing factors," relates to the first but emphasizes knowledge and skills related to factors that increase or decrease crash risk, ranging from those connected directly to driving conditions (e.g., the effects of ice and snow) through to risks deriving from social pressure and lifestyle (at the upper end of the column). The competencies in the lower half of this column are usually addressed in defensive driving courses and so-called insight learning courses[12] (p. 314). The third column, "self-evaluation" refers to the process of reflective thinking whereby an individual tries to get feedback on his or her personal actions "from within the self"[13] (p. 56). The idea here is to train self-evaluative skills, which "are a feature of experts and do not develop automatically"[12] (p. 314).

31.3 THE GOALS FOR DRIVER EDUCATION MATRIX, OTHER CONCEPTUAL FRAMEWORKS, AND DRIVER DISTRACTION

It is beyond the scope of this chapter to prescribe instruction theories, methods, and media that are appropriate for imparting, through education and training, the skills, knowledge, and attitudes necessary to prevent and mitigate the effects of distraction. Other reference sources provide guidance on this issue for driver education and training generally (e.g., Refs 8, 9, 19–22). It is possible, however, to use the GDE matrix to define, in a systematic way, some basic competencies that might be addressed in driver distraction education and training programs. To this end, the cells of the GDE matrix have been numbered in Table 31.1, from 1 to 12. In the following section of the chapter we consider, for each cell in the matrix, distraction management competencies that might be addressed in driver education and training programs.

The GDE matrix is only one conceptual framework that can be used for this purpose. The ideas presented in Chapter 4 provide another perspective from which to derive education and training needs. In that chapter, driving, as a control process, was described at three levels (operational, tactical, and strategic), each operating at

different time horizons. The three levels were also used to describe the control of attention to competing activities. At the operational level drivers control resource *investment*; at the tactical level they control task *timing*; and at the strategic level they control *exposure* to potentially demanding situations. Distraction-related mishaps result from a breakdown of control at any one level, and from the accumulation of control problems that compound as they propagate across levels. In the following section, we also identify, within the relevant cells of the GDE matrix, distraction management competencies deriving from this perspective that might be addressed in driver education and training programs.

The GDE matrix defines a hierarchy of competencies needed to be a safe driver of current generation vehicles. However, as noted in previous chapters, the driving task is rapidly evolving as new technologies (e.g., in-vehicle navigation, intelligent speed adaptation, adaptive cruise control) make their way into the cockpit that automate, partly or fully, some elements of driving. This has important implications for education and training, particularly as it relates to the management of distraction. Relevant here is a conceptual framework proposed by Donmez et al.[23] (see Table 31.2). Donmez et al. distinguishes between driving- and nondriving-related mitigation strategies for driver distraction that are applicable for different levels of system automation. Table 31.2 provides a framework for considering the various mechanisms by which technology can be used to minimize distraction, by moderating the demands of both the driving task and competing tasks. The table shows, in the left column, three levels of automation—high (automation takes control and ignores human), moderate (automation executes action only if human approves) and low (human does it all)—that can be used in designing a distraction mitigation system. The table further distinguishes between driving-related (e.g., steering, braking) and nondriving-related tasks (e.g., tuning a radio, talking on a mobile phone). Strategies that address driving-related tasks focus on the roadway environment and directly support driver control of the vehicle, whereas strategies for nondriving-related tasks focus on modulating driver interaction with telematics devices.[23,24] Within each of these strategies (i.e., driving and nondriving related), the support provided by technology can be system or

TABLE 31.2
Mitigation Strategies for Driver Distraction

	Driving-Related Strategies		Non-Driving-Related Strategies	
Level of Automation	**System Initiated**	**Driver Initiated**	**System Initiated**	**Driver Initiated**
High	Intervening	Delegating	Locking and Interrupting	Controls-presetting
Moderate	Warning	Warning tailoring	Prioritizing and filtering	Place keeping
Low	Informing	Perception augmenting	Advising	Demand minimizing

Source: Adapted from Donmez, B., Boyle, L. N., and Lee, J. D., *Human Factors*, 48(4), 786, 2006. With permission.

driver initiated. Within this conceptual framework, drivers interact with technology to varying degrees, depending on the particular mitigation strategy employed. These technologies, in turn, introduce new training needs, which will vary according to whether the strategies employed are system initiated or driver initiated.

In the sections that follow we consider, using the GDE matrix as the principle organizing structure, distraction education and training needs from the perspectives of all three of these frameworks.

31.4 HIERARCHY OF COMPETENCIES NEEDED TO EDUCATE AND TRAIN DRIVERS TO MANAGE DISTRACTION

In Table 31.1, the cells of the GDE matrix have been numbered from 1 to 12. In this section we consider, for each cell in the matrix, distraction management competencies that might be addressed in driver education and training programs. These derive from the three conceptual frameworks described earlier.

