19 Factors Moderating the Impact of Distraction on Driving Performance and Safety

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CONTENTS

19.1 INTRODUCTION

The fact that a driver's attention is diverted away from activities critical to safe driving and toward a competing activity does not by itself guarantee that performance and safety will be compromised. This point was underscored in Chapter 5. There are many factors that moderate the outcome of such an interaction: the complexity of the competing activity and current driving demands; how often, and for how long, the driver is exposed to the competing activity; and driver characteristics such as age, gender, driving experience, driver state, and willingness to engage. All of these factors affect the driver's ability to prevent and mitigate the impact of the competing activity. As noted in Chapter 7, the risk of crash is influenced by extrinsic and intrinsic factors. Extrinsic factors may include the driving task, traffic density, speed, and weather conditions, and intrinsic factors may include an individual's risk-taking propensity, driving experience, age, and state (e.g., fatigued, drowsy, inebriated). Many of these factors may change between episodes of exposure.

Understanding the factors that make drivers more or less vulnerable to the distracting effects of competing activities is important when designing countermeasures to prevent and mitigate the effects of distraction. The potential for a competing activity to distract the driver and degrade safety is determined by the complex interaction of a number of factors. This chapter will examine a number of these moderating factors, both intrinsic and extrinsic, for which there is some accumulated knowledge. These include drivers' willingness to engage in distracting activities, their ability to compensate for the increased demands imposed by a competing activity (self-regulation), driving task demands, driver characteristics (e.g., age, gender, driving experience), task familiarity, and driver state. Other moderating factors, such as exposure to, and the complexity of, distracting activity, are discussed in other chapters of this book (see Chapters 3 and 7 for exposure and Chapters 12 and 13 for secondary task complexity) and hence will not be reviewed here.

19.2 RELATIONSHIP BETWEEN MODERATING FACTORS AND DISTRACTION

As alluded to earlier, the potential for a secondary activity to distract drivers and degrade driving performance is moderated by a number of complex and interacting factors. Figure 19.1 displays a number of key moderating factors and the mechanisms by which they might influence drivers' willingness to engage in a secondary activity, their self-regulatory behavior, and the effect of the activity on driving performance and safety. It is important to note that the figure is not intended to contain an exhaustive list of all possible moderating factors. Rather, it is provided to illustrate the relationship between some key moderating factors discussed in the chapter and the mechanisms underlying these relationships. It also provides a means to draw together and summarize, in a simplified manner, the various concepts discussed throughout the chapter.

19.3 SELF-REGULATION

A fundamental question regarding the effect of competing activities on driving performance is whether and how drivers compensate for any decrease in attention to the driving task (i.e., self-regulate) to maintain adequate safety margins. Surprisingly, little research has directly addressed this issue. Indeed, as noted in Chapter 5, much of the distraction research has tended to view drivers as passive receivers and processors of distracting information. Drivers, however, can, and do, actively adjust their driving behavior in response to changing or competing task demands to maintain an adequate level of safe driving.[1]

Self-regulatory behavior can occur at a number of levels ranging from the strategic (e.g., choosing not to use a mobile phone while driving) to the operational level (e.g., reducing speed)[2] (see also Chapter 4). At the highest level, drivers can moderate their exposure to risk by choosing not to engage in potentially distracting activities while driving. Research has shown, for example, that the driving performance of older drivers is impaired to a greater degree than that of younger drivers when using a mobile phone, and this appears to encourage them to engage in compensatory

