Driving impairments in teens and adults with attention-deficit/hyperactivity disorder

Russell A. Barkley, PhD

Department of Psychiatry, Medical University of South Carolina, Harborview Office Tower, 19 Hagood Avenue, Room 910, Charleston, SC 29425, USA

Attention-deficit/hyperactivity disorder (ADHD) is a well-researched developmental disorder characterized by deficits in sustained attention or persistence, resistance to distraction, voluntary motor inhibition, and the regulation of activity level relative to same-aged peers [1,2]. The disorder affects up to 5% to 8% of children and 4% to 5% of adults [3,4]. Originating in early childhood in most cases, ADHD is a relatively persistent condition, with up to 80% of diagnosed children continuing to meet diagnostic criteria in adolescence [5,6]. Recent research suggests that up to 66% of children with ADHD will continue to have clinically significant symptoms of the disorder in adulthood [7].

In childhood, the disorder has a substantial impact on numerous major life activities, including family functioning, social relationships, and educational success [8]. By adolescence, up to 35% to 45% of children with ADHD are prone to conduct problems or delinquency; 15% to 20% are prone to substance abuse, and 36% are prone to not complete high school [2,6]. Adults diagnosed with ADHD in childhood demonstrate significantly greater impairments in employment performance and interpersonal adjustment and greater antisocial behavior and associated substance dependence and abuse [2,9].

Driving risks associated with attention-deficit/hyperactivity disorder

Until a decade ago, one domain of major life activity for teens and adults that had not been explored well in ADHD research was driving, or the independent operation of a motor vehicle. Driving is often an underappre-
ciated domain of self-sufficiency and major life activity for adults. Yet it is one that facilitates most other adaptive domains, including employment, family care, responsibilities, and overall functioning, education, social engagements, shopping, and entertainment, among others, all of which would suffer extreme curtailment if an adult were to be deprived of this privilege, especially in the United States. In all of these domains, driving permits greater independence from others, exposure to more numerous opportunities, and greater efficiency in accomplishing various goals. It also, however, opens up greater exposure to harm to one’s self, to others, and to property, by providing access to a 1- to 2-ton projectile that often is used at speeds in excess of 50 to 60 miles per hour. Thus, any disorder that may impact driving adversely would be expected to have a pervasive, albeit secondary, impact on many other domains of daily adaptive functioning in other major life activities while simultaneously exposing the individual to greater liabilities.

An early longitudinal study of hyperactive children followed to adulthood suggested that the disorder might be associated with greater adverse outcomes associated with driving. Weiss et al [10] found that as adolescents and young adults, individuals with this disorder were more likely to be involved in traffic accidents as drivers than their normal peers. They were also more likely to incur greater damage to their vehicles relative to normal controls [11]. Interesting as the results were concerning a likely relationship of ADHD to poor driving, these risks were determined largely through self-reports and were not corroborated through the official driving records of the participants. Nor was the basis for these driving-related adverse outcomes evident in this early study. Was it the attentional deficits associated with ADHD that led to such risks, the impulsiveness, or both? Or were these risks the result of comorbid disorders, especially conduct disorder, and thus one more manifestation of antisocial conduct?

That ADHD, or hyperactivity, should predispose toward greater driving risks and adverse outcomes should not be surprising for several reasons. First, a major cause of vehicular crashes is driver inattention, including a proneness to distraction by in-vehicle sources of distracters (eg, other riders, radio, cell phones, pets, or other distractions) more than outside-the-vehicle distractions [12]. It would make sense, then, that individuals suffering from a disorder of inattention involving a significant susceptibility to distraction might be more prone to such accidents. Second, adult psychiatric patients have a one- to sixfold increase in risk for auto accidents relative to normal control groups [13,14]. The highest rates for adverse outcomes are among those men with conduct and antisocial symptoms or those with substance abuse disorders, especially alcohol [15,16]. These risk factors (being of male gender, displaying antisocial behavior, or using substances) are more likely to be found in those with ADHD than in the normal population. Those factors alone would argue for a substantially increased risk of adverse driving outcomes for those having ADHD. Third, many inter-related factors have been proposed to contribute to risk for serious traffic
offenses, vehicular crashes, and related injuries and fatalities among adolescents and young adults. Many of these occur more often in those with ADHD. These include excessive anger, aggression, and risk-taking [17–20], infrequent use of seat belts, greater use of alcohol and drugs, affiliation with peers who tolerate and support drug use, lack of parental monitoring, stress, and the presence of persistent behavioral or emotional difficulties [21–25]. Taken together, these findings suggest that teens and adults with ADHD, especially those with a history of conduct disorder, may have the highest rates of adverse driving outcomes, particularly if they are of male gender. Among this group, those with increased alcohol use or abuse may have the highest risks of all.

These various lines of reasoning led my colleagues and I to undertake a series of studies on the driving problems associated with ADHD. The first project involved a 3- to 5-year follow-up survey of normal adolescents and those with ADHD who had been recruited into an earlier study of teens with ADHD and their family functioning [26]. The survey asked parents about a variety of negative driving outcomes their teens may have experienced in the interim follow-up period since they began driving. The survey found that teens and young adults with ADHD were:

- More likely to have driven an automobile illegally before the time they became eligible as licensed drivers
- Less likely to be employing sound driving habits in their current driving performance, as reported by their parents
- More likely to have had their licenses suspended or revoked
- More likely to have received repeated traffic citations, most notably for speeding
- Nearly four times more likely to have had an accident while they were driving a vehicle

The survey also found that while the degree of current ADHD symptoms was associated with driving risks, some risks were associated further with the degree of oppositional and conduct problems.

This led the author and his colleagues to question adults with ADHD about their driving problems when they were recruited to participate in a separate study on clinical impairments associated with ADHD. That study used 171 adults diagnosed with ADHD and 30 adults seen in this same clinic but not diagnosed with ADHD (predominantly diagnosed with anxiety or mood disorders) [27]. Similar results to those found for teens with ADHD were evident. The adults with ADHD were more than three times as likely to have had automobile accidents. Additionally, they tended to have more such accidents ($P < .06$), and they had more traffic citations for speeding than the psychiatric control group.