31.4.1 Cells 1 to 3—Vehicle Maneuvering

31.4.1.1 Cell 1 (Vehicle Maneuvering—Knowledge and Skills)

This cell of the GDE matrix pertains to knowledge and skills the driver has to master relating to vehicle handling; that is, to control of the vehicle and knowledge of vehicle properties, tire grip and friction, physical phenomena, and so on.

From a distraction perspective this cell is relevant to driver operation of vehicle systems that have potential to distract them, whether they be factory fitted, aftermarket, or nomadic. It is critical within this cell of the matrix that drivers develop the knowledge and skills they need to use systems, design features, and functions in a manner that minimizes the potential for saturation effects at the operational level of control (see Chapter 4) and hence minimizes distraction. Several recommendations can be made here.

Drivers need to be able to operate vehicle systems in a way that minimizes distraction. Here, for example, it is critical to ensure that drivers be aware of design features in their vehicles (e.g., steering wheel-mounted controls, speed alerters and limiters) that have potential to limit distraction and that drivers be able to use these features in the manner that is least distracting.

Drivers need to be able to perform all *competing* tasks that are nondriving-related and legally allowed (e.g., tuning radios, adjusting climate control systems, using hands-free mobile phones) in a way that minimizes distraction. Here, for example, it is critical to ensure that drivers are aware of design features in their vehicles (e.g., radio presets, steering wheel controls, voice-activated dialing) that have the potential to limit distraction and that drivers are able to use these features in a manner that is least distracting.

Where vehicles are equipped with advanced driver assistance systems (e.g., in-vehicle navigation systems, adaptive cruise control), it is critical that drivers be aware of those system functions and features that have the potential to distract them and that drivers are able to operate the system in the manner that is least distracting.

Where vehicles are equipped with real-time distraction mitigation systems (e.g., workload managers and distraction warning systems), drivers must be able to operate the systems in the manner intended.

Drivers must be made aware of, and be prepared for, unexpected or unwanted system functions and operations that have potential to distract them (e.g., seatbelt reminder warnings, low fuel warnings, radio mute functions which suddenly deactivate and startle the driver).

Drivers need to be trained how and under what circumstances automation in a vehicle cockpit is system initiated (see Table 31.2). For example, if a system warns a driver (under "driving related strategies") to take a necessary action (e.g., slow down, increase headway) and if the driver fails to self-regulate early in a chain of events in response to the demands of a distracting task or is judged to be too distracted to react in a timely manner later in the chain, it is important that the driver understand the meaning and intent of the information displayed.

Where the system intervenes to take control of the vehicle (see Table 31.2), for example if the driver fails to self-regulate or is it too distracted to react in a timely manner, and this intervention is noticeable to the driver, training can be important in demonstrating system effectiveness and promoting trust in system operation. On the other hand, if a system locks out or interrupts (under "nondriving activities"; see Table 31.2) information displayed by a telematics device because the demands of the driving situation are judged to be too high, knowledge of system operation may not be necessary. If the system locks out access to control functions, however, knowledge of system operation may be desirable to ensure driver acceptance of the system.

Training is likely to be more important where the provision of automation is driver initiated (see Table 31.2). Drivers may, for example, delegate authority to a system, so that it warns them or takes control of the vehicle if it judges that they are failing to self-regulate or are too distracted to react in a timely manner when interacting with a competing task. Under such circumstances, drivers need to know when and under what circumstances it is appropriate to delegate authority to a system, and what form the level of intervention will take.

From an automation perspective, training is likely to be most important for "nondriving-related strategies" (see Table 31.2) that are driver initiated in relation to telematics devices with low levels of automation. In this case it is important for drivers to know, for example, which modes of operation for a particular telematics device are least distracting (i.e., demand minimizing).

31.4.1.2 Cell 2 (Vehicle Maneuvering—Risk Awareness)

Cell 2 covers vehicle maneuvering factors that increase risk and that the driver must be aware of and be able to avoid, such as vehicle properties, friction, and so on.

From a distraction perspective, education and training have several roles to play here:

- To ensure that drivers understand what distraction is
- To ensure that drivers understand why, when, and how vehicle systems, design features, and functions can distract them

- To ensure that drivers understand the limitations of real-time distraction mitigation systems, so that they do not become complacent and believe that they can divert attention away from activities critical for safe driving in circumstances that will not be detected by the system
- To ensure that drivers understand the adverse effects that distraction can have on their driving performance (e.g., impaired event detection, lateral and longitudinal control)
- To ensure that drivers understand the relative risks associated with interaction with vehicle systems, design features, and functions that are known to degrade safety
- To make drivers aware of how inclement road conditions can interact with distracting activities to undermine their performance

31.4.1.3 Cell 3 (Vehicle Maneuvering—Self-Evaluation)

Cell 3 focuses on awareness and self-evaluation of personal strengths and weaknesses in relation to driving skills, maneuvering in hazardous situations, and so on.

