34 Some Concluding Remarks

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In this book, we have reviewed much of the knowledge that exists on driver distraction—what it means, theories describing its mechanisms, its effects on driving performance and safety, and strategies for preventing or mitigating its effects. On the basis of the material reviewed, several conclusions can be drawn.

There is converging evidence that driver distraction is a significant road safety problem worldwide. Findings from the analysis of police-reported crashes, reviewed in Chapter 16, suggest that driver distraction is a contributing factor in 10 to 12% of crashes. Data from the 100-car naturalistic driving study in the United States, also reviewed in Chapter 16, suggest that distraction from secondary tasks may be a contributing factor in up to 23% of crashes and near-crashes. Although estimates vary due to differences in definitions, data collection methods, and classification schemes, there is good reason to believe that all of these estimates underestimate the true scale of the problem. About one-third of all distractions appear to derive from outside the vehicle, and between about 15% and 20% involve driver interaction with technology. Distraction appears to be largely associated with rear-end crashes, same travelway or same direction crashes, single-vehicle crashes, and crashes occurring at night.

Driver distraction is a complex, multidimensional problem. The impact of distraction on driving performance and safety depends on many interrelated factors, such as the concurrent demands of driving and nondriving tasks (see Chapter 4); moderating factors such as the state, age, level of experience, and personality of the driver (see Chapter 19); understanding what is distracting the driver (see Chapter 15); how often and for how long the driver is distracted (see Chapters 17 and 18); when and where the driver is distracted (see Chapters 16 and 17); the momentary configuration of physical circumstances that determine whether the driver fails to maintain an appropriate distribution of attention relative to the changing demands of the roadway (see Chapters 2 and 4); the degree to which the driver, the vehicle being driven, and the physical environment is tolerant of the consequences of distraction (see Chapter 33); and even a certain amount of luck. Therefore, the prevention, mitigation, and management of distraction is a complex undertaking.

It is unlikely that distraction will ever be eradicated as a road safety problem. There are various reasons for this: humans are fundamentally limited in their capacity to simultaneously attend to multiple activities; driving is a "satisficing" task, leaving free attention that can be used to accomplish other tasks; vehicles are likely to continue to be designed solely for single-person operation; drivers are biologically primed to be attracted, sometimes beyond their control, to certain objects, events, and activities that are salient or novel; different social roles motivate drivers, sometimes through necessity, to engage in certain activities that have potential to distract them; and new sources of distraction will continue to emerge as the driving task, and society itself, evolve. At best, driver distraction can be effectively managed.

Effective management of road traffic safety issues has a number of defining characteristics. Johnston[1] argues that the current "best practice" model for road traffic policy making, intervention programming, and effective implementation of integrated countermeasure programs has the following defining features (Chapter 4, p. 16):

- Routine surveillance of safety progress, using comprehensive, high-quality data systems, covering the gamut of road safety problems
- Strategic targeting of the key problems using evidence-based strategies and program options
- The provision of adequate resource for meaningful implementation
- Rigorous evaluation of the effectiveness of the interventions
- Continuous improvement in implementation based upon the evaluation results and maximum coordination among all relevant institutions

When judged against these criteria, it is clear from the material reviewed in this book that countermeasure development for preventing and mitigating the effects of distraction is still in its infancy, even in developed countries with relatively good road safety records. Perhaps this is not surprising. Governments continue to rely heavily, often overly, on crash data to justify and stimulate countermeasure development. However, to date, distraction has been poorly defined and systems for accurately and reliably collecting and analyzing data on its role in crashes do not exist in many jurisdictions. Technological change introduces new distractions at a great rate and makes crash data a lagging and ineffective indicator of the distraction problem. Many policymakers are also unaware of converging evidence, from epidemiological and other studies, that implicates distraction as a road safety problem. In turn, this has thwarted attempts by governments to strategically target key distraction problems using evidence-based strategies, and to justify adequate resources for meaningful implementation of effective countermeasures.

Rigorous evaluation of intervention effectiveness is also lacking. Noteworthy is a lack of published research on the effectiveness of existing distraction prevention and mitigation measures. The limited data that do exist pertain mainly to the impact of banning handheld mobile phone use while driving and suggest that, while rates of handheld mobile phone use initially decline after such bans are implemented, they drift back toward prelegislation levels at a rate contingent on the amount of ongoing enforcement of the ban and associated publicity. Vehicle manufacturers, to their credit, have been proactive in undertaking and commissioning research to understand distraction, and in developing methods, tools, guidelines, and standards for the design and evaluation of products to limit distraction. Even for these interventions, however, there is limited published data on their effectiveness in limiting distraction, let alone enhancing safety. Effective mechanisms for ensuring that the outputs of distraction countermeasure evaluation are fed back into the countermeasure development process do not currently exist, and are complicated by institutional and industry complexity.