About this time, Lambert [28] provided an unpublished report to the US Department of Transportation’s National Highway Traffic Safety Administration using her longitudinal study of hyperactive and control children.
She found that, by age 25 years, those having severe ADHD in childhood had a significantly greater likelihood of traffic citations in their later driving histories than did control children or those with mild ADHD. They were also more likely to repeat the same traffic offenses than were the comparison groups. There was also a trend for the severe ADHD group to have had more accidents, but this was not statistically significant. Also around this same time, an epidemiological study of adolescents followed in the Dunedin longitudinal project documented increased driving offenses and vehicular crashes in teens with significantly elevated symptoms of ADHD [29]. A comparable study using the Christchurch longitudinal sample in New Zealand also found a similar association of attentional difficulties with risk for accidents involving injury, driving without a license, and traffic violations even after controlling for conduct problems, driving experience, and gender [30].

**Current models of driving performance: implications for drivers with attention-deficit/hyperactivity disorder**

The author’s initial findings and those from the New Zealand epidemiological studies strengthened the conclusion that ADHD somehow was associated with increased risks for various adverse outcomes related to driving. Such studies did little to reveal the basis for this association, however. The process or mechanisms by which ADHD disrupts driving to result in these adversities remained unknown. To get a clearer picture of the means by which ADHD was disrupting driving the author and his colleagues sought a better understanding of the process of driving itself and how it might be studied in those with ADHD.

Driving is certainly a multi-dimensional human activity. Michon [31] has conceptualized these dimensions as involving a control hierarchy. He theorized that the task of driving is comprised of a series of three hierarchically organized levels of abilities or competencies in which higher levels can harness lower levels to serve larger goals. Deficits in abilities lower on the hierarchy may have profound effects on higher level driving performance, however, while deficits at higher levels may have little or no influence on lower level competencies and be undetected by measures assessing that lower level. Furthermore, the level at which impairment is found may have a significant bearing on the focus of rehabilitative strategies to be tried with the impaired driver. It may even determine whether such individuals should be granted driving privileges at all.

The first and lowest level is the operational level. It comprises basic rudimentary mental functions such as attention and concentration, reaction time, visual scanning, spatial perception and orientation, visual–motor integration, speed of cognitive processing, motor coordination, and other basic neuropsychological abilities inherent in driving.

The second level is the tactical level, which includes those behaviors, skills, and decisions involved in driving while in traffic. Such abilities as
tracking and adjusting one’s speed to the context and changes in it (e.g., moving from freeway into residential neighborhoods or entering school zones), turning on headlights during reduced visibility, deciding when passing is appropriate, and adjusting actual driving to environmental conditions are ascribed to this level. Impulsivity and reduced executive control over ongoing driving behavior may be manifested at this level, as might poor judgment, poor estimation of risks, inadequate adaptation of driving to the context, and an inability to shift behaviors as demands change.

At the third level, known as the strategic level, are those decisions and planning abilities pertaining to the reasons the vehicle is being used. It includes not only the goal(s) for this particular drive, but also the choice of routes one might take, the time of day to best undertake a planned trip, planning a sequence of subtrips (subgoals) within the larger outing, and evaluating general risks of traffic, conditions, density, and climate as they pertain to the excursion. This seems to involve higher order planning, forethought, goal-directed behavior, and other meta-cognitive or executive strategies so as to drive in the most effective, adaptive, and efficient way to achieve the end purposes the driving is designed to accomplish.

Summala [32] has organized these dimensions of driving into a three-dimensional grid rather than viewing them as necessarily hierarchically organized. A hierarchical model of driving very similar to Michon’s was also proposed by Keskinen [33] that included the following levels: 1) vehicle maneuvering, 2) mastering traffic situations, 3) goals and context of driving, and 4) goals for life and skills for living. The latter level has no corresponding level in Michon’s model but pertains to the importance of vehicles and driving for personal development, autonomy, and self-sufficiency. A study of 28,500 drivers in Finland [34] between 18 and 50 years of age demonstrated that younger, more novice drivers and particularly young men have greater problems at the higher levels of this hierarchy than middle-aged novice drivers. Female drivers had more difficulties at the lower levels of the hierarchy. As has been found repeatedly in studies of driving risks, young men had the highest rates of accidents and offenses.

It is evident that the nature of ADHD is such that it should produce some deleterious effects on all levels of these models. Deficiencies in sustained attention, concentration, persistence of effort, activity regulation, resistance to distraction, and rule-following behavior are primary features of the disorder in childhood and in adolescence and adulthood [5,35–37]. Slow and highly variable reaction time has a longstanding association with the disorder also [38]. These neuropsychological deficits would impact the basic operational level of Michon’s hierarchy. Teens with ADHD also seem to have a greater likelihood of risk-taking behavior, impulsive decision-making, and limited motor response inhibition relative to normal teens of the same age [35,39]. Consequently, one might expect such behaviors to have a significant impact at Michon’s tactical level of driving competence. Finally, albeit more speculatively, teens and adults with ADHD may have
greater impairments in the behavior and decision-making involved at the strategic (executive) level of driving. For instance, the evidence available from follow-up studies indicates that young adults with ADHD have difficulties in executive forms of behavior, such as performing independent work, establishing and following through on long-term plans, and using time efficiently on the job \[6\]. Deficits in laboratory tasks evaluating executive functioning are also evident in teens and adults with ADHD \[35,37,40\]. All of this would imply some adverse impact of ADHD on the capacity to operate at the strategic level of driving.

An alternative and even complementary model of driving is Rasmussen’s skill-rule-knowledge framework \[41\]. The skill-based level of driving is the lowest one and involves the well-learned procedures for the operation of the vehicle, known as automated schemata. The rule-based or second level includes the activation of rules for the safe operation of the vehicle on roadways and in traffic. The third level is knowledge-based and pertains to conscious problem solving while driving and is especially pertinent to driving in novel situations for which no existing rules are applicable. To some extent, these correspond to Michon’s levels, though not precisely. A fourth level, known as judgment-based behavior, was added to this model by Lehto \[42\]. It was intended to bring into the model the value judgments, emotional reactions, and motivational state of the driver in determining behavior while driving. By combining the two models orthogonally, one could obtain a matrix of driving performance that more comprehensively captures its nature (Table 1) \[43,44\]. As with Michon’s model, it is relatively easy to see how foregoing basic cognitive and executive deficits associated with ADHD might adversely affect all levels of this hierarchy.

**Exploring the basis for elevated driving risks in drivers with attention-deficit/hyperactivity disorder**

Using Michon’s model, the author and colleagues have conducted several studies exploring the impact of ADHD at the operational and tactical levels of driving. They also have examined driving knowledge in addition to operational skills. Strategic driving, however, has not been evaluated in these studies, leaving open the issue of the impact of ADHD on driving at this level and suggesting an avenue for future research.

