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Examining Attention, Impulsiveness, and Cognitive Failures in Driving Behaviors

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Examining Attention, Impulsiveness, and Cognitive Failures in Driving Behaviors

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ABSTRACT

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Dangerous driving behaviors are influenced by multiple factors including cognitive processes such as impulse inhibition and attentiveness. Impulsiveness, inattention, and cognitive failures have been linked to other risky behaviors, but a comprehensive evaluation using multiple methods of measurement of these has never been conducted to analyze their impact on dangerous driving. The purpose of this study was to examine influences of attentional abilities, impulsiveness, and cognitive failures on reported and demonstrated dangerous driving behaviors. Seventy-five participants completed a self-report dangerous driving measure, a self-report ADHD measure, a self-report impulsiveness measure, a continuous performance task to measure behavioral impulsivity and inattention, a measure of cognitive failures, and a driving simulator task. Two hierarchical linear regressions with simultaneous entry into blocks were used to analyze contributions of impulsiveness, inattention, and cognitive failures assessments in predicting dangerous driving behavior. Results indicated these assessments accounted for a significant proportion of the variance in Dula Dangerous Driving Index (3DI) scores above and beyond the effects of age and sex, Adjusted $R^2 = .20$, $F(6, 59) = 2.51$, p < .05, but no significant individual predictors emerged. Scores on these measures were also found to account for a significant amount of the variance in risky driving as measured by the driving simulator, above and beyond the effects of age and sex, Adjusted $R^2 = .15$, $F(6, 60) = 2.91$, $p < .05$, and identified BIS-11 scores and ADHD-RS impulsiveness scores as significant individual predictors. It seems

that despite multiple methods of assessment, it is still difficult to capture the assumed relationships between each of these factors and driving. Though each assessment measures different aspects of constructs related to dangerous driving, the lack of relationships and predictive abilities may indicate that impulsiveness, inattention, cognitive failures, and dangerous driving may be more complex and multifaceted than previously understood.

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CHAPTER 1

INTRODUCTION

Injury prevention through a better understanding of driving behavior has been an emerging area of research over the past 2 decades. Driving is a ubiquitous behavior, engaged in daily by much of the world, and with driving comes an inherent risk for injury or death in the form of motor-vehicle collisions. Motor-vehicle collisions are the most common cause of death for people ages 1 to 33 and the leading cause of injury among all age groups in the United States (National Safety Council, 2010; U.S. Department of Health and Human Services, 2010). This constitutes a significant public health concern, especially because most of these injuries and deaths are, in theory, preventable. Motor-vehicle collisions are also economically costly. In 2000 alone, the National Highway Traffic and Safety Administration (NHTSA) estimated the total economic cost of motor vehicle crashes to be $230.6 billion, including medical expenses, lost productivity, property damage, legal costs, and other factors (NHTSA, 2002). With such a wide range of health and economic consequences, it is essential to learn more about the behaviors, emotions, and cognitive processes that contribute to collisions and other problems in driving.

There are numerous causes of collisions that have garnered attention in research, law enforcement, and public policy. Past research and interventions have focused on reducing high risk behaviors such as driving without wearing a safety belt or driving while intoxicated (Little & Clontz, 1994; Young et al., 2008). For example, it was reported that roughly 22% of all crash costs, 10% of all property damage costs, 21% of nonfatal injury costs, and 46% of fatal injury costs are related solely to alcohol intake prior to and/or while driving (NHTSA, 2002). These and most other causes of collisions can be considered as dangerous driving behaviors. Dangerous driving is characterized by three broad subcategories: intentional acts of aggression, negative cognitions and emotions, and risk taking behaviors engaged in by drivers (Dula & Geller, 2003; Willemsen, Dula, Declercq, & Verhaeghe, 2008). *Dangerous driving* is a term used to more accurately encompass all behaviors related to problems with aggressive, emotional, and risky driving that were not previously fully clarified under terms such as *road rage* and *aggressive driving* (Dula & Geller, 2003). Though dangerous driving includes a myriad of behaviors, researchers have striven to identify ways to more accurately measure dangerous driving and identify common correlates.

The ability to understand and predict features of dangerous driving is essential to the improvement of traffic safety. Employers with job openings related to driving (e.g., truck driver, cab driver) can use such information to guide in the hiring of safe drivers. Insurance companies can better determine risk based on an understanding of the characteristics of a dangerous driver. Law enforcement can prevent damage or injury when they appreciate common tendencies of dangerous drivers. Though driving has been increasingly more common over the last century, there are still some gaps in our understanding of dangerous driving behavior.