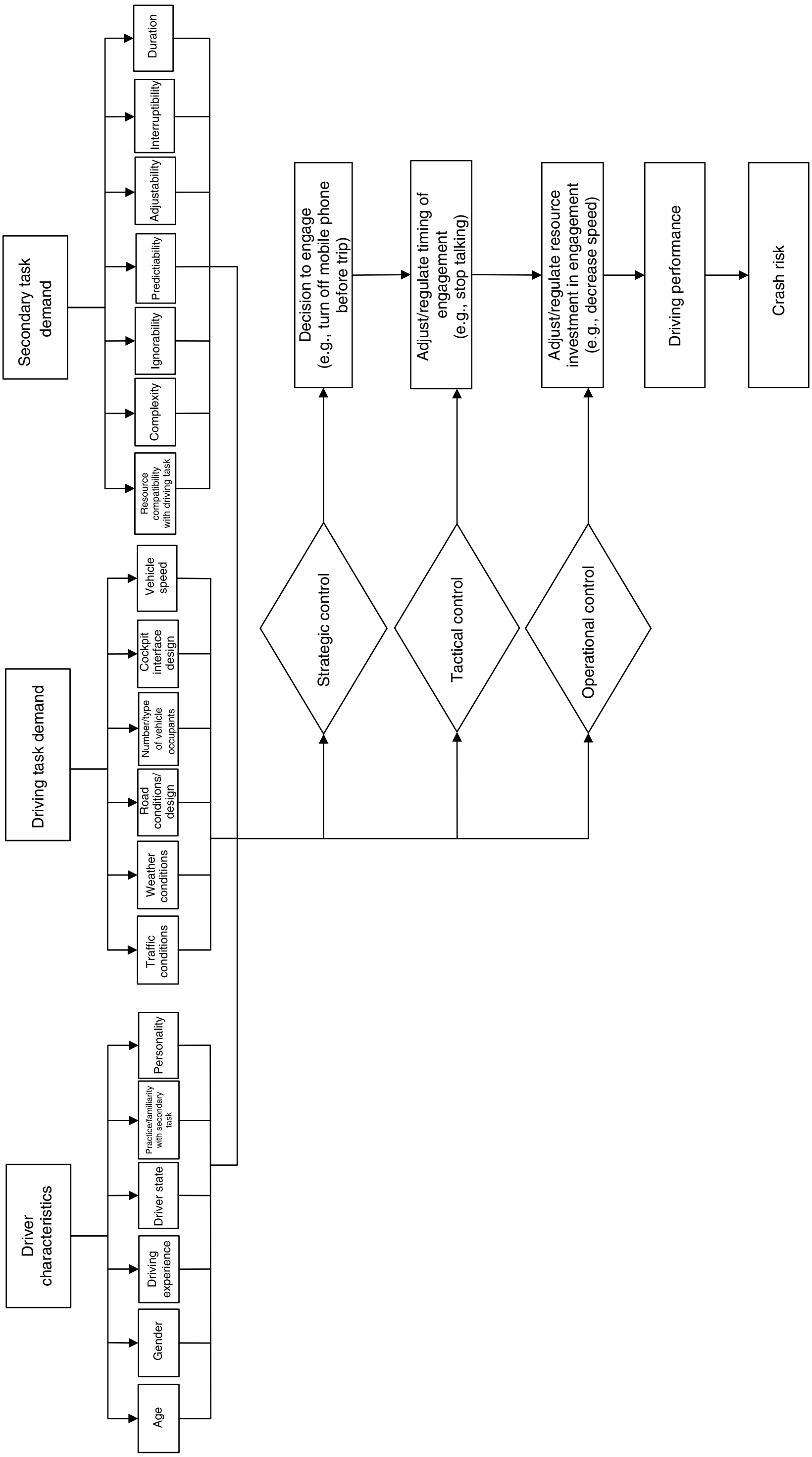

FIGURE 19.1 Factors that moderate the effects of distraction on driving performance and crash risk.

behavior at the strategic level; many older drivers choose to not use a mobile phone while driving.[3,4] Research that requires older drivers to use in-vehicle devices while driving may, therefore, overestimate the risks of these devices for this driving population because they tend not to use them in real driving situations (see Chapter 19 for further discussion of older drivers and distraction).

At the tactical and operational levels, research has shown that drivers attempt to reduce workload and moderate their exposure to risk while engaging in secondary activities, through a number of means: by decreasing speed,[1,5–7] by increasing intervehicular distance,[8–10] and by reducing or ceasing to engage in certain driving tasks, such as checking mirrors and instruments less frequently.[11–13] These self-regulatory behaviors can be viewed as examples of performance trade-offs, because by performing these behaviors, drivers are changing the relative level of priority that they assign to the driving task to accommodate performance of the competing activity.

A number of on-road and simulator studies have found that drivers typically decrease their driving speed when engaging in a secondary task. Haigney et al.[1] examined the effects of handheld and hands-free mobile phone tasks on simulated driving performance. Thirty participants completed four simulated drives while completing a grammatical reasoning task designed to simulate a mobile phone conversation. The results revealed that the mean speed and standard deviation of accelerator travel decreased while participants were conversing on the mobile phone. More recent research carried out in a driving simulator by Rakauskas et al.[7] also found that drivers' mean speed decreased while carrying out a naturalistic conversation on a mobile phone. Drivers also tend to reduce speed when using other in-vehicle devices. Chiang et al.,[14] for example, found that drivers decreased their speed when entering destination details into a route navigation system, whereas Horberry et al.[15] found that drivers' mean speed decreased when interacting with an in-car entertainment (radio and CD player) system.