In the author’s initial pilot study, the research team \[45\] compared 25 young adults with ADHD with 23 young adults from the community. Not only were the participants interviewed about their driving histories and traffic offenses and crashes (adverse driving outcomes) as in past studies, but the study also obtained their official driving record from the state Department of Motor Vehicles (DMV). The driving abilities of participants also were assessed using a computer-simulated driving test like that sometimes used by occupational therapists or clinical neuropsychologists to assess driving ability among elderly or neurologically impaired patients \[46\]. The test was chosen as
a means of determining the basis for the driving problems that seemed to be associated with ADHD. The testing device was comprised of a computer monitor placed on top of a small cabinet that also contained a small steering wheel and directional signal, both of which were connected to a computer. The apparatus also included gas and brake pedals on the floor likewise connected to the computer hardware. A two-dimensional roadway, like a maze, moved vertically across the monitor, and the subject had to steer a small rectangle (the vehicle) through the roadway (maze) while following various instructions from the examiner. The author and colleagues also evaluated driving knowledge and decision-making abilities using a videotape test of actual driving situations [47]. This commercially available videotape is used to screen applicants for commercial transportation companies.

As in earlier studies, more of these young adults with ADHD had received speeding tickets (100% versus 54%), had their licenses suspended or revoked (32% versus 4%), and had been involved in a crash as the driver than members of the control group (80% versus 52%). They also had received more speeding tickets (4.9 versus 1.3) and experienced significantly more crashes (2.7 versus 1.6). More of the ADHD group also had been involved crashes resulting in injuries (60% versus 17%). DMV records corroborated many of these adverse outcomes. The young adults with ADHD rated themselves as employing poorer driving habits while operating their own motor vehicles and were rated by others as using poor driving habits compared with the control group. No differences in driving knowledge were evident on the videotape test, suggesting that those with ADHD seemed to know as much about driving as the control group. But the ADHD group showed significantly more erratic control of the simulated motor vehicle in the driving simulator and had more scrapes and crashes in this test. This was the first study to demonstrate that ADHD may adversely affect an individual’s tactical management of a motor vehicle beyond predisposing them toward more traffic offenses and vehicular crashes. Thus, the author and colleagues were able to conclude that the tactical level of driving is

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problematic for those with ADHD, while problems with knowledge were not evident here. The study, however, did not explore the operational level concerning basic cognitive abilities that are essential for safe operation of the vehicle, though such deficits were established clearly in earlier research on the disorder. Unfortunately, the small samples used in that study reduced its statistical power such that it was able to detect only large effect sizes as significant. That may have accounted for its failure to find any group differences on the videotape test of driving knowledge and decision-making ability.

This small study was sufficiently promising to warrant a much larger examination of driving in ADHD [48]. The author and colleagues did so by comparing large samples of ADHD (N = 105) and community control teens and young adults (N = 64). As in the pilot study, this one not only used self-reports of driving history and negative outcomes but also obtained the DMV records on all participants. It once again evaluated the actual driving behavior of participants through self-ratings and ratings by others who knew the participant’s driving well. Unlike any prior studies of ADHD, this one studied the cognitive abilities necessary for safe driving, such as reaction time, visual discrimination, and rule-following ability. This provided for a multi-method, multi-informant, and multi-level evaluation of driving knowledge, competence, and adverse outcomes of the participants more comprehensive in scope than had been attempted in prior studies.

Again, this study found that young adults with ADHD experienced more adverse driving outcomes than control adults both in the participants’ own self-reported histories and in their official DMV records. Young adults with ADHD received more than twice the number of driving citations (11.7 versus 4.8), particularly for speeding (3.9 versus 2.4), than the control group and had more license suspensions/revocations in their relatively short driving careers (0.5 versus 0.1). Moreover, the ADHD group reported being involved in more vehicular crashes as the driver (1.9 versus 1.2) over the average of 4.5 years they had been driving, being at fault in more such crashes (1.3 versus 0.9), and having more severe crashes as reflected in dollar damage than did the control group ($4221 versus $1665). With the exception of vehicular crashes, group differences on several of these adverse outcomes were corroborated in the official DMV records. Such driving risks may begin even earlier in adolescence in the ADHD group than in the control group. As found in a previous smaller study of teens [26], significantly more of the ADHD group (64% versus 40%) reported having driven a motor vehicle illegally as teenagers before being licensed to drive than the control group. These findings clearly highlight the high risk that those with ADHD have in their daily driving activities.

Moreover, this large-scale study extended earlier research by examining multiple levels of basic cognitive ability and driving performance beyond just assessing adverse outcomes from driving histories. Here also, the ADHD group manifested some limitations in basic cognitive functions
related to driving. On the continuous performance test, the ADHD group was substantially less attentive during the task than the control group. They were not, however, more impulsive on that task (but were on a computerized continuous performance test). The ADHD group also performed comparable to the control group on basic visual discrimination and reaction time tasks, suggesting no perceptual impairments that might affect driving. In contrast, the ADHD group made significantly more errors when the instructions for this task were reversed, implying difficulties in rule-governed behavior under such circumstances. In other words, they were more governed by the events in the stimulus fields than by the rules in effect that competed with those stimuli. And they achieved significantly fewer correct responses in a visual scanning task, particularly when items were presented to the right visual field. Why this should be the case is unclear and is deserving of replication in future studies.

The difficulties with attentiveness, impulse control on a continuous performance test (CPT), and rule following evident here have been found in previous studies of cognitive functioning in children with ADHD [2]. They extend those deficits to the young adult age group of this disorder and may provide some hint as to one reason for the greater frequency of accidents in the ADHD group. Driver inattentiveness was given by both ADHD and control participants here as the single most frequent reason for their vehicular crashes (approximately 45%). The author and colleagues also assessed executive functioning in these adults. The ADHD group demonstrated greater deficits in some executive functions, such as vigilance, inhibition, working memory, sense of time, and interference control [37,49]. Evidence was found in this driving study for a significant albeit modest relationship between laboratory measures of poor inhibition and increased accidents, whereas deficient interference control (resistance to distraction) was related significantly to the number of driving citations received. These results clearly suggest that ADHD has an adverse impact on the operational or basic cognitive level necessary for driving and that driver inattention, poor rule adherence, reduced inhibition, and deficient resistance to distraction may be mechanisms by which ADHD adversely impacts driving.