In this case, education and training have three main roles to play in relation to distraction:

- To make drivers reflect on their own strengths and weaknesses in their ability to limit distraction when using vehicle systems, design features, and functions
- To expose drivers, in a safe environment, to distractions deriving from inappropriate operation of vehicle systems, design features, and functions within vehicles they drive, enabling them to reflect and become self-aware of the impact of these distractions on their driving performance
- To support feedback control (see Chapter 4) by making drivers self-aware of the effects of distraction deriving from inappropriate operation of vehicle systems, design features, and functions that have no overt impact on performance in normal conditions (e.g., cognitive distraction when talking on a mobile phone) but which could compromise performance and safety in safety-critical situations (e.g., when a pedestrian unexpectedly steps out from behind a parked car)

31.4.2 Cells 4 to 6—Mastery of Traffic Situations

31.4.2.1 Cell 4 (Mastering Traffic—Knowledge and Skills)

Cell 4 pertains to knowledge and skills the driver has to master relating to road rules, speed adjustment, safety margins, signaling, and so on.

The perspective in this cell is that the driver is operating not in isolation but in conjunction with other road users. At this level of the GDE matrix, it is usually assumed that drivers are operating at the tactical level of control. From a distraction perspective, however, drivers must control both resource investment (operational control) and task timing (tactical control) in managing distraction in traffic situations. Hence, following from the discussion in Chapter 4, it is assumed that in managing

distraction the driver is operating at this level of the matrix at both the tactical and operational levels of control. Drivers need to know how to control resource investment and task timing in a range of traffic situations. From a distraction perspective, education and training have several roles to play here.

Education is important in providing drivers with knowledge about road laws and regulations designed to limit distraction.

Training is necessary to support feedback control (see Chapter 4) and to enable drivers to make the best use of feedback that leads to immediate performance improvement in response to distraction—for example, to train them to interpret and respond appropriately to warnings and feedback from real-time distraction mitigation systems and from tactile edge lines on roads.

Similarly, training can support feed-forward control (see Chapter 4) by equipping drivers with the ability to better anticipate and respond to the demands of driving and of the other objects, events, and activities that compete for their attention. Training products and techniques that have been developed to improve young drivers' ability to detect, perceive, and respond to actual and potential traffic hazards (e.g., Refs. 16, 25–28) could also improve feed-forward control.

Training programs for enhancing situation awareness (e.g., Ref. 29) could support feed-forward control by helping the driver develop an accurate internal model of the future state of the traffic system (see Chapter 4).

Improving drivers' ability to combine driving and competing tasks can limit distraction. Relevant research in this area has been conducted in the aviation domain (to improve the attention-sharing ability of military pilots; Gopher, 1992) and in the driving domain.[26] A CD-ROM-based training product has been shown in a simulator evaluation study to significantly improve the attention-sharing skills of young novice drivers.[16] Products such as this have the potential to support adaptive control at both the operational and tactical levels of control (see Chapter 4).

Drivers need to be able to self-regulate at the tactical level of control—to know *when* it is appropriate to adjust their driving behaviors to compensate for the added or anticipated load imposed by a competing task (e.g., when approaching an intersection; when hearing an ambulance siren; when driving into a storm); and, conversely, to know when to moderate their interactions with competing tasks to minimize interference with the driving task (e.g., when a conversation with a passenger becomes too complex or emotional). Training can facilitate development of this ability.

Similarly, drivers need training in how to self-regulate at the operational level of control—that is, to know *how* to adjust their driving behavior to compensate for the added or anticipated load imposed by a competing task (e.g., by slowing down, increasing headway, taking an easy route, avoiding bad weather), and, conversely, to know how to moderate their interactions with competing tasks to minimize interference with the driving task (e.g., by using speed-dial on a mobile phone, avoiding complex or emotional conversations, avoiding reading and sending text messages).

Distraction can also be reduced by improving the ability of drivers to interrupt competing activities and return to activities that are critical for safe driving. Concurrent feedback (see Chapter 29) provides a suitable mechanism for enhancing this ability.

Finally, training can play an important role in enabling drivers to adopt a graded rather than a "brittle" resource allocation and performance tradeoff when interacting with competing tasks (see Chapter 4).

31.4.2.2 Cell 5 (Mastering Traffic—Risk Awareness)

Cell 5 covers risk-increasing factors relating to the selection of inappropriate speeds, narrow safety margins, neglect of road rules, difficult driving conditions, vulnerable road users, and so on.