An increase in following distance is another compensatory behavior that has been displayed by drivers while they are interacting with in-vehicle devices. Using a driving simulator, Strayer et al.[10] found that conversing on a hands-free mobile phone while driving led to an increase in following distance from a lead vehicle, and this increase was particularly pronounced under high traffic density conditions. Strayer and Drews[9] also found that drivers' following distance to a lead vehicle increased by 12% when drivers were conversing on a hands-free mobile phone under simulated driving conditions. Finally, in a driving simulator study, Jamson et al.[8] revealed that drivers adopted longer headways from a lead vehicle while processing e-mails using a speech-based e-mail system. Interestingly, although the drivers in all three studies attempted to compensate for their reduced attention to the roadway by adopting longer following distances, in many cases this increased headway was often inadequate to avoid collisions with other road users.

Another compensatory behavior that drivers engage in when interacting with in-vehicle devices is to reduce or cease their engagement in certain, and perhaps less critical, driving tasks, such as monitoring mirrors and instrument panels. Brookhuis et al.,[11] for example, found that drivers paid less attention to other traffic (as measured by the frequency of checking the rearview and side mirrors) on a quiet motorway when engaging in a mobile phone conversation. In another on-road assessment, Harbluk et al.[13] also found that when drivers were performing demanding cognitive tasks (adding double-digit numbers), they reduced their monitoring of vehicle mirrors and instrument panel and some drivers abandoned these tasks altogether.

There are a number of possible mechanisms underlying drivers' self-regulatory behavior when they engage in competing activities. The observed changes in speed and headway while engaging in secondary activities could be the result of drivers increasing their safety margins to compensate for their diminished ability to respond to roadway demands. They could also simply be exhibiting diminished driving performance resulting from them allocating too much attention to the secondary task and insufficient attention to the primary driving task. Or it may be the case that drivers are willingly and consciously accepting a diminished driving performance criterion. All of these explanations can have road safety implications. For example, if a driver does not allocate sufficient resources to the driving task, he or she may fail to detect hazards in the road environment, or it may be that the driving performance standard that drivers are willing to accept may fall below societal norms for safe driving.

There are a number of conditions under which it is difficult or impossible for drivers to self-regulate their driving in response to a competing activity. These conditions occur when tasks, either the driving or the secondary task, are unpredictable, nonignorable, uninterruptible, and nonadjustable (see also Chapter 2). A task is unpredictable when its onset is unexpected or its consequences cannot be foreseen by the driver. A task is nonignorable when it is so compelling or demanding that the driver cannot disengage from it. An uninterruptible task is one that cannot be postponed or cannot be resumed after interruption. And finally, a task is nonadjustable when it cannot be altered to lower the demand it places on the driver. When a task, whether it is a driving or secondary task, has these four characteristics, it is difficult or impossible for drivers to regulate or adapt their pattern of interaction or behavior in relation to the task. When a driving situation and a secondary task, each possessing these four characteristics, overlap with each other temporally, the consequences for safety may be adverse, as the driver is not able to trade off performance on either task. Further discussion of these four task characteristics and their affect on distraction is contained in Chapter 2.

Overall, a number of factors can influence a driver's self-regulation strategies in response to a competing task and, thus, their vulnerability to being distracted by this task. It is to these factors that we now turn.

19.4 DRIVING TASK DEMANDS

The demands of the driving task itself, such as increases in traffic density and the complexity of the traffic environment, can influence the distracting effects of secondary activities. For instance, the use of mobile phones on a quiet country road may have a considerably different effect on driving performance than mobile phone use in a busy urban environment. The complexity of the driving environment can moderate the effects of distraction on driving performance and safety in two ways: (1) by increasing or decreasing the driver's mental workload and, hence, reducing or increasing the amount of cognitive resources available for performing competing activities, and (2) by modifying the probability that the driver will have to react rapidly to an unexpected critical event that can give rise to a collision.

A number of studies have examined the interaction between performance of a secondary activity (primarily mobile phones) and the complexity of the driving task.[10,11,15–18] Strayer and Johnston,[18] for example, examined the effects of increasing the complexity of the driving environment on simulated driving (pursuit tracking) performance while using a mobile phone. Participants were required to converse on handheld and hands-free mobile phones while performing easy and difficult pursuit tracking tasks, which involved participants using a joystick to keep a cursor as closely aligned as possible to a moving target on a computer screen. The results revealed that when using a mobile phone, participants missed almost twice as many tracking targets as when they were not using a mobile phone and that this effect was more pronounced when the participants performed the difficult tracking task. Consistent with Lee et al.,[19] Strayer et al.[10] also found that conversing on a hands-free mobile phone while driving led to an increase in reaction times to a lead braking vehicle, and this impairment in reaction times became more pronounced as the density of the traffic increased. One interesting aspect of this finding is that neither the test car nor the lead vehicle interacted with other vehicles on the road, suggesting that simply increasing the perceptual complexity of the road environment can intensify the distracting effects of engaging in a phone conversation while driving.