Four areas of knowledge were assessed here. In three of these, the ADHD group did not differ from the control group, suggesting equivalent knowledge in perceptual skills, traffic risk situations, and driving procedures. In contrast, general driving knowledge (driving laws and rules of the road) was significantly lower in the ADHD group than in the control group. This was the first study to document that drivers having ADHD may be at a disadvantage in some areas of driving knowledge compared with non-ADHD drivers. It is not clear whether this represents a deficit in driving knowledge or in the rapid application of that knowledge during decision-making.

Efforts were made here to evaluate the tactical or operational driving performance of participants through the use of a computer-based driving simulation program previously used for screening elderly and head-injured
adults. The previous study of a smaller sample of young adults [45] found the ADHD group to have more steering incoordination, more scrapes, and more crashes of the simulated vehicle while driving through the three different courses. This study was unable to replicate these results. This occurred despite testing participants twice on the simulator to enhance the sensitivity of the measure to any potential impairment in the ADHD group. It is possible that young adults with ADHD simply have no difficulties with the tactical operation of a motor vehicle in terms of negotiating driving courses. Or, it may be that the previous results were caused more by group differences in IQ, than to ADHD, given that the effect of IQ level on simulator performance in that study was not examined.

It is also possible that an inexpensive, computer-based simulator such as the one used here is simply not sensitive enough to any subtle difficulties that young adults with ADHD may have in operating a motor vehicle. After all, a cabinet with a computer monitor and small steering wheel hardly approximates a real vehicle, nor does a two-dimensional black-and-white maze have much similarity to three-dimensional roadways with traffic. The results here may suggest that simple driving simulators are inadequate for evaluating the driving risks of young adults with ADHD. More modern, virtual reality driving simulation systems may be required to detect group differences.

Although these simulator results might suggest that those with ADHD have no difficulties in the tactical level of driving, the ratings noted previously concerning the actual use of safe driving habits while driving suggest otherwise. Both the ADHD drivers and others who knew them well rated them as poorer in the management of their vehicle and in other tactical aspects of safe driving behavior than was the case in the control group. This constitutes the third study to find such group differences on ratings of actual driving and clearly supports a problem with the safe tactical operation of a vehicle in those with ADHD. Given that such ratings have been shown to have a significant relation to accidents and traffic citations [26], such poor ratings have some predictive validity.

This study made special efforts to examine what factors besides ADHD may have contributed to these group differences. Sex of the participants and ADHD subtype appeared to make no contribution, nor did the initial group differences in IQ. Although several of the laboratory measures of basic cognitive abilities and driving knowledge and performance showed significant main effects for IQ level in this study, in no instance was there a significant interaction of group with IQ level. Comorbid oppositional defiant disorder (ODD), depression, anxiety, and frequency of alcohol or drug use, and drunkenness also did not account for the group differences reported here. It is still possible that these comorbid conditions may contribute small effects to the measures collected here that went undetected given the relatively modest sample sizes available for each comparison. Nevertheless, these results give some confidence to the conclusion that the group differences evident here are largely, if not wholly, the result of ADHD.
To summarize, ADHD clearly predisposes drivers to greater risks of adverse driving outcomes, such as more traffic citations, repeated vehicular crashes, more severe crashes, and ultimately a greater likelihood of license suspension or revocation. One basis for such elevated risks appears to be the underlying cognitive impairments inherent in the disorder, specifically attentional deficits, poor resistance to distraction, greater difficulties with response inhibition, and problems in executive functioning such as rule adherence and working memory. ADHD therefore disrupts the operational level of driving in Michon’s hierarchy of driving performance. It remains likely that ADHD also contributes to difficulties at the tactical level of vehicular operation. Although this was evident in one study using a relative simple driving simulator, it was not replicated. A more modern virtual reality driving simulator, however, is showing some promise in detecting such tactical deficits in the driving of adults with ADHD. Even so, if behavior ratings of the use of safe driving habits in natural settings can be taken as an index of this level of driving, then all of studies have found ADHD to be associated with such poor use of safe driving behavior. The two studies examining the knowledge aspect of driving have not made a convincing case that ADHD disrupts this dimension or component of driving. The author’s initial small study found no differences in knowledge, while the larger subsequent study found a deficit mainly in knowledge of driving laws but not in three other areas of driving knowledge. No studies have examined the strategic level of driving in Michon’s model, much less the higher dimensions of driving identified in other models, such as value judgments or the emotional/motivational aspects of driving or how it contributes to larger life goals and self-sufficiency.

The potential impact of alcohol and drug use on driving in adults with attention-deficit/hyperactivity disorder

The results of the author’s previous studies found that the teens and young adults with ADHD consumed more alcohol in an average week than the control group and had gotten drunk more times in the past 3 months than control subjects. In the author’s largest, most recent study [48], both the number of drinks per week \( (r = 0.28, N = 129, P = 0.002) \) and the number of times the participant got drunk in the past 3 months \( (r = 0.30, N = 129, P = 0.001) \) correlated significantly with the self-reports of the number of citations received for driving while intoxicated. They also correlated significantly with the DMV records for the number of citations for driving while intoxicated (drinks per week: \( r = 0.18, N = 160, P = 0.023 \); drunk in past 3 months: \( r = 0.16, N = 160, P = 0.048 \)). Both correlated significantly with the self-ratings of driving performance (drinks per week: \( r = -0.16, N = 160, P = 0.041 \); drunk in past 3 months: \( r = -0.21, N = 160, P = 0.008 \)) but not with the other ratings of driving.
It is known that the susceptibility to a vehicular crash while driving increases significantly at 50 mg/dL of blood alcohol concentrations (BAC) and increases more steeply past the level of legal intoxication (typically 80 mg/dL) [50]. It also is known that the frequency of alcohol and other drug use among adolescents and young adults is a significant predictor of later serious crashes and traffic offenses [24]. Trauma center patients having been involved in driving while injured likewise have a significantly greater history of alcohol and drug use/dependence and higher blood alcohol levels and a greater propensity for risk-taking [51]. Given that teens and young adults with ADHD consume more alcohol weekly and become drunk more often than their peers, are more likely to use other substances, and display greater risk taking dispositions, their risks for adverse driving outcomes would be expected to be greater as a function of these group differences, regardless of the negative effects of ADHD itself on driving. The combined conditions of ADHD and alcohol use before driving would be expected to compound these risks further, beyond that resulting from any condition alone. Some indication of this was found in the author’s prior study in which both ADHD symptoms and alcohol use significantly predicted poorer self-ratings of typical driving practices.