Maximum coordination among all relevant institutions is a crucial element in effective countermeasure development. One of the defining features of road traffic safety, however, is its institutional complexity.[1] Many different stakeholders have a vested interest in managing the safety of the road system. The management of driver distraction is no different and is further complicated by technological developments that outpace the rate at which effective legislation can be written and adequately enforced. These developments make it possible for drivers to interact with functions available on nomadic and aftermarket devices, developed by industries not accustomed to considering how its products affect driving safety.[2] Other developments that enable drivers to see and hear inside the vehicle traffic and nontraffic-related information normally displayed to them visually outside the vehicle adds yet another layer of complexity. These developments appear to be occurring in isolation. Who, for example, is responsible for coordinating the simultaneous flow and integration of information to drivers from inside and outside the vehicle? Who is responsible for coordinating the simultaneous flow and integration of information to drivers from Original Equipment Manufacturer (OEM), aftermarket, and nomadic devices within the vehicle? Lacking in the management of distraction are institutional arrangements, which ensure that there is mutual cooperation and cross talk between the automotive industry, traffic engineers, aftermarket suppliers, and nomadic device suppliers to ensure that the total demands of driving are within the capacity of the driver. Without such cooperation, the best efforts of one sector in limiting the effects of distraction might be partly or completely undermined by another.

The management of distraction is therefore a fertile area for countermeasure development. The key to effectively tackling the driver distraction issue is to stop blaming drivers who deliberately or inadvertently fail to attend to activities critical for safe driving. We must start looking at the issue from a broader, system-wide perspective. To this end we have proposed in this book (Chapters 30 through 33) an integrated approach to the prevention and mitigation of distraction and have recommended specific countermeasures for addressing the problem across a broad range of areas.

The injury prevention countermeasures presented are framed in large part around two organizing frameworks: a conceptual framework, referred to in Chapter 33 as an "integrated safety chain" that stimulates consideration of options for limiting distraction pertaining to the driver, vehicle, and roadway environment at each stage leading to a crash; and a theoretical account of driver distraction, presented in Chapter 4 that describes the diversion of attention away from activities critical for safe driving toward a competing activity as a breakdown in multilevel control processes, with different timescales characterizing each level. These conceptual frameworks are useful in stimulating interdisciplinary thinking about the interactions that occur between the three road traffic entities—driver, vehicle, and environment—and between each stage in the crash sequence, and how these might guide countermeasure development. Many of the countermeasures presented in this book are derived not from "hard data," but from current understanding of the mechanisms that appear to characterize distraction. There is no guarantee that the countermeasures recommended, whether derived from "hard" or "soft" data, will be effective in preventing and mitigating the effects of distraction. This can only be determined through careful evaluation. The fact that efforts to manage distraction are still in their infancy may be a virtue from an evaluation perspective, as it may enable the effectiveness of new policies and programs that are rolled out to be evaluated in relative isolation.

Some concluding comments can be made about our current state of knowledge regarding driver distraction.

Distraction is a poorly defined concept. Even within this book definitions of it vary widely. The lack of a consistent definition across studies makes the comparison of research findings difficult or impossible. Inconsistent definitions also lead to different interpretations of crash data and, ultimately, to different estimates of the role of distraction in crashes. The definition of distraction coined in Chapters 1 and 3 of this book—*distraction is the diversion of attention away from activities critical for safe driving toward a competing activity*—is presented as a first step in resolving these issues. Deriving from this definition we have further proposed, in Chapter 15, a taxonomic description of those sources of distraction that have been identified as contributing to crashes and near-crashes. The taxonomy is intended to resolve confusion about what are, and are not, the sources of distraction; to provide a framework for classifying sources of distraction; and to support the development of more reliable and less variable methods for collecting and coding crash and epidemiological data. The taxonomy will, of course, require further refinement as driving and non-driving tasks performed while driving continue to evolve.