From a distraction perspective, education and training have several roles to play here:

- To provide drivers with knowledge about the full range of activities that have potential to distract them (see Chapter 15)
- To provide drivers with knowledge about the adverse effects of different distracting activities on performance (see Chapters 11 through 14), and the mechanisms that moderate these effects (see Chapters 3, 4, and 19)
- To provide drivers with knowledge about the relative risks associated with different sources of distraction (see Chapters 15 through 17)

It is important that drivers understand that the distraction posed by a competing activity may persist even after it has ended, for example when they continue to think about aspects of the driving task or about what they have just seen on an advertising billboard.

31.4.2.3 Cell 6 (Mastering Traffic—Self-Evaluation)

Cell 6 focuses on driver awareness and self-evaluation of personal skills, driving style, hazard perception, and so on, from the viewpoint of strengths and weaknesses. Education and training have several roles to play here:

- To expose drivers in a safe environment to high risk distractions to enable them to become self-aware of the impact of these distractions on their driving performance.
- To make drivers self-aware of the effects of distractions deriving from different sources which have no overt impact on performance (e.g., cognitive distraction when talking on a mobile phone) but which can compromise performance and safety in safety-critical situations (e.g., when a child chasing a ball unexpectedly runs across the road into the path of a vehicle). This supports feedback control at the operational level of control (see Chapter 4).
- To make drivers self-aware of the effects of distraction on their driving performance when in different driving states (e.g., when fit to drive, when fatigued, drowsy, emotionally upset, inebriated, and so on).
- To make drivers self-aware of the differential effects of distraction on their driving performance when driving at different speeds, on different routes and in other situations that moderate their vulnerability to distraction.
- To make drivers self-aware of strengths and weaknesses in their ability to self-regulate in response to distraction.

- To make drivers self-aware of strengths and weaknesses in their ability to take into account future demands as well as current demands in deciding whether, when and how to attend to competing tasks.
- To make drivers self-aware of their strengths and weaknesses in being able to determine when their driving performance is being compromised by distraction to a dangerous degree.
- To calibrate drivers, so that they acquire the ability to match the joint demands of driving (with and without competing tasks) to their own driving capabilities[30,31]—and, in doing so, to support and enhance adaptive control (see Chapter 4).

31.4.3 Cells 7 to 9—Goals and Context of Driving

31.4.3.1 Cell 7 (Driving Goals and Context—Knowledge and Skills)

Cell 7 pertains to journey-related knowledge and skills the driver has to master such as the effect on safety of goals, environment choice, effects of social pressure, evaluation of necessity to drive, and so on.

Drivers at this level of the matrix are operating at the strategic level of control. At this level they control exposure to potentially demanding situations. Here, drivers require knowledge and skills to develop and optimize strategic control. From a distraction perspective, education and training have several roles to play here.

First, education is important in providing drivers with knowledge about driving routes, situations, and scenarios in which drivers are most vulnerable to the effects of distraction (see Chapters 16, 17, and 19).

Second, education and training can provide drivers with knowledge and skills that enable them to plan and manage their interactions with competing tasks that are known to be contributing factors in crashes (see Chapter 15):

- When interacting with *things brought into the vehicle* (e.g., to plan a route beforehand to minimize eyes off-road-time when navigating using a paper map; not to use the phone while driving; if it is necessary to use a mobile phone, to use a hands-free phone and keep calls short; to tell the person at other end of the mobile phone that they are driving)
- When interacting with *vehicle controls and devices* (e.g., using radio preset buttons to find a radio station rather than a more distracting mode of operation; choosing to dial a phone only during the day on straight roads rather than at night on curves)
- When interacting with *vehicle occupants* (e.g., looking at them infrequently rather than frequently when conversing with them; using them as copilots to assist with driving tasks such as navigation or to answer the car or cellular phone if it rings)
- When interacting with *objects that move or have potential to move within the vehicle* (e.g., properly restraining animals prior to departure; placing drink containers in locations where they won't fall over and spill)

- When engaging in *internalized activities* (e.g., to the extent that it is possible, choosing when and where to allow themselves to daydream)
- When engaging with *external objects and events* (e.g., choosing not to dwell visually on crash scenes; using optimal search strategies to safely navigate to a destination)

Third, education and training can support feed-forward control by developing in drivers the ability to anticipate the confluence of driving and competing task events (see Chapter 4).

Education and training can also play an important role in training drivers and passengers to cooperate as a team in the vehicle cockpit to limit distraction. Regan et al.,[32] for example, have advocated the use of team training techniques, such as Crew Resource Management (CRM), to equip young passengers with the skills, knowledge, and attitudes required to behave and perform as copilots rather than as backseat drivers when traveling with young drivers. This includes performing some secondary tasks for the driver to reduce exposure to risk (e.g., answering the phone), performing for the driver some aspects of the driving task itself (e.g., navigating, alerting the driver to unnoticed hazards) and in behaving in a way that minimizes distraction (e.g., moderating conversation with drivers when traveling through busy intersections).