There is reason to suspect that alcohol consumption may have a differentially greater adverse impact on driving performance in young adults with ADHD than it would in the normal population. This is because those with ADHD already have an impairment in behavioral inhibition as a major feature of their disorder [2]. Alcohol is known to produce a disinhibiting effect on behavior initially [52]. In the presence of an already disinhibited individual having ADHD, such an effect may result in a substantially steeper decline in driving performance as a function of blood alcohol concentration than would be expected in normal peers. Indeed, the off-alcohol performance of those with ADHD on driving ratings and laboratory tasks related to driving seems to resemble that of a normal individual who is mildly intoxicated (ie, poorer inhibition, slower and more variable reaction times, slower decision-making, and more erratic steering and motor control). A project underway in the author’s laboratory seeks to test this possibility through the examination of the effects of alcohol consumption on the simulated driving performance and other laboratory tasks of basic psychological abilities related to driving performance in ADHD and community control young adults.

In doing so, the author and colleagues are using a virtual reality driving simulator (FAAC, Ann Arbor, Michigan) that more closely approximates a real vehicle and more realistic driving situations. This simulator can present various realistic driving scenarios and measure variables related to driving performance (eg, steering variation in the roadway, speed, duration spent speeding, and reaction time to critical events). The actual simulator is shown in Fig. 1. It consists of five 32-inch television monitors that constitute the driver’s windshield and surround the driving platform (seat and
Fig. 1. A virtual reality driving simulator used in research on driving in adults with ADHD at the Medical University of South Carolina.
participant approaches a car parked along the shoulder of the road, the car suddenly pulls out into the participant’s path. The participant must react by braking in time to avoid a collision. Should a collision occur, the simulator jump the subject back to the driving location 30 seconds before the collision and permit them to drive through the scene again while recording the frequency of collisions. The simulator records reaction time to these critical events along with measures of steering variability, speed, time spent exceeding the speed limit, appropriate uses of turn signals, number of times the car is driven out of the normal roadway and the duration of each such mistake, and the total number of collisions during the 12-minute course. A separate standardized program also has been created that comprises an obstacle course that the participant must negotiate as fast as possible while keeping the car within the designated roadway and not colliding with any of the obstacles encountered. The individual also rates his or her own driving performance after completing the simulator courses, and the examiner uses a similar rating scale to rate the participant’s driving performance in the simulator. Evidence from initial work with this simulator indicates that a combination of simulator measures and the examiner rating scale are significantly predictive of actual driving as rated by the individual and others who have ridden with the subject. Initial findings indicate that adults with ADHD perform more poorly on this simulator in contrast to earlier research, in which such findings were inconsistent when a simpler driving simulator was employed.

This means of evaluating driving should provide a more sensitive, realistic, and valid means of studying the effects of alcohol or other medications on driving in adults with ADHD without the risk of harm or destruction that might exist from using an actual road test with a real vehicle for these purposes. If the results of this study support these hypotheses, it would result in encouraging clinicians to warn adults with ADHD and parents of teens with ADHD against the use of even small amounts of alcohol while driving.

Self-evaluation of driving performance in adults with attention-deficit/hyperactivity disorder

Research shows that children with ADHD show a positive illusory bias in their self-perceptions of competence in multiple domains such as academic competence, athletic competence, social acceptance, and physical appearance [53]. In addition, ADHD children often overestimate their performance on laboratory tasks immediately after completing the tasks [54,55]. The benefit of laboratory studies is that children’s self-perceptions of performance can be compared directly to their actual performance. Often, inflated self-evaluations for children with ADHD result from self-assessments that are similar to (as opposed to more positive than) self-evaluations of comparison children, despite ADHD children’s worse actual performance [56].
The overestimated self-assessments of those with ADHD may be especially meaningful in relation to the concept of meta-cognition, a term more frequently used in the developmental, educational, and neuropsychology literatures. Meta-cognition refers to the monitoring and regulation of one’s cognitive capabilities and processes. Broadly, the term encompasses self-awareness (self-monitoring) and the use of strategies based on this awareness aimed at facilitating learning or performance. In neuropsychology, this set of abilities often is referred to as executive functioning [2]. Therefore, meta-cognitive or executive abilities include accurate assessment of one’s ability and the ability to modify one’s behavior according to such on-line assessments. Accurate assessments of ability and performance are naturally a prerequisite to the use of adaptive strategies; one must know what needs to be modified before one can modify it.

Such self-awareness may be especially important while driving, because individuals must react to changes in the relationship between the vehicle, the driving environment, and their own skills in accordance with their motivational goals [32]. Therefore, an accurate awareness of driving skills can help a driver use appropriate strategies to avoid accidents. For example, drivers may reduce speed on a windy mountain road, because they know that their skills are less adequate in that situation than under normal conditions. Inaccurate assessments of driving skill, however, may contribute to accidents. For example, novice drivers are often overconfident in their developing abilities, causing them to underestimate the amount of risk in a given situation and contributing to an increased accident rate [20].

If persons with ADHD lack the requisite awareness of their driving deficits, it may contribute to the continuation of maladaptive strategies and the preclusion of adaptive ones, especially in more dangerous situations. Those with ADHD have been shown to have difficulties in the areas of self-awareness, self-monitoring, and strategy usage, and such difficulties are predicted by developmental theories of the disorder [2]. ADHD may be related not only to inaccurate self-assessments, but it also may preclude the use of adaptive strategies, a possibility that may become immediately important when adults with ADHD get behind the wheel.

Overestimates of ability had not been examined previously in adults with ADHD. Knouse et al (unpublished paper, University of North Carolina at Greensboro) therefore set out to evaluate this domain of potential deficiency. Several studies from social psychology have addressed this issue in normal adults. Kruger and Dunning [57] have shown that in normal populations, meta-cognitive inaccuracies have been associated with incompetence in several domains. The nearly universal to rate one’s self above the mean, known as the above average effect, has been documented well, but this tendency may have greater implications for those who are less competent. Those who are the least competent in a domain overestimate their actual percentile ranking by the greatest margin. Kruger and Dunning [57] assert that the knowledge necessary for competence in a domain is the
same knowledge required for assessing competence. Thus, incompetence impairs the ability to recognize and correct mistakes. If self-awareness of abilities is a prerequisite to the modification of maladaptive behavior, then those with less competence in a domain may remain less competent, because they fail to realize it.