Adverse weather conditions have also been shown to influence distracted drivers' ability to make safe cross-traffic turning decisions.[16] When drivers were engaged in a mobile phone task, they did not take into account the road surface condition (whether it was wet or dry) when deciding whether to accept or reject a gap. Indeed, on the wet road surface, participants were estimated to have initiated twice as many potential collisions when distracted by verbal messages.

Research by Horberry et al.,[15] however, failed to reveal any interaction between the complexity of the driving environment and conversing on a hands-free mobile phone. They manipulated the complexity of the driving environment by increasing the number of billboards and advertisements placed on the roadside and the number of buildings and oncoming traffic. Participants drove along the simple and complex driving environments while interacting with the mobile phone and while not performing any secondary task. Interacting with the mobile phone affected driving performance, by decreasing mean speed, increasing speed variability, and decreasing responses to a pedestrian hazard. However, no interaction between the distracter task and environmental complexity was revealed, suggesting that driving performance while interacting with a mobile phone was not further degraded by increased complexity of the traffic environment.

The type of objects used to increase the complexity of the driving environment may explain why the Horberry et al.[15] study failed to find that more complex driving environments further degrades driving performance when distracted. Horberry et al. used objects that were not central to the driving task to increase the complexity of the drives, such as billboards and buildings, whereas other research has tended to increase the complexity of the driving environment by manipulating objects central to driving such as other traffic and the difficulty of the driving terrain. It is possible that increasing the number of objects that are not central to the driving task has little effect on increasing the demands of the driving task because drivers simply ignore environmental features that are not essential to the driving task when already under increased load (e.g., when performing a secondary activity).

The moderating effect of driving task demand on driver distraction raises a number of questions regarding the evaluation of in-vehicle systems. In particular, it raises questions regarding the driving conditions under which in-vehicle systems should be evaluated and whether we can validly set specific pass/fail criteria for in-vehicle systems, given that the environment in which the system is evaluated will modify its effect on driving performance. This is an important issue that warrants further investigation and discussion in the literature and in design and evaluation guidelines. The moderating effect of the roadway environment also has important implications for developing adaptive vehicle-based systems to mitigate distraction, an issue considered in Chapter 27 of this book.

19.5 DRIVER CHARACTERISTICS

There is a large body of evidence that driver characteristics can influence the distracting effects of secondary activities.[20–25] Characteristics such as driver age, driving experience, and gender can affect drivers' willingness to engage in distracting activities, their ability to divide attention appropriately between multiple tasks, and their ability to self-regulate their driving to maintain suitable safety margins when distracted.

19.5.1 Age and Driving Experience

It is difficult to separate the effects of age and driving experience on driving performance, because they are highly correlated (e.g., young drivers are inexperienced drivers, and older drivers typically have many years' driving experience). Moreover, most of the driver distraction research has not attempted to separate the moderating effects of age and driving experience on distraction. As such, these two factors will be discussed together in this section. Chapter 20 discusses issues related to older drivers and distraction in more detail; however, older drivers will also be discussed briefly here.

Older drivers often have a decreased ability to share their attention between two concurrent tasks due to decreases in their visual and information processing capacities,[26] and hence, they may be more susceptible to the distracting effects of using a device while driving than their younger counterparts. Similarly, it is widely recognized that young or inexperienced drivers often lack the driving skills necessary to operate and maneuver a vehicle using only minimal attentional resources and, therefore, do not have sufficient spare attentional capacity to devote to secondary activities.[27] Young drivers also have a greater propensity for risk taking, are relatively poor at judging risk, and are vulnerable to the effects of peer pressure, all of which can encourage them to engage in risky behaviors, including distracting activities.[28]

Research has examined the moderating effects of age at the strategic level, that is, on drivers' decisions to engage in distracting activity while driving. Survey research by McEvoy et al.[29] found that young drivers, aged between 18 and 30 years, are more likely than 50- to 65-year-old drivers to engage in distracting activities while driving, including using a mobile phone (including text messaging), handling in-vehicle equipment, and attending to events, objects, or people outside the vehicle. Moreover, the young drivers rated many of the distracting activities as being less risky than did the older drivers, and they were significantly more likely to report that they had been involved in a distraction-related crash in the past 3 years.[29] Other research by Lamble et al. also found that young drivers (aged 15–24 years) reported a much higher level of mobile phone use while driving than did older drivers (55 to 65+ years).