Finally, following from Table 31.2, education and training have two additional roles to play:

- Where there is *system* initiation of technologies that automatically regulate driver exposure to distraction (e.g., workload managers; see Table 31.2), drivers need to understand the manner and circumstances under which this occurs. A lack of such understanding might generate distraction—for example, if a driver is expecting a phone call that does not arrive when expected because it is temporarily suppressed by a workload manager.
- Where there is *driver* initiation of technologies that regulate driver exposure to distraction (see Table 31.2), drivers need to know when, and under what circumstances, it is appropriate to initiate the technology, and what form the level of intervention will take.

31.4.3.2 Cell 8 (Driving Goals and Context—Risk Awareness)

Cell 8 covers risk-increasing factors the driver must be aware of and be able to avoid relating to trip goals, driving state, social pressure, purpose of driving, and so on. From a distraction perspective, this cell in the matrix is concerned with factors that increase the risk of having a distraction-related crash that relate to trip goals, driving state, social pressure, and so on.

Drivers require knowledge about factors at this level of the matrix that moderate distraction-related crash risk, such as driver state (e.g., fatigued, inebriated), productivity pressures (e.g., when driving for work purposes), circumstances that act to displace the primacy of their social role as driver (e.g., when tending to a screaming child; when using an iPod; when interacting socially with passengers; see Chapter 2), age, experience, driving routes, and travel patterns (e.g., day versus night driving).

The technologies that drivers interact with provide a mechanism for regulating their exposure to distraction, and hence their exposure to risk. The different distraction mitigation strategies shown in Table 31.2 involving the use of technology can affect driver exposure to distraction in different ways, some of which have implications for training. As noted in Chapter 2, for example, driving is, in its current form, a "satisficing" task—it does not require continuously perfect behavior and total attention, which leaves free attentional resources that drivers can use to do other things that might distract them. Mitigation strategies in Table 31.2 that involve high levels of automation, therefore, are likely to make the driving task more "satisficing" than it already is, perhaps encouraging drivers to take on other roles which expose them to other forms of distraction. In this context, the role of education and training should be to make drivers aware of the potential risks that may arise in using free attentional resources to willingly engage in distracting activities that have potential to compromise their safety.

31.4.3.3 Cell 9 (Driving Goals and Context—Self-Evaluation)

Cell 9 concerns awareness and self-evaluation of personal planning skills, typical driving goals, and driving motives. The role of education and training is to develop knowledge and skills that enable drivers to self-evaluate their ability to manage distraction.

Education and training would seem to have three main goals here:

- In making drivers self-aware of their strengths and weaknesses in planning trips in a manner that limits their exposure to distractions
- In making drivers self-aware of the different factors that influence their propensity to engage in distracting activities (e.g., their awareness of the demands associated with a distracting activity in a given environment; their appreciation of their own ability to handle the demands associated with the activity in that situation; the propensity of the individual to take risks; whether laws exist that permit engagement in the activity; productivity and other pressures; driving culture and societal norms)
- In making drivers self-aware of different risky driving motives, attitudes and emotions that influence their propensity to engage in distracting activities

31.4.4 Cells 10 to 12—Goals for Life and Skills for Living

31.4.4.1 Cell 10 (Life Goals and Skills—Knowledge and Skills)

Cell 10 relates to how general life goals and values, behavioral style, group norms, and other factors affect driving. Here, the role of education and training is to make drivers aware of these factors and their relationship with distraction.

31.4.4.2 Cell 11 (Life Goals and Skills—Risk Awareness)

Cell 11 is concerned with the driver's personal control over risks connected with life goals and values, behavioral style, social pressure, substance abuse, and so on. Here, the role of education and training is to provide drivers with knowledge and skills to manage distraction-related risk that may derive from these higher-order goals.

31.4.4.3 Cell 12 (Life Goals and Skills—Self-Evaluation)

Finally, Cell 12 pertains to the driver's impulse control, motives, lifestyle, values, and so on. Here, the role of education and training is to make drivers self-aware of how these personal factors moderate their propensity to be distracted.

At this level of the GDE matrix, the link between life goals and distraction is less straightforward, which makes it difficult to formulate concrete options for countermeasure development. Further research and thinking is needed to develop this level of the GDE matrix for the management of distraction.

31.5 SUMMARY AND CONCLUSIONS

The management of distraction by drivers can be regarded as an ability that can be developed and improved through education and training. In this chapter we have used three organizing frameworks to define a range of distraction management competencies that might be addressed in driver education and training programs.