Knouse and colleagues (unpublished paper, University of North Carolina at Greensboro) therefore tried to determine whether adults with ADHD are more likely than a comparison group to show inaccuracies in perceptions of their driving behavior in naturalistic settings and in a virtual reality driving simulator. They compared driving behaviors and self-assessments in adults with ADHD to a general population comparison group in two different domains: self-reports of their naturalistic driving behavior and history and performance on a virtual reality driving simulator. Thus, Knouse and colleagues examined self-perceptions of driving using both ecologically valid criteria (eg, actual driving history) and in a highly controlled driving simulator. They hypothesized that adults with ADHD would show a positive illusory bias and would overestimate their driving ability and performance significantly in both domains relative to the comparison group. Consistent with the literature on positive illusory bias in children with ADHD, Knouse and colleagues expected that ADHD adults’ overestimates would result from estimates of performance that are similar to the comparison group despite a significantly worse driving history and significantly worse performance on simulator measures.

The results showed that the adults with ADHD not only performed worse on naturalistic measures of driving but also on the latest driving simulator (see Fig. 1), confirming the earlier studies and also detecting driving deficits using a laboratory-based driving simulator. More important here was the finding that these adults also significantly overestimated their performance to a greater extent than did the comparison group on naturalistic and simulator driving indicators. Participants in both groups tended to overestimate their performance in comparison to the rest of the sample as predicted by the above-average phenomenon. The magnitude of this overestimation was significantly higher for the ADHD group than the comparison group on naturalistic variables and nearly all simulator variables, however. ADHD and comparison participants did not differ on their mean perceived percentile rankings of driving ability, suggesting that the increased overestimation in the ADHD group is a result of skill deficits, not inflated estimates that grossly exceed those given by comparison participants.

These findings are quite consistent with recent studies showing a positive illusory bias in children with ADHD and extend that finding to an adult ADHD population and to an adult domain of functioning. To the author’s knowledge, the current study is the first to address specifically the issue of self-estimates and positive illusory bias in adults with ADHD. The fact that those with ADHD overestimated their performance compared with their peers suggests that they may suffer from a more limited awareness of the
severity of their skill deficits and negative outcomes, both on the road and in other domains. Misperceptions or inaccuracies in self-reports about symptoms are suggested by a longitudinal follow-up study comparing self- and parent-reported severity of symptoms for adults with a history of ADHD in childhood [7]. In particular, parents reported substantially more symptoms than did the adults themselves. Parents’ reports were also a better predictor of major life outcomes in educational, occupational, and social domains than self-reports, indicating that at best adults with ADHD may not be aware of the severity of their deficits.

The ADHD adults’ inaccuracies in their self-estimates of driving safety and performance may be related to a lack of knowledge about what constitutes good driving performance or having lower standards for good driving. This is consistent with earlier findings of a deficit in some aspects of driving knowledge. Kruger and Dunning [57] suggest that incompetence in a domain is associated with overestimations of performance in that domain, because competence is a prerequisite to being able to recognize good performance. Therefore, it is possible that ADHD participants overestimated their driving performance simply because their lower level of competence rendered them unable to recognize their shortcomings as such. Lack of competence may account for inaccurate self-estimates in other areas of research also. For example, just as ADHD participants’ self-estimates did not differ from those of the comparison group, older adults’ meta-cognitive estimates in memory tasks do not differ from those of younger adults, but their skills deficits render these self-estimates less accurate. A lack of awareness of deficits may prohibit adults with ADHD from using meta-cognitive skills to guide their behavior or from adopting strategies that might lessen their driving risks.

Another possible explanation for these findings is that meta-cognitive deficits are a hallmark of ADHD itself. Meta-cognition is related closely to the neuropsychological concept of executive functions, which often are identified as being deficient in children and adults with ADHD. Therefore, meta-cognitive difficulties and inaccurate self-estimates would be predicted in these adults with ADHD. These possible explanations warrant further empirical attention. In addition, they are not mutually exclusive explanations. For example, Kruger and Dunning’s [57] incompetence hypothesis may explain in part how lower driving ability levels and a lack of awareness (which might be initially a function of the ADHD symptoms themselves) could serve to maintain one another. That is, lower ability prevents the person from recognizing competence, and this lack of recognition maintains misperceptions about driving ability and maladaptive driving behavior. Such findings have implications for assisting teens and adults with ADHD to improve their driving. They suggest that simply explaining such deficits to them or exposing them to better driver training programs may not be sufficient. These teens and adults may not accept or use such skills or information or even bother attending a remedial driving course, as they do not see themselves as deficient in their driving relative to others.
Driving-related anger, hostility, and aggression (road rage)

Recent studies have documented a significant relationship between driver emotional status, aggressive driving, and risks for various adverse driving outcomes such as citations and crashes. For instance, Porter and Berry [58] used a US probability sample of 880 drivers to survey them about various driving behaviors. Level of frustration was associated with the likelihood of most risky driving behaviors such as speeding, tailgating, weaving in and out of traffic, and gesturing angrily at other drivers. Another recent study of drivers aged 18 to 24 years found that aggressive behavior while driving could be reduced to a two-dimensional structure comprised of irritability while driving and degree of driving violations [59]. The authors found that irritability (ie, frustration, anger, and aggression) while driving was among the most important predictors of involvement in car crashes apart from simply the age of the driver (younger drivers having higher crash rates). Many other researchers have reported findings that clearly link level of irritability, anger, and aggression to detrimental driving practices and risk of car crashes [60,61].

Deffenbacher et al have conducted multiple studies on the relationship of anger, hostility, and aggression to unsafe driving and risk for vehicular crashes [62–64]. In one such study [62], high levels of driving anger appeared to constitute a motive for the adoption of risky driving behaviors and thus contributed ultimately to crash risk. Others have found a similar relationship between driving anger as a basis for opting to use high-risk driving practices (eg, tailgating, weaving, or speeding) [65,66]. In a subsequent study by Deffenbacher [63] results indicated that driving anger was correlated positively with loss of concentration while driving, loss of vehicular control, near-collisions (close calls), and generally aggressive driving practices. A recent study by this same research team [67] compared high anger drivers with low anger drivers in their driving behavior patterns. As one might expect, high anger drivers reported more frequent and intense episodes of anger while driving, reported more aggressive and less constructive forms of expressing anger while driving, engaged in more aggressive and risky behavior on the road, were more likely to display anger and aggressive driving when provoked, and experienced more accidents than low anger drivers. Research consistently reveals a significant relationship of anger, hostility, and aggression behaviors, particularly while driving, and elevated risks for various adverse driving outcomes, particularly citations and crashes. Other researchers [68] have identified high sensation seeking as being related to higher frequencies of aggressive driving, a greater propensity for speeding, and an increased use of alcohol, including while driving. Thus, it also may constitute an additional personality factor that contributes to aggressive driving and elevated driving risks.