In addition to the effects of age on willingness to engage in distracting activities, numerous studies have examined the interactive effects of driver age and distraction on driving at the tactical and operational levels.[3,21,22,25,30] Using a simulated driving task, McKnight and McKnight[21] found that drivers aged 46–80 years demonstrated a greater deficit in being able to respond to traffic signals while conversing on a mobile phone than did younger (17–25 years) and middle-aged (26–45 years) drivers. Drivers in the youngest age group demonstrated a similar level of decline in responsiveness to traffic signals as middle-aged drivers when engaged in a simple or intense phone conversation, but they responded to significantly less signals than both the older and middle-aged drivers when tuning the radio. Alm and Nilsson also found that during simulated driving, phone use increased drivers' reaction times to a braking lead vehicle and that this effect was more marked for older drivers (aged 60 years or older) than for the younger drivers (below 60 years).

More recently, Greenberg et al.[31] reported that when compared with drivers aged 25–66 years, teenage drivers (16–18 years) detected fewer events occurring in a simulated roadway when dialing a handheld phone and had a higher lane violation rate when accessing voice mails. In addition, Schreiner et al.[24] also found, in a closed-course study, that older drivers' (mean age 57 years) ability to detect forward and peripheral events while concurrently driving and using a voice recognition system to dial phone numbers was impaired compared with their baseline performance. The younger to middle-aged drivers (mean age 23 years), however, did not demonstrate a performance decrement when interacting with the voice recognition system. Similarly, McPhee et al.[22] found that compared with the younger to middle-aged drivers (aged 17–33 years), older drivers (56–71 years) were less accurate and slower at identifying target signs in a digitized image of a traffic scene when engaging in a simulated conversation (e.g., listening to and answering questions about a short paragraph). Finally, driving simulator research by Shinar et al.[25] demonstrated that older drivers' (60–71 years) driving performance (e.g., speed control and lane keeping) was more adversely affected by phone conversations than that of middle-aged (30–33 years) and young, inexperienced (18–22 years) drivers. The driving performance of the young and middle-age groups when distracted was similar.

Naturalistic driving studies conducted in the United States have revealed that younger drivers have a higher rate of involvement in inattention- and distraction-related crashes and incidents than older drivers.[32,33] The recent 100-car naturalistic driving study, for example, found that the rate of inattention-related* crash and

* In the 100-car study, inattention included secondary task distraction, inattention to the forward roadway (e.g., driving behavior that directs driver's attention from the forward field of view), drowsiness, and nonspecific eye glance away from the forward roadway.

near-crash events decreases dramatically with age. Furthermore, the rate of being involved in an inattention-related crash or near-crash was as much as four times higher for the 18- to 20-year-old age group compared with the 45–54 and 55+ driver groups.

An Australian study has also examined, for drivers of different ages, the association between distraction inside and outside the vehicle and the risk of being involved in a crash.[20] Fatal and injury crash data collected by New South Wales police during the years 1996 and 2000 were examined, and crashes were categorized as resulting from no distraction or distraction inside or outside the vehicle. In-vehicle distractions included using a handheld phone, attending to passengers, tuning the radio, and adjusting the CD player and smoking. Results revealed that, with the exception of mobile phones, the risk of being involved in a fatal or injury crash resulting from in-vehicle distractions increased with increasing age. In relation to mobile phones, drivers in the 25–29 year age group had the highest risk of being involved in a fatal or injury crash while using a handheld phone. However, Lam suggested that this finding is likely to have resulted from differential exposure to mobile phone use across age groups, rather than to differences in attention sharing ability; that is, young drivers may be more likely to use their mobile phones while driving than older drivers, and this increased exposure heightens their crash risk.

It is difficult to draw firm conclusions regarding the moderating effects of age on driver distraction, given that the classification of younger, middle-aged, and older drivers varies considerably across studies. For example, younger drivers have been defined as ranging from 17 to 25 years,[21] 16 to 18 years,[31] and 18 to 22 years,[25] whereas older drivers have been defined as ranging from 46 to 80 years,[21] 56 to 71 years,[22] and 60 to 71 years.[25] It is particularly difficult to draw conclusions regarding whether and how younger drivers' driving performance decrements when distracted differ from that of middle-aged drivers, as a number of studies have grouped younger and middle-aged drivers together. In the studies that have compared these two age groups, their driving performance decrements when distracted appear to be largely similar; however, the younger drivers, particularly teenage drivers, do exhibit greater performance decrements on some measures of driving performance (e.g., hazard detection rates and steering variability) than middle-aged drivers.[25,31] The wide age range that defines "young" drivers across studies is particularly problematic given the dramatic change in their crash rates in the first months and years of driving.[34]