The GDE matrix is a useful organizing structure for defining the competencies needed to manage distraction. It emphasizes the overlap between education and training and the role of higher-level goals and motives in guiding the development and deployment of skills lower in the hierarchy. The focus of this framework, however, is on the development of competencies needed to be a safe driver, regardless of the level of vehicle system automation. Donmez et al.[23] distinguish between driving- and nondriving-related mitigation strategies for driver distraction that are applicable for different levels of system automation. To this end, Table 31.2 provides a complementary framework for considering the various mechanisms by which technology can be used to minimize distraction, by moderating the demands of both the driving task and competing tasks, and for considering the implications of this for driver education and training. The theoretical framework presented in Chapter 4 provides another, complementary, perspective by considering distraction as a problem of control at three levels (operational, tactical, and strategic), each operating at different time horizons. According to this view, distraction-related mishaps result from a breakdown of control at any one level, and from the accumulation of control problems that compound as they propagate across levels. Understanding why and how each control type might fail at each time horizon prompts consideration and derivation of education and training initiatives that can be implemented to support and maintain control, and prevent such failures.

Given the paucity of empirical data that is currently available to guide the design and evaluation of education and training programs, the choice of competencies presented in this chapter is based largely on the material reviewed in this book and on the general knowledge and judgment of the authors. In the absence of any empirical data on the effectiveness of driver education and training initiatives directly concerned with the prevention and mitigation of distraction, it is difficult to know which of the competencies presented are most likely to be effective in preventing and mitigating the effects of distraction. Paradoxically, it is the competencies at the higher levels of the GDE matrix, which are the least developed and researched, that may have the greatest influence in doing so.

It is beyond the scope of this chapter to prescribe theories of learning, instructional methods, and media and delivery mechanisms that can be used to turn the learning objectives presented here into actual countermeasures; although, where relevant countermeasures and delivery mechanisms already exist, they have been identified. Noteworthy, in this context, however, are the ideas introduced by Donmez et al. in Chapter 29. They highlight the role that different types of feedback, delivered over different timescales, can have in preventing and mitigating the effects of distraction. They distinguish between four such timescales—concurrent (milliseconds), delayed (seconds), retrospective (minutes, hours), and cumulative (days, weeks, months)—which have implications both for the design of education and training programs. Retrospective and cumulative feedback appear, in particular, to be suited to the design of distraction education and training programs. Retrospective feedback, which is provided to the driver immediately after a trip, provides information to the driver about inappropriate and appropriate behavior during that trip (e.g., number of distracting tasks performed during dangerous situations, duration of eyes-off-road time, etc.). Such feedback can influence future driving behavior by informing drivers of what constitutes safe driving, when not to engage in distracting activities, and what speed to maintain in different driving conditions. Cumulative feedback, which integrates driving data over many trips spanning several weeks and months, can help drivers assess their overall level of driving performance by highlighting persistent distraction-related behaviors that compromise their safety. Donmez et al. argue that feedback at this timescale is more likely to lead to lasting behavioral change, whereas concurrent feedback can enhance driving performance. New technologies exist to support the provision of feedback at multiple timescales and, in doing so, to positively change driver performance and induce lasting behavioral change.

Young novice drivers, in their roles as drivers and passengers, would appear to be the group most important to target for education and training, as data reviewed in this book suggest that they are relatively more likely than more experienced drivers to be exposed to distraction and appear to be relatively more vulnerable to its effects. Commercial drivers, especially urban bus drivers, warrant particular attention. There is at present little empirical evidence to suggest that older drivers require special education and training, although this may be warranted in future as they become more tech savvy and drive in proportionately larger numbers.

Driver education and training are, in most countries, responsibilities shared between professional driving instructors, parents (in the case of young novice drivers), and other supervising drivers. Increasingly, automotive companies, point-of-sale staff, and even rental car companies are becoming involved in driver education and training. Responsibility for the design and development of driver training curricula and materials is also shared between multiple stakeholders—professional driving instructors, road authorities (e.g., in prescribing jurisdictional training and assessment regimes and standards; in developing materials to structure and guide the accumulation of on-road driving practice during the learner and probationary periods), educational authorities (for school-based driver training programs), training authorities (for accrediting driving instructors and the training they provide), and vehicle manufacturers, suppliers, and sales personnel. The recommendations made in this chapter are therefore relevant to a wide range of stakeholders. The roles and

responsibilities of the various parties in providing training in distraction management need to be carefully defined and delineated.

Awareness campaigns involving mass media and pitched at the public at large can complement education and training initiatives. Such campaigns need to be designed to increase public understanding of the nature of driver distraction, its relative standing in relation to other traffic safety issues, the relative dangers associated with engaging in distracting activities (deriving from inside and outside the vehicle), its impact on driving performance and safety, the factors that increase driver vulnerability to distraction, strategies for minimizing the effects of distraction, and the penalties associated with engaging in distracting activities, where applicable.[1,33] Awareness campaigns should also seek to raise employer awareness of tools, available to them, which can be used to limit employee exposure to distraction while driving company vehicles (see Chapter 30).