Research on adults with ADHD has begun to suggest that these adults may be more prone to frustration, anger, hostility, and aggression. They are
also more likely to manifest sensation seeking, frank antisocial conduct, greater use of alcohol and drugs, and thus a greater likelihood of comorbid substance use disorders. This research would suggest that adult drivers having ADHD may be more prone to anger, hostility and aggression behaviors while driving and that such behaviors may elevate their driving risks beyond that contributed by ADHD itself. It also suggests that other personality and behavioral factors (ie, sensation seeking, antisocial behavior, and drug use) may contribute to their elevated driving risks further. Yet no published studies have examined specifically the extent to which this greater occurrence of AHA behavior among adults with ADHD may affect their driving and associated risks for adverse driving outcomes. Nor have any published studies focused on the contribution of sensation seeking, antisocial behavior, or drug use and its disorders, to level of anger, hostility, and aggression behaviors in adults with ADHD while driving or to the driving risks associated with that anger, hostility, and aggression behavior pattern.

Richards (unpublished data, 2003) compared college students with low and high symptoms of ADHD and showed that those with high symptoms of ADHD experienced more driving anger, displayed such anger in more hostile/aggressive ways, were more aggressive and risky on the road, experienced more crash-related outcomes, were more generally angry, and tended to display anger in socially unacceptable ways. She noted that although her findings were only of a correlational nature, the results suggested that this anger may contribute to difficulties on the road (eg, more traffic citations and more crash-related outcomes). Yet she identified several limitations in her study: 1) the participants were not diagnosed ADHD, but instead were placed in low and high ADHD symptom groups based on self-report of current and childhood symptoms; 2) gender analyses were not conducted because of a low number of high ADHD symptom females, and 3) all participants in the study were college students, and thus the results may not generalize to other age groups, noncollege students, or clinical patients with ADHD.

Some of these limitations were addressed recently by Richards in her dissertation conducted in part in my driving laboratory. ADHD adults (n = 56) from the author’s clinic completed measures on driving anger; driving anger expression; angry thoughts behind the wheel; and aggressive, risky and crash-related behavior. Results were compared with two non-ADHD control groups, one obtained from the same community as the ADHD sample (n = 106) and the other from college students (n = 432) who completed all instruments. The adults with ADHD reported more driving anger and aggressive expression through the use of their vehicle and less adaptive/constructive anger expression than their non-ADHD peers. Adult drivers with ADHD rated themselves as more angry, risky, and unsafe and reported experiencing more losses of concentration and vehicular control than the control groups.

Despite its encouraging findings, this study leaves much to clarify about this relationship. First, does level of anger, hostility, and aggression within
drivers with ADHD contribute independently to further risky driving practices and a greater likelihood of adverse driving outcomes beyond that contributed by severity of ADHD symptoms alone? It is possible that anger, hostility, and aggression behaviors simply are serving as a proxy variable for severity of ADHD and make no independent contribution to driving risks. Although this explanation seems doubtful, it remains a viable alternative until it can be ruled out by empirical research. Second, to what extent do other factors such as sensation seeking, antisocial behavior, degree of alcohol and drug use, or depression and anxiety contribute to level of anger, hostility, and aggression behaviors. As noted previously, these factors occur more often among adults with ADHD and may contribute to their increased anger, hostility, and aggression behaviors while driving and thereby to their increased probability of using unsafe and risky driving practices. My colleagues and I plan to explore these questions further in a subsequent study of adults with ADHD.

Driving in adults diagnosed with attention-deficit/hyperactivity disorder as children

All of the aforementioned studies of driving in ADHD have been done with clinically referred teens and adults known to have the disorder or, in the case of Richards’ studies on anger, hostility, and aggression, with college students manifesting high symptom levels of ADHD. This raises the related question of whether children diagnosed with ADHD are more prone to driving impairments and adverse outcomes when they reach driving age than are control children followed over the same time period. Mariellen Fischer at the Medical College of Wisconsin and I have been involved in a long-term study that followed hyperactive children into adulthood. In a recently completed paper submitted for publication (unpublished data, 2003), the author and colleagues reported on the results of this longitudinal study of hyperactive/ADHD children followed to young adulthood in which driving-related cognitive abilities, driving behavior, and history of adverse driving outcomes were examined in detail.

A multi-method, multi-level, multi-source battery of driving measures was collected at the young adult follow-up (mean 20 years) on a large sample of hyperactive (N = 147) and community control (N = 71) children followed for more than 13 years. More of the hyperactive group reported having been ticketed for reckless driving and driving without a license, having hit-and-run crashes, and having their licenses suspended or revoked. Official driving records also revealed a greater proportion of the hyperactive group having received traffic citations and receiving more such citations than the community control group. The author and colleagues did not, however, document a greater frequency of accidents in the hyperactive group as had been found among clinic-referred adults. This may have to do with the author’s reliance on self-reported information for this outcome. The cost of
damage in their initial crashes, however, was also significantly greater in the hyperactive than community control group. Both self-report and other ratings of actual driving behavior revealed less safe driving practices being used by the hyperactive group, while observations by driving instructors during a behind-the-wheel road test indicated significantly more errors in driving caused by impulsiveness. Driving performance on a simulator further revealed slower and more variable reaction times, greater errors of impulsiveness (eg, false alarms and poor rule following), more steering variability, and more scrapes and crashes of the simulated vehicle against road boundaries than in the community control group. These findings largely corroborated prior research discussed previously on clinic-referred adults with ADHD and add to a growing literature on the significant driving risks associated with hyperactivity/ADHD at all levels of driving performance.

Implications of research findings for treatment

In view of the pervasive adversities established at all levels of driving performance studied (operational, tactical) and negative driving outcomes resulting from ADHD, it is imperative that adults with ADHD and parents of adolescents with ADHD be counseled about the driving risks now reasonably well-documented as accruing from this disorder. The author and colleagues would even go so far as to propose a more graduated, restrictive licensing system for teens about to begin their driving careers such that they progress more slowly toward independent licensed driving than other teens. Given that teens are among the highest risk drivers, teens with ADHD may be at an inordinate risk that warrants consideration of a more step-wise, graduated approach to licensing.