It is interesting to note that although many driver distraction studies collect information on both driver age and driving experience, they typically only report the effects of age on distraction and do not attempt to separate the moderating effects of age versus driving experience on distracted driving performance. This is likely to be due to the difficulties inherent in discriminating between the effects of age and inexperience, particularly for younger drivers. Age and driving experience are highly correlated; young drivers are typically inexperienced drivers, and experienced drivers are typically older. You can always find exceptions, however. In some U.S. states, for example, drivers can receive a driver's license as young as 14 years. By the time these drivers reach the age of 16, they have more driving experience than their newly licensed counterparts in other states, making distinguishing the effects of age versus experience easier. Then there is also the problem that factors other than age and driving experience may confound the relationship between these two factors and crash risk; personality characteristics, for example, may lead some drivers to obtain their license early or late, and that may also contribute to increased crash risk.

A number of studies in the general young driver literature have investigated the relative contribution of age versus driving experience to increased crash involvement,[35,36] although it has not been examined widely in distraction research. These studies have found conflicting results, with some finding that age is a greater contributor to young driver crashes,[37,38] whereas others have found that driving experience is more important than age in determining crash involvement.[35] Many of these studies suffer from methodological limitations such as imprecise measurement of driving experience and the assumption that differences in crash involvement between drivers of different ages and driving experience levels are due solely to age and driving experience and not other factors that may lead drivers to obtain a license early or late. Despite the difficulties inherent in discriminating the relative effects of age versus driving experience on driving performance and crash involvement, research should be conducted to establish the relative influence of age versus driving experience in moderating the effects of distraction on driving performance. Such knowledge may assist with countermeasure development; for example, in targeting training methods and education campaigns for reducing young drivers' involvement in risky driving behaviors rather than targeting time-sharing skill development if age was found to be a more important moderating factor.

Overall, it appears that older drivers demonstrate greater decrements in driving performance when engaged in competing tasks than do middle-aged and young drivers. It is important to note that although younger drivers may perform better than older drivers when engaging in secondary activities (i.e., because they are better at multitasking), they are also more likely to engage in nondriving tasks, and this greater level of exposure can increase their crash risk. However, drawing firm conclusions regarding the moderating effects of age on driver distraction is difficult, given that the classification of younger, middle-aged, and older drivers has varied considerably across studies. It is also not possible to draw firm conclusions regarding the relative influence of age versus driving experience in moderating the effects of distraction on driving performance, as most distraction studies have either ignored driving experience as a factor or have not separately examined the effects of these two variables.

19.5.2 Task Familiarity and the Effects of Practice

In addition to driving experience, a driver's familiarity, or experience, with a competing activity can influence how this activity affects driving performance. Practice improves task performance, and this is particularly true for dual-task performance.[39] Practice can improve dual-task performance in a number of ways. First, practice on a task may permit it to be performed almost automatically or in a more economical manner, reducing the amount of resources required to perform it and thereby reducing its ability to interfere with, or be affected by, the concurrent performance of another task.[40,41] Second, practice allows a person to develop strategies for executing each task and prioritizing the performance of multiple tasks in an optimal manner.[42] This research suggests that with increasing practice on both the driving and competing activities, drivers can learn to better prioritize the driving and competing tasks and perform the competing activity with less interference to the driving task than would be expected from the performance of an unfamiliar or unpracticed competing activity.

In many distraction studies, the effect of competing activities on driving performance is typically examined only over a limited number of trials. Participants are not usually given the opportunity to interact with the in-vehicle device or perform the secondary activity over multiple trials, and therefore, any learning effects, whereby drivers learn to effectively time-share the competing and driving tasks, are not assessed. Although the results of this research might provide important insights into how the performance of secondary tasks can affect driving for novice users, it very likely overestimates the effects of these tasks on driving for more experienced users.

Research by Dingus et al.,[43] as part of the TravTek study, examined the effects of repeated experience with the TravTek route guidance system on driving performance. Participants were tested once before they had any previous experience with the TravTek system and once after they had used the system everyday for 6 weeks. The results revealed that, with practice, the drivers developed strategies for using the system in a more economical and safer manner. Specifically, after experience, drivers glanced at the navigation display fewer times and for shorter durations and made a smaller number of large steering reversals than they did before experience with the navigation system. Performance on lateral and longitudinal driving measures and subjective workload did not change with increased experience.