The impact of distraction on driving performance depends on many interrelated factors (see Chapters 4 and 19). Much of the distraction research to date has focused on the impact of sources of distraction deriving from within the vehicle related to technology use. Little is known about the impact on performance of other sources of distraction, identified in Chapter 15, deriving from inside or outside the vehicle. Of those studies that have investigated the distraction potential of technologies, surprisingly few have investigated the distraction potential of everyday driving-related tasks associated with driving (e.g., changing gears, monitoring speedometers, etc.). The lack of research on factors—the age, state (e.g., drowsy, drunk, etc.), level of experience, and personality of the driver—that moderate the effects of distraction, and the mechanisms through which this moderation occurs is also notable. The manner in which drivers self-regulate in response to distraction, and in response to other road users they perceive to be distracted is not well understood; and evidence for it is sparse and ambiguous[3] (see Chapter 19). As noted in Chapter 20, age may become a more salient moderating factor as the driving population continues to age. Owing to age-related functional declines, older drivers appear on first principles to be relatively more vulnerable to the effects of distraction. There exists, however, little research to confirm this. Even less is known about how older drivers self-regulate in response to distraction. Similarly, as noted in Chapter 21, further research is needed to establish whether fatigue effects moderate the effects of distraction and the potential role of distractions in offsetting the effects of driver fatigue.

Techniques are available to improve the quality of crash data, and these were discussed in Chapter 16. The solutions, however, are not simple. Unlike crashes that involve drugs, alcohol, or speed, in which there is a clear marker of a causal agent, crashes deriving from distraction leave no telltale trace.[4] In managing distraction, therefore, it is not appropriate to rely solely on crash data to prioritize countermeasure development; although, for governments, crash data is likely to remain important in justifying and stimulating countermeasure development. Approaches to data collection that involve collection of naturalistic driving data and data derived from on-board data loggers show promise, and help to provide an indication of the level of underestimation involved in traditional crash studies in quantifying the role of distraction in crashes. In the end, however, all methods have their limitations. As noted by Caird and Dewar,[3] the degree to which drivers are absorbed in thought, their allocation of attention to competing tasks, and strategic choices to self-regulate in response to distraction are behaviors not evident through observation alone. A combination of different methods will need to be used to investigate crashes to build up a complete crash picture.

With the advent of naturalistic driving studies, remarkable progress has been made in the capacity to assess drivers' exposure to many distracting activities while driving (see Chapter 17). However, much work remains to be done in this area. Establishing risk estimates for the full gamut of distracting activities that occur while driving remains an important area for research, particularly for activities unrelated to technology use and those deriving from driver interaction with objects and events outside the vehicle. Further investigation into the circumstances during which distracting activities present the greatest risk is also warranted. Further naturalistic driving studies, employing sound epidemiological methods and larger, more representative driving populations are therefore warranted.

The automotive industry has been proactive in developing countermeasures to prevent and mitigate the effects of distraction (see Parts 7 and 8 of this book). However, as an industry, it cannot be expected to shoulder the burden of good design in limiting distraction. Driving is a complex, multitask activity, and elements of the driving task itself (relating to both vehicle control and roadway monitoring) have the potential to divert the attention of the driver away from activities critical for safe driving. From a design perspective, the implication of this is that distraction can be limited by reducing the demands of driving tasks themselves (which, in turn, reduces vulnerability to distraction from competing tasks) and by directly limiting the distraction potential of competing tasks. The critical units of analysis for driver-centered design to limit distraction, therefore, should not be the physical aspects of the vehicle-driver interface, but rather the driving tasks, such as navigation, following the road, monitoring speed, avoiding collisions, following traffic rules, and controlling the vehicle (Brown, 1986, cited in Ref. 5) as well as the nondriving tasks that have potential to divert attention away from activities critical for safe driving. Responsibility for mitigating, through driver-centered design, the propensity for competing tasks to divert attention away from activities critical to safe driving is therefore a joint responsibility shared by multiple stakeholders—vehicle manufacturers, aftermarket suppliers, nomadic device suppliers, and traffic engineers. Also critical is the development of institutional arrangements which ensure that, at a macro level, there is mutual cooperation and cross talk between the relevant stakeholders to develop a coordinated design for driver interaction with the myriad of competing tasks (driving and nondriving) that compete for driver attention, so that it does not lead to a breakdown in multilevel control processes (tactical, strategic, or operational). As argued in Chapter 22, coordinated design of this kind can only be achieved through a formal requirement, in the form of a process-based code of practice that requires all stakeholders to adhere to a common safety management system—a systematic process that defines and prioritizes human factors and safety considerations that must be addressed throughout the design cycle.