Defining and Measuring Dangerous Driving Behaviors

Until recently there were many inconsistencies in the research regarding dangerous driving behaviors. Terms like *road rage* and *aggressive driving* were used interchangeably and often inconsistently. For the layperson this may be expected, but in order to advance this field of study consistency is necessary. Rathbone and Huckabee (1999) concluded that there was considerable variability in the definition of road rage and that descriptions were often vague or lacking in concrete operational definitions. Rage implies extreme negative emotionality and associated thoughts. However, as was discovered in aggression-related work across previous decades, many become angry, upset, frustrated, and so forth, and yet do not aggress toward others while in such cognitive or emotional states. Others encouraged the scientific community to refrain from using the term *road rage* in the literature completely, due to the inconsistency, ambiguity, and difficulty in defining it operationally (Dula & Geller, 2003; Tasca, 2000). Previously the term *aggressive driving* had been applied to all manner of behaviors, regardless of whether the behavior implied intent to harm others, which is considered a hallmark of aggressive behavior in virtually all other aggression-related literature (e.g., social, ethology). Thus, weaving in traffic, speeding, running red lights, etc. were considered aggressive though rarely would one intend to cause harm to another by engaging in such goal-directed behavior.

Thus, Dula and Geller (2003) proposed that the term *dangerous driving* be used to describe the three major classes of potentially harmful driving behavior: (a) intentional acts of physical, verbal, or gestured aggression with a goal of causing physical and/or psychological harm; (b) negative cognitions and emotions (e.g., anger, frustration) experienced while driving; and (c) risk-taking (e.g., speeding, running red lights, frequent lane changes, lapses of attention, driving while intoxicated).

Dangerous driving behaviors have been measured using several methods. Tasca (2000) said that the available aggressive driving measures (then encompassing all manner of dangerous driving constructs) at the time could be categorized into two main groups: 1) self-report surveys and 2) small-scale field studies involving select samples, though this latter group appears less frequently in the literature (e.g., Boyce & Geller 2001, 2002; Chase & Mills, 1973; Diekmann, Jungbauer-Gans, Krassnig, & Lorenz, 1996; Doob & Gross, 1968; Hennessy & Wiesenthal, 1999; Kenrick & MacFarlane, 1986, Ludwig & Geller, 1997; Sarkar , Martineau, Emami, Khatib & Wallace, 2000; Thompson et al., 2012). These studies have included diverse methods ranging from simple observation of real-world driving behavior, provoking drivers to action, assessing driver behavior while driving via cell phone, and use of instrumented vehicles.

Some relevant self-report measures include the Aggressive Driving Behavior Scale (Houston, Harris, & Norman, 2003), Driver's Stress Profile (Larson, 1996), Driving Anger Scale (Deffenbacher, Getting, & Lynch, 1994), Driving Behaviour Inventory (Glendon et al., 1993), Dula Dangerous Driving Index (Dula & Ballard, 2003), and Propensity for Angry Driving Scale (DePasquale, Geller, Clarke, & Littleton, 2001). While commonly used, the main difficulties with self-report measures are the well-known issues of inaccurate recall of actual events (e.g., Loftus, 1974, 2003) and self-presentation biases (e.g., Marlow & Crowne, 1961). Further, self-report measures have also been critiqued as being inadequate in predicting real-world driving outcomes (Houston, Johnson, Skinner, & Clayton, 2006).

One method being used more frequently in the research is performance on a simulated driving task (Vadeby et al., 2010). Data from studies using driving simulators to measure behavior seem to support the notion that this method is a practical and valid (i.e., safe, accurate, and generalizable) means to study dangerous driving behaviors. Deery and Fildes (1999) showed self-report measures of risky driving behavior were correlated with performance on a driving simulator task. Other studies reported that individual factors such as personality and cognition play a role in driving simulator performance (Kass, Beade, & Vodanovich, 2010). Specifically, qualities such as boredom proneness and inattention led to more dangerous driving behaviors on a simulator, including centerline crossings and greater driving speed. Recent studies have demonstrated the negative effects of sleepiness (Vadeby et al., 2010) and substance use on driving in a simulator (Lenné et al., 2010) and found that results are similar to previous research using self-report data (Boyle, Tippin, Paul, & Rizzo, 2008; Movig et al., 2004). These studies and others like them used simulators to reproduce findings from previous research that used other methods to measure dangerous driving behavior (i.e., self-report, analysis of driving record), increasing confidence that performance on a driving simulator is a valid and useful assessment of driving behavior.

As stated previously, much dangerous driving research focuses on personality traits. Though important, it has been reported that traits such as aggression and anger only account for a small percentage of the variance in accidents, and studies examining dangerous driving behavior may be better served measuring cognitive variables (Rimmo & Aberg, 1999).