A more recent study by Shinar et al.[25] examined whether repeated practice of conversing on a mobile phone led to a learning effect, whereby drivers became better able to share the phone and driving tasks, thus reducing the effects of the secondary task on driving performance. Thirty participants carried out two mobile phone tasks (a mathematical operation task and emotionally engaging conversation) over five driving sessions. As expected, the use of the mobile phone had a negative impact on driving performance, with drivers displaying lower mean speeds and greater speed and steering variability. However, over the course of the five sessions, the negative effects of the phone tasks on driving performance diminished so that, on several of the driving measures, there was no difference observed between performance in the distraction and no-distraction conditions on later trials.

In short, it appears that the studies that examine the effects of a competing activity over a limited number of trials may be overestimating the detrimental effects of particular competing activities on driving performance, particularly for experienced users. Of course, certain properties of the competing task, such as how redundant it is (e.g., Ref. 44), will greatly influence the degree to which it becomes automated with practice and, hence, the degree to which it will interfere with driving, even after further dual-task practice. Clearly, further research is needed to determine the extent to which practice is capable of diminishing the adverse effects of distraction. Nevertheless, the epidemiological and crash data reviewed in other chapters of this book suggest that even experienced drivers, who engage in highly overlearned competing activities (e.g., talking, smoking, daydreaming), are vulnerable to the effects of distraction.

19.5.3 Gender

Gender differences in drivers' exposure to, and ability to cope with, distraction have been relatively underexamined in the literature compared with other driver characteristics, such as age. The results regarding the effects of gender on distraction exposure and distractibility are mixed.

Sullman and Baas[45] and Poysti et al.[2] found that males reported that they use mobile phones more often when driving than females, whereas Wogalter and Mayhorn[46] found that a greater number of females reported using mobile phones while driving. Differences between these studies may result from age-related differences in the samples surveyed. Sullman and Bass' participant sample was older, by an average of 10 years, than Wogalter and Mayhorn's sample, and these age differences may influence the use of phones while driving across genders. In terms of gender differences on driving performance, some studies have found that distraction has a greater impact on the driving performance of female than male drivers,[16,47,48] whereas other studies have found no gender differences in the effects of distraction.[18,21,23,49] Again, age differences between the study samples may be driving the discrepancies in the results. The studies that found gender effects tended to have an older participant sample than studies that found no effects. Indeed, Hancock et al.[48] found an interaction between age and gender, whereby no differences in the effect of distraction were found between younger male and female drivers, but that distraction had a greater effect on older female drivers than on older males.

The limited, and more general, body of literature on dual-task performance and gender does not appear to indicate that one gender is any better than the other in maintaining primary task performance in the presence of a competing task. It is probable that if there are gender differences in drivers' ability to cope with distraction, these are less likely to derive from biological differences and more likely to derive from differences between genders in such things as the amount of practice they have in driving while distracted, differences in their propensity to engage in particular activities that may distract them, and differences in the extent to which their attention is unwillingly diverted away from the driving task (e.g., by the content of advertising billboards).

19.6 INTERACTION BETWEEN DRIVER STATE AND DISTRACTION

There has been very little research examining the interaction between various driver states (e.g., fatigue, drowsiness, intoxication by drugs or alcohol, emotional state, mood) and distraction. A number of driver states, including distraction, increase crash risk, and this crash risk could be increased further if drivers are affected by a combination of driver states. Driver state has the potential to interact with distraction, by increasing or decreasing a driver's willingness to engage in distracting activities, by interfering with the self-regulation strategies normally adopted by drivers to compensate for being distracted, or by influencing the degree to which a competing activity will affect driving performance and safety. The relationship between driver fatigue and distraction is discussed in Chapter 20. This section will focus on what is known about the interactive effects of alcohol and distraction.

A number of studies have been conducted to compare the effects on driving performance of engaging in secondary activities with that of driving with a blood alcohol concentration (BAC) at or above a particular level. Very few studies, however, have examined the combined effects of alcohol and engagement in a secondary activity (e.g., mobile phone use) on driving. It is likely that alcohol interacts with distraction in a number of ways: (1) by making drivers more or less likely to engage in distracting activities, (2) by affecting how drivers self-regulate their driving when distracted, and (3) by increasing the degree to which engagement in a distracting activity will affect driving performance (e.g., both alcohol and distraction reduce drivers' reaction times; thus, in combination, these two factors might have a cumulative effect on reaction time).