At a more micro level, as argued in Chapter 25, the development of tools, methods, and metrics for designing products to limit distraction should be seen as a product in itself that is calibrated to the needs of its users and packaged in an appropriate manner. Development of a human factors and ergonomic "toolbox," which includes formative (design) methods, guidelines, and clear decision criteria is seen as an essential target for future research and development. Guidelines and standards (both design and performance standards) exist which aim, through good design, to limit distraction deriving from in-vehicle information and communication systems that are peripherally related, or unrelated, to driving. These are reviewed in Part 7 of this book, and the issues that remain to be resolved in ensuring that they achieve their intended purpose have been discussed. Noteworthy is that the principles contained in some guidelines (e.g., the European ESoP guidelines) currently apply solely to in-vehicle information systems. These will need to be reexamined and extended to advanced driver assistance systems, given that these are designed to assist the driver in performing driving tasks (see Chapter 22). The increasing integration of functions within in-vehicle systems will also necessitate revision or extension of existing guidelines (see Chapter 23), and as noted in Chapter 25, few current guidelines have concrete performance criteria. Guidelines by themselves are, however, insufficient. Mechanisms are needed to ensure that designers are aware of guidelines and standards, have the resources and skills to apply them effectively, and comply with them. The development of tools, methods, and metrics for designing products to limit distraction should not be confined to the automotive industry. Aftermarket suppliers, nomadic device suppliers, traffic engineers, and other relevant stakeholders are in need of guidance in how to ergonomically design the road environment and the nomadic devices brought into vehicles, to limit distraction. The establishment of institutional arrangements that ensure that this is done as a coordinated activity is critical.

There has been a proliferation of methods and metrics for measuring the impact of distraction on driving performance (see Part 3 of this book). These pertain, however, almost entirely to the measurement of distraction deriving from driver interaction with technologies within the vehicle. Certain challenges still remain. The repertoire of methods and metrics must be expanded to enable the assessment of the impact on performance of distractions deriving from outside the vehicle, and as for in-vehicle distractions, to develop reference tasks that provide a benchmark against which the impact on driving performance of external distractions (both driving and nondriving related) can be established. Some guidance on this issue is given in Chapter 13.

Collectively, assessment methods for all distractions must be cost-effective and easy to use by designers. Appropriate reference tasks must be developed, which are unambiguously defined, repeatable across different test environments, and induce mechanisms of distraction identical to those induced by the distracting activity under investigation.

There is currently little consensus regarding which assessment methods and metrics should be used for the evaluation of particular activities with potential to distract drivers (see Chapter 7). The outputs of projects such as HASTE, AIDE, and CAMP will provide some guidance in this area. Rapid evaluation procedures are needed that do not require sophisticated equipment and months of time. The lane change test is such a procedure although, as is noted in Chapter 25, the notion that a single, low cost test can assess the interference with driving of a competing task, regardless of its visual, auditory, cognitive, and psychomotor demands may be unrealistic. Table 15.5 in Chapter 15 of this book identifies mechanisms that moderate the effects of distraction that might be considered in refining the sensitivity and scope of existing assessment procedures, including checklists. In future, rapid evaluation procedures might include computational models of driver performance such that preliminary design concepts can be evaluated more quickly and earlier in the design and development cycle. Some models of this kind already exist (see Chapter 25).

Real-time distraction countermeasures (RDCs) have perhaps the greatest potential as a design countermeasure to prevent and mitigate the effects of distraction and save lives (see Chapters 26 through 28). These systems adaptively prevent or limit driver exposure to competing tasks when the concurrent demands of driving are estimated to be high (real-time distraction prevention) and mitigate the effects of distraction once it occurs, by providing feedback and warnings to drivers that redirects their attention to relevant aspects of the driving task (real-time distraction mitigation). These systems have many advantages over nonadaptive approaches to system design. First, these approaches are potentially capable of detecting whether a driver is distracted regardless of the competing activity (driving or nondriving related) and whether driver engagement in the competing activity is voluntary or involuntary, regardless of whether the impetus for the competing activity derives from inside or outside the vehicle. Second, the system can be optimized so that it is adaptive to factors that moderate the effects of distraction (e.g., driving demand, competing task demand, driver state, age, and experience; such as by issuing more conservative warnings if the driver is inebriated). Third, they can be used to prime and activate the operation of other active and passive safety systems at different stages of the integrated safety chain to optimize driver safety during all stages of the crash sequence. Finally, through the provision of real-time feedback to drivers, they have potential to provide long-term benefits in calibrating drivers to the dangers of distraction so they can better manage distraction, even when they drive vehicles not equipped with such systems. As discussed in Chapter 29, the design of feedback to mitigate distraction, whether it be in real time or delayed is a whole research field in itself. RDC is currently a very active research field, with some first generation products on the market. However, the field is still developing and largely technology driven. Further work is needed to identify the RDC functions that have the largest impact on driving safety, efficiency, and comfort; to improve the measurement and assessment of driving task demand and driver state; to optimize the systems for driver acceptance; and to develop suitable methods for evaluating their impact on driver acceptance, performance, and safety.