It is also imperative that treatments be tested for their efficacy in reducing these driving impairments and adversities. The author and colleagues are not optimistic about the efficacy of cognitive, behavioral, family, or educational interventions for teens and young adults with ADHD for their driving performance impairments and greater adverse outcomes for several reasons. Research on cognitive therapy in children with ADHD has not found this mode of intervention to be effective for this disorder [69–71]. It remains an open question whether adults with ADHD may prove more responsive to such treatments given their greater cognitive maturity. But if the same results are found for adults with ADHD, then teaching teens and adults with ADHD self-instruction and self-control procedures to employ while driving would seem to be an ineffective modality.

Behavioral (contingency management) interventions have proven effective for symptom reduction in home and classroom settings [2], but they have been found to produce results that are highly situation- and domain-specific. And they are dependent on the motivation of caregivers to implement and maintain the management programs. Most disheartening, however, is that such programs must be instituted at the critical points of
performance in the natural ecology of the person with ADHD if they are to succeed [72]. Needless to say, parents and others cannot be with an ADHD teen or young adult most of the time that the ADHD individual is driving. A treatment is needed that alters the individual’s driving behavior when that individual is operating a motor vehicle and at times when no caregiver may be nearby to apply that intervention.

Medication is the only treatment that meets these requirements and therefore may have some hope of improving the driving performance and risks for youth with ADHD. Two classes of medication are available that may offer some promise for treating the driving problems of those with ADHD. These are stimulant medications, such as methylphenidate (eg, Ritalin, Focalin, Concerta, and Medadate CD) and amphetamines (eg, Dexedrine, Adderall, and Adderall XR) and the most recent noradrenergic reuptake inhibitor, atomoxetine (Strattera).

As noted previously, research demonstrated that ADHD is associated with impaired motor inhibition, reaction time, visual-motor coordination, decision-making, and rule-governed behavior. The latter deficit is particularly evident when rules are reversed from those in prior tasks and so are in opposition to the compelling stimuli present in the immediate context. Such deficits in basic psychological processes that carry over into poor motor vehicle operation are unlikely to respond to psychosocial forms of intervention given the aforementioned limitations of those approaches in the context of independent driving. In contrast, stimulant medications routinely have been found to improve these domains of psychological functioning in children with ADHD [73,74]. Such medications have the added advantage of being in the bloodstream at critical points of performance during independent driving, provided that the individual has taken his or her dose of medication within an adequate time before operation of a motor vehicle. For these reasons, the author and colleagues believe that stimulant medications offer the greatest promise for managing the driving-related problems of teens and young adults with ADHD. Yet the efficacy of stimulants for improving driving performance in those with ADHD has not been studied well, and the efficacy of atomoxetine for this purpose has received no previous attention at all.

There is suggestive evidence that stimulant medications may be useful for driving. In their longitudinal study, Weiss and Hechtman [6] found that hyperactive adolescents and young adults who had remained on medication had significantly fewer accidents and traffic citations than those adults who had not remained on medication. This hints at the possibility that stimulants may reduce driving risks in this population. For these reasons, the author and colleagues believe that stimulant medications offer the greatest promise for managing the driving-related problems of teens and young adults with ADHD. Yet the efficacy of stimulants for improving driving performance in those with ADHD has not been studied well, and the efficacy of atomoxetine for this purpose has received no previous attention at all.

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and other driving measures (self-ratings). They found suggestive evidence that methylphenidate improved the simulator performance of the ADHD drivers. This may intimate a positive impact on their driving in more natural circumstances. The author and colleagues are testing this possibility directly in a much larger study of adults with ADHD using acute doses of methylphenidate using their own virtual reality driving simulator (see Fig. 1) among other measures. A similar study will begin shortly examining the effects of atomoxetine on these same driving measures. Obviously the author’s hypothesis is that these medications may provide some beneficial effects on reducing the driving problems documented previously in adults with ADHD.

Summary

Available research provides compelling evidence that ADHD is associated with significantly increased risks for various adverse outcomes while driving, including increased traffic citations (particularly speeding), motor vehicle crashes for which the driver is at fault, repeated crash occurrences, and more severe crashes as determined from dollar damage and likelihood of bodily injuries from the crash. Not surprisingly, teens and adults with ADHD are more likely to have their licenses suspended and even fully revoked. Research further suggests that these driving risks cannot be accounted for by the comorbid disorders likely to be associated with ADHD, such as ODD, conduct disorder (CD), depression, or anxiety, or by lower than normal levels of intelligence.

Recent attempts to study the processes or mechanisms involved in driving in adults with ADHD offer some explanation of how the disorder conveys such increased risks. Driving can be conceptualized usefully as involving at least three or more dimensions or levels, including basic cognitive abilities necessary for driving (operational), actual skills for maneuvering the vehicle in traffic (tactical), and the more executive, goal-directed aspects of driving (strategic). The findings of studies indicate that ADHD interferes with the basic operational components of driving by means of the impairments it produces in attention, resistance to distraction, response inhibition, slower and more variable reaction time, and the capacity to follow rules that may compete with ongoing sensory information. Accumulating evidence also points to a problem in the tactical level of driving, such that those with ADHD rate themselves and are rated by others as employing less safe driving habits during their normal operation of a vehicle than are adults in community control groups. Although this has been more elusive to demonstrate through the use of simple laboratory-based driving simulators, more modern virtual reality driving platforms offer greater promise in providing more realistic appraisals of driving performance and thus more direct evidence of the problems that occur at the tactical level from the disorder. Research has not examined the impact of ADHD at the higher strategic level or goal-directed
aspects of driving. But given the mounting evidence that ADHD adversely affects executive functioning in adults, the author and colleagues anticipate that this level also will be found to be impaired in adults with ADHD. Indeed, it recently has been shown that adults with ADHD overestimate their driving abilities relative to normal adults, a problem that likely can be ascribed to more limited self-awareness and related meta-cognitive abilities for self-evaluation arising from the disorder.

Although further research on the driving problems posed by ADHD is in order, sufficient evidence exists to warrant focus on possible treatments that may serve to improve these driving problems and reduce the risk for these adverse outcomes. High on the list of such treatments deserving further research and clinical attention is the use of stimulant medication. The more recent noradrenergic reuptake inhibitor, atomoxetine, also may have some promise in this regard. Studies are underway in the author’s driving laboratory to see if this is the case. Meanwhile, adults with ADHD and parents of teens with ADHD should be advised about these heightened risks and encouraged to take steps that may reduce them, including the consideration of more graduated licensing for adolescents with ADHD and the possible use of stimulant medication in teens and adults with ADHD while they are operating a motor vehicle.

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