A number of studies have found, under dual-task conditions, that alcohol intoxication affects the capacity to divide attention.[50] However, these studies have typically examined the effects of alcohol on dual-task performance using laboratory-based tasks (i.e., shadowing messages heard through headphones). Studies examining the effects of alcohol on real or simulated driving performance under dual-task conditions are scarce. A study by Brewer et al.,[51] however, examined a South Australian in-depth crash database to determine the extent to which crashes involving alcohol-intoxicated drivers were characterized by the driver's attention being diverted to a nondriving activity before the crash. The study found that a greater proportion of drivers who had a BAC above 0.05 (Australian legal limit) were involved in a secondary activity shortly before the crash than drivers who were not intoxicated (50% of intoxicated drivers versus 38% of nonintoxicated drivers). The authors concluded that the data suggest that intoxicated drivers may be more likely than sober drivers to engage in distracting activities while driving. However, given the lack of data on secondary activity involvement among crash-free drivers, it is not possible to establish a causal relationship between intoxication and precrash secondary activity. Furthermore, it is not clear whether the effect of alcohol was to encourage a diversion of attention away from driving toward a competing activity, to exacerbate the adverse effects of distraction on dual-task performance, or both.

A more recent study by Rakauskas and Ward[52] examined the combined effects of alcohol impairment and engagement in a distracting task on simulated driving performance. Drivers performed a mobile phone task and other in-vehicle tasks (e.g., interacting with the radio or heating, ventilation, and air-conditioning system) while sober or with a BAC of 0.08. The results indicated that although the performance of the secondary tasks degraded driving performance, these degradations were similar, in direction and magnitude, across the sober and intoxicated drivers, indicating that the presence of alcohol did not further affect driving performance when distracted. However, a number of factors may have attenuated the interactive effects of alcohol and distraction on driving in this study. First, only 9 of the 24 drivers in the alcohol condition reached a BAC over 0.08. It is possible that alcohol may only exacerbate the effects of distraction on driving at higher levels of intoxication. Second, only males aged over 21 years participated in the study. It is possible that male drivers have a higher tolerance to alcohol than female drivers and that younger drivers are more adversely affected by the combined effects of alcohol and distraction than older drivers. From an exposure perspective, it is also possible that males have more experience in dealing with distraction when inebriated than females, given their generally greater tendency to drink and drive. These are all issues that merit further investigation.

Overall, despite a lack of empirical evidence, it is likely that driver state is a factor that moderates the effects of distraction on driving performance and safety. More research should be devoted to examining the interaction between distraction and various other driver states and their combined effects on driving performance.

19.7 CONCLUSIONS

A range of factors influence whether drivers will engage in distracting activities while driving and how they will cope with these activities once engaged. These moderating factors interact in complex ways to determine whether and how driving performance will be affected by distracting activities. Factors such as age, driving demands, and driver state, for example, all influence how drivers self-regulate their driving when engaged in a competing activity; and self-regulation can, in turn, influence the degree to which distraction affects driving performance.

Understanding the factors that moderate distraction and the mechanisms underlying these relationships can inform the development of distraction countermeasures and mitigation strategies. For example, it has been found that both older and young, experienced drivers demonstrate greater decrements in driving performance when engaged in secondary tasks than do middle-aged drivers. Thus, it appears that age is an important factor moderating distraction. However, the mechanisms underlying the relationship between age and distraction are different for the two age groups, suggesting that different countermeasures are needed for these two driving groups. The larger observed decrements in older drivers' driving performance are believed to result from diminished visual and cognitive capacity and physical limitations associated with aging, which decrease their ability to perform multiple tasks concurrently. Distraction countermeasures for older drivers should be aimed at addressing and supporting the visual, physical, and cognitive limitations, such as the use of larger fonts and buttons on in-vehicle displays and limiting the amount of information presented to drivers at any one time.

For younger drivers, driving inexperience and their greater propensity to engage in risky behaviors are believed to underlie their increased vulnerability to distraction. Inexperienced drivers will often lack the skills necessary to operate a vehicle using only minimal attentional resources, leaving them with limited spare attentional capacity to devote to secondary activities. Graduated licensing systems, which ban drivers from engaging in certain distracting activities (e.g., mobile phone use and passenger carriage) for the first year or two of licensure, are one category of countermeasures that can mitigate the effects of distraction for young drivers.[53] Training and educational campaigns that make young drivers aware of the dangers of distraction and inform them of ways in which they can regulate their behavior to better cope with distractions are another measure that may be effective in reducing their willingness to engage in distracting activities and the negative impact of distraction on them as a driving population.

Much of the distraction research to date has focused on the negative effects of distraction on driving performance. Few studies have directly examined the factors that moderate this relationship. It is important that researchers and practitioners understand not only the factors that moderate distraction but the mechanisms through which this moderation occurs. Such knowledge can play an enormous role in guiding the development of effective countermeasures that are targeted at addressing the capabilities and limitations of different driver populations.

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DRIVER DISTRACTION

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