There are some possible drawbacks of improved vehicle and technology design that must be considered. Well ergonomically designed interfaces can, for example, encourage drivers to use them more often, thus increasing their exposure to risk (the so-called "usability paradox," as discussed in Chapter 3). The more automated is the driving task, the less demanding it may be, or appear to be (see Chapter 2), freeing up driver attention that can be used by drivers to take on other roles within the vehicle that may have potential to distract them. Emerging technology poses obvious distractions in the form of infotainment systems. More subtle threats, however, may lie in driver support systems, particularly as many of these systems are combined. Technology that automates elements of the driving task could surprise drivers and distract them as they try to figure out how to get it to do what they want. Effective driver-centered design requires continuous evaluation and feedback to identify and rectify these and other unintended side effects.

A fundamental issue, raised in several chapters, is how to bridge the gap between measurement of distraction and its link with real-life crash causation. As noted in Chapter 25, equations are needed that relate performance in various tests to fatalities and injuries likely at that level of performance. Distraction metrics are surrogate metrics intended to predict crash involvement. Data derived from naturalistic driving studies may provide a mechanism for bridging the performance and safety gap by identifying critical scenarios and events that characterize real-world crashes that can be used as assessment scenarios. However, the combinations of coincidences between tasks (e.g., navigating, dialing) and traffic conditions (e.g., intersection, merging) that give rise to crashes and near-misses may be difficult to test in experimental settings and to observe in naturalistic driving studies.[3] As noted in Chapter 22, a particular challenge is how to combine individual assessment methods into an overall integrated methodology to make predictions about safety in use. The control theoretic approach to understanding the processes that underlie distraction, described in Chapter 4, attempts to describe the relationship between distraction related performance degradation and crash risk, and provides a theoretical account of the critical links that may be useful in framing future research activities.

It is notable is that the study of distraction has been confined almost entirely to the road transport domain, although some related work has been going on in the computing and aviation domains under the guise of "interruptions."[6,7] Even within the road transport domain, the focus of distraction efforts to date has been on drivers, whereas distracted walking and distracted riding, whether on bicycles or motorcycles, are potential areas of concern that appear to be totally unexplored and researched. Notable also is the paucity of research on driver distraction in the public and commercial transport sectors. The limited research undertaken in this field, reviewed in Chapter 14, suggests that distraction is a problem in bus and heavy vehicle transport operations. Bus drivers, in particular, are required to take on multiple, and at times competing roles while driving, which make them particularly vulnerable to the effects of distraction. This is exacerbated by the demands of bus driving itself, which is arguably a less "satisficing" task than ordinary driving, particularly in residential areas. Further research is required to identify and classify the sources of distraction that exist in the public and commercial transport sectors and to quantify their impact on driving performance and safety. In the meantime, Chapter 14 provides initial guidance on preventing and mitigating the effects of distraction in bus operations.

Not all distraction is bad distraction. The driver distraction issue has a flip side too. Some potentially distracting activities may have safety benefits, such as combating the effects of drowsiness or fatigue (as in the case of a truck driver using a CB radio as discussed in Chapter 21). There are also situations in which the attention of the individual in charge of the vehicle is drawn to circumstances other than its momentary control that may be beneficial for the personal safety and even survival of the driver, for example when taking a hand off the wheel to parry the attack of a snake coiled on the passenger seat (see Chapter 2). The scientific, philosophical, legal, and moral issues concerning the nature and interpretation of driver behavior in these circumstances are important ones that remain to be explored.

The tragic incident that occurred on the morning of December 31, 2001, on Port Arlington Road, near Geelong, Australia—in which a 24-year-old female dentist preparing to send a mobile phone generated text message while driving crashed into, and killed, a 36-year-old mechanical engineer riding a bicycle—need not have happened. It is hoped that the knowledge provided in this book will help to prevent further tragedies of this kind from occurring.

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DRIVER DISTRACTION

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