An important issue to resolve is the point in training at which it is best to start exposing young novice drivers to distracting activities, such as carrying passengers or using mobile phones. Unfortunately, there is no known empirical research on this topic to guide countermeasure development, despite evidence that even apparently "automated" tasks, such as manual gear-shifting, significantly impair the sign detection performance of novice drivers using standard shift compared with novice drivers using automatic transmission.[34] How quickly drivers become invulnerable to the demands of secondary activities varies considerably. Epidemiological and crash data, reviewed in this book (see Chapters 16 and 17), have been used to support the introduction of licensing restrictions for young and novice drivers, as part of GDL systems. In several jurisdictions, young and novice drivers are banned from using mobile phones and from carrying passengers in the first year of solo driving. At some point in their driving careers, however, they will inevitably be exposed to one or more of these distractions. Clearly, research is needed to determine at what point in the learning curve it is appropriate to introduce these and other sources of distraction (over which some degree of exposure control can be exercised) and in what manner, instructionally, to do so.

Ideally, education and training in how to manage driver distraction should commence early in the life cycle of the road user, and be structured such that the knowledge, skills, and attitudes acquired (e.g., in how to manage distraction as a pedestrian or bicycle rider) transfer positively to driving later in life. Determining how such early programs should be designed and delivered to promote positive skill transfer is a challenging area for further research. As technologies continue to evolve, at an increasingly rapid rate, a more critical issue is how to continue, through education and training, to maintain this skill transfer and provide drivers with better support for both feedback and feed-forward control of distraction.

In the next chapter, options for countermeasure development are presented in the areas of vehicle, technology, and road design.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Peter Burns, Transport Canada, and Phil Wallace, Learning Systems Analysis Pty Ltd, Australia, for their insightful comments on earlier versions of this chapter.

REFERENCES

1. Hedlund, J., Simpson, H., and Mayhew, D., International conference on distracted driving—Summary of proceedings and recommendations, *International Conference on Distracted Driving*, Traffic Injury Research Foundation, Toronto, Canada, 2006.
2. Mayhew, D. R. and Simpson, H. M., The safety value of driver education and training, *Injury Prevention,* 8(Suppl II), 3–8, 2002.
3. Baker, S. and Spina, K., Drivers' attitudes, awareness and knowledge about driver distractions: Research from two central Sydney communities, *First International Conference on Distracted Driving*, Sydney, Australia, 2005.
4. Barker, C., Key findings from focus group research on inside-the-vehicle distractions in New Zealand, *First International Conference on Distracted Driving*, Sydney, Australia, 2005.
5. Beirness, D. J., Distracted driving: The role of survey research, *International Conference on Distracted Driving*, Toronto, Canada, 2005.
6. Rudin-Brown, C. M., Driver distraction from in-vehicle telematics devices: The public opinion, *International Conference on Distracted Driving*, Toronto, Canada, 2005.
7. Sundeen, M., Distracted driving legislation, *International Conference on Distracted Driving*, Toronto, Canada, 2005.
8. Senserrick, T. and Haworth, N., *Review of Literature Regarding National and International Young Driver Training, Licensing and Regulatory Systems*, Report No. 239, Monash University Accident Research Centre, Melbourne, Australia, 2005.
9. Engström, I., Gregersen, N. P., Hernetkoski, K., Keskinen, E., and Nyberg, A., *Young Novice Drivers Education and Training: Literature Review*, Report No. VTI Report 491A, VTI, Linköping, Sweden, 2003.
10. Woolley, J., *In-Car Driver Training at High Schools: A Literature Review*, Report No. Transport SA Report 6/2000, Transport Systems Centre, University of South Australia, Adelaide, Australia, 2000.
11. Hatakka, M., Keskinen, E., Gregersen, N. P., Glad, A., and Hernetkoski, K., From control of the vehicle to personal self-control; broadening the perspectives to driver training, *Transportation Research, Part F*, 5, 201–215, 2002.
12. Hatakka, M., Keskinen, E., Hernetkoski, K., Gregerson, N. P., and Glad, A., Goals and contents of driver education, in *Driver Behaviour and Training*, Dorn, L. (Ed.), Ashgate, England, United Kingdom, 2003.
13. Hernetkoski, K. and Keskinen, E., Used methods and incentives to influence young drivers' attitudes and behaviour, in *Young Novice Drivers Education and Training: Literature Review*, Engström, I., Gregersen, N. P., Hernetkoski, K., Keskinen, E., and Nyberg, A. (Ed.), VTI, Linköping, Sweden, 2003.
14. Christie, R., *The Effectiveness of Driver Training as a Road Safety Measure*, Report No. 01/03, Royal Automobile Club of Victoria, Melbourne, Australia, 2001.
15. Fisher, D. L., Laurie, N. E., Glaser, R., Connerney, K., Pollatsek, A., Duffy, S., and Brock, J., The use of a fixed base driving simulator to evaluate the effects of experience and PC based risk awareness training on drivers' decisions, *Human Factors,* 44, 287–302, 2002.
16. Regan, M. A., Triggs, T., and Godley, S., Simulator-based evaluation of the DriveSmart novice driver CD ROM training product, *Road Safety Research, Policing and Education Conference*, Brisbane, Australia, 2000.
17. Michon, J. A., A critical review of driver behaviour models: What do we know, what should we do?, in *Human Behaviour and Traffic Safety*, Evans, L. and Schwing, R. (Eds.), Plenum Press, New York, 1985.

18. Falkmer, T. and Gregerson, N. P., The TRAINER project—The evaluation of a new simulator-based driver training methodology, in *Driver Behaviour and Training*, Dorn, L. (Ed.) Ashgate, England, United Kingdom, 2003.
19. Global Road Safety Partnership, Road safety publicity campaigns, GRSP, Geneva, Switzerland, 2002.
20. Simons-Morton, B. G., Hartos, J. L., Leaf, W. A., and Preusser, D., The persistence of effects of the checkpoints program on parental restrictions of adolescent driving privileges, *American Journal of Public Health*, 95, 447–452, 2005.
21. Tovey, M. D. and Lawlor, D. R., *Training in Australia: Design, Delivery, Evaluation, Management*, Pearson Prentice Hall, Australia, 2004.
22. Wallace, P. R. and Regan, M. A., Case study: Converting human factors research into design specifications for instructional simulation, *Third International SimTect Conference*, Adelaide, Australia, 1998.
23. Donmez, B., Boyle, L. N., and Lee, J. D., The impact of distraction mitigation strategies on driving performance, *Human Factors*, 48(4), 785–804, 2006.
24. Lee, J. D., Driver distraction: Breakdowns of a multi-level control process, *Journal of the Australasian College of Road Safety*, 16(2), 33–38, 2005.
25. Fisher, D. L., Using eye movements to evaluate a PC-based risk awareness and perception training program on a driving simulator, *Human Factors*, 48(3), 447–464, 2006.
26. Regan, M. A., Deery, H., and Triggs, T., Training for attentional control in novice car drivers, *42nd Annual Meeting of the Human Factors and Ergonomics Society*, Chicago, IL, 1998.
27. Regan, M. A., Deery, H. A., and Triggs, T. J., A technique for enhancing risk perception in novice car drivers, *Road Safety Research, Policing and Education Conference*, Wellington, New Zealand, 1998.
28. Triggs, T. J. and Regan, M. A., Development of a cognitive skills training product for novice drivers, *Road Safety Research, Policing and Education Conference*, Wellington, New Zealand, 1998.
29. Endsley, M. R. and Garland, D. J., Pilot situation awareness training in general aviation, *XIVth Triennial Congress of the International Ergonomics Association and 44th Annual Meeting of the Human Factors and Ergonomics Society*, San Diego, CA, 2000.
30. Mitsopoulos, E., Triggs, T., and Regan, M., Examining novice driver calibration through novel use of a driving simulator, *SimTect 2006* Melbourne, Australia, 2006.
31. Triggs, T. J., Human performance and driving: the role of simulation in improving young driver safety, *12th Triennial Congress of the International Ergonomics Association*, Toronto, Canada, 1994.
32. Regan, M., Salmon, P. M., Mitsopoulous, E., Anderson, J., and Edquist, J., Crew resource management and young driver safety, *Human Factors and Ergonomics Society 49th Annual Meeting*, Orlando, FL, 2005.
33. Regan, M., Young, K., and Johnston, I., MUARC Submission to the Parliamentary Road Safety Committee Inquiry into Driver Distraction, Monash University Accident Research Centre, Melbourne, Australia, 2005.
34. Shinar, D., Meir, M., and Ben-Shoham, I., How automatic is manual gear shifting? *Human Factors* 40(4), 647–654, 1998.

DRIVER DISTRACTION

Theory, Effects, and Mitigation

Edited by
Michael A. Regan
John D. Lee
Kristie L. Young

CRC Press
Taylor & Francis Group
Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **informa** business

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

Printed in the United States of America on acid-free paper
10 9 8 7 6 5 4 3 2 1

International Standard Book Number-13: 978-0-8493-7426-5 (Hardcover)

Library of Congress Cataloging-in-Publication Data

Driver distraction : theory, effects, and mitigation / edited by Michael A. Regan, John D. Lee, Kristie Young.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-8493-7426-5
ISBN-10: 0-8493-7426-X
1. Distracted driving. 2. Automobile driving. 3. Automobile drivers. 4. Traffic safety. I. Regan, Michael A. II. Lee, John D. III. Young, Kristie L. IV. Title.

HE5620.D59D75 2009
363.12'414--dc22 2008014178

Visit the Taylor & Francis Web site at
http://www.taylorandfrancis.com

and the CRC Press Web site at
http://www.crcpress.com