Predictive Factors of Interest

Through multiple avenues of assessment several demographic trends have emerged in driving safety research. Sex differences are consistently shown in driving research. Males have exhibited more risky driving behaviors than females on driving simulator tasks (Kass et al., 2010; Lenné et al., 2010) and report risky driving behavior more often (Dula & Ballard, 2003; Ellison-Potter, Bell, & Deffenbacher, 2001). Age is a somewhat more complicated factor. Younger drivers typically exhibit more risky behaviors (Dula & Ballard, 2003; Owsley, McGwin, & McNeal, 2003), yet as drivers reach advanced ages, a decline in some cognitive abilities can lead to unsafe driving performance (Shanmugaratman, Kass, & Arruda, 2010). Social factors such as anonymity (Aronson, 1999), perceived intentions (Lajunen & Parker, 2001), and cognitive scripts (Baumeister & Boden, 1998) have also been shown to be related to dangerous driving behaviors. Though research on these social and demographic areas provides excellent insight into dangerous driving behaviors, there are many other variables that influence dangerous driving.

Recent traffic safety research has focused on the contribution of driver personality characteristics to dangerous driving. Some of the most common attributes reported to impair driving include anger and aggressiveness (Dahlen, Martin, Ragan, & Kuhlman, 2005; Maxwell, Grand, & Lipkin, 2005), Type A personality (Perry & Baldwin, 2000), and sensation seeking

(Dahlen et al., 2005; Iversen & Rundmo, 2002). However, the consistency of these findings is somewhat questionable, and these factors account for only a small percentage of variance in crashes caused (Rimmo & Aberg, 1999). Rimmo and Aberg (1999) suggested personality traits may not be as important as cognitive factors with regard to driving safety. These factors include such constructs as inattention, impulsiveness, and cognitive failures (i.e., absentmindedness or being prone to cognitive mistakes). Based on this suggestion, which has yet has to be systematically investigated, and due to their high co-occurrence with other risky behaviors, this study examined these three factors specifically. Though each of these factors has been studied individually in relation to dangerous driving, a comprehensive examination of their relationships using multiple methods of assessment has thus far been lacking.

Attention**.** Attention deficits have been related to several types of risky behavior, including sexual risk-taking, gambling addiction, and substance abuse (Derevensky, Pratt, Hardoon, & Gupta, 2007; Flory, Molina, Pelham, Gnagy, & Smith, 2006; Whitmore, Mikulich, Ehlers, & Crowley, 2000). Distracted driving falls within the Risky Driving category of dangerous driving proposed by Dula and Geller (2003), and attention and distractibility have been the subject of much driving research recently (e.g., Drews, Pasupathi, & Strayer, 2008; Dula, Martin, Fox, & Leonard, 2011; Wilson & Stimpson, 2010). With the increasing use of cell phones, video players, and music devices in vehicles, research has begun to examine the effects that these distractions have on driving behavior. It turns out that handheld and hands-free phone conversations negatively influence the ability to drive safely (Cohen & Graham, 2003; Drews et al., 2008; Dula et al., 2011; McKnight & McKnight, 1993; Redelmeier & Tibshirani, 1997; Strayer, Drews, Albert, & Johnston, 2003). Word recognition memory during a simulated driving scenario was 50% lower for groups who talked on a cell phone during the scenario compared to those who did not talk on a cell phone.

Attention is a limited cognitive resource, and divided attention leads to poorer driving performance (Drews et al., 2008). Deficits in attention, such as those exhibited in Attention-Deficit/Hyperactivity Disorder (ADHD), have also been related to dangerous driving. Drivers diagnosed with ADHD have been linked to higher rates of traffic tickets and collisions (Thompson, Molina, Pelham, & Gnagy, 2007) and poorer performance on a simulated driving task compared to nonclinical controls (Fischer, Barkley, Smallish, & Fletcher, 2007).

Impulsiveness. Closely related to inattention is impulsiveness. Along with deficits in attention, impulsiveness is a key feature of ADHD. Impulsiveness is defined as a predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to potential negative consequences of these reactions (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). Impulsiveness has been associated with numerous disorders and problematic behaviors such as aggression, criminality, bulimia, self-mutilation, substance abuse, obesity, and several personality disorders (Cheung, Mitsis, & Halperin, 2004; Magid, MacLean, & Colder, 2007; Schmidt, Fallon, & Coccaro, 2004). Dangerous driving has been linked to impulsiveness through self-report measures (Owsley et al., 2003; Teese & Bradley, 2008) and behavioral data (Dula et al., 2012; Fischer et al., 2007; Fox, Dula, Martin, & Leonard, 2012; Stanford, Greve, Bourdreaux, Mathias, & Brumbelow, 1996). Impulsiveness has been associated with drunk driving and reduced seatbelt use in youth (Stanford et al., 1996) as well as driver anger (Dahlen et al., 2005), and reckless drivers often report themselves as being impulsive (Taubman-Ben-Ari, 2008). Paaver and colleagues found speeding to be more strongly associated with a general excitement seeking, whereas drunk driving was more strongly associated with maladaptive impulsivity (e.g., thoughtlessness, inability to plan) (Paaver, Eensoo, Pulver, & Harro, 2006).

Cognitive Failures. Related to inattention and impulsiveness, cognitive failures are somewhat less well understood in regards to driving. Cognitive failures are defined as enduring trait-like deficits in thinking processes that are manifested by mistakes and/or errors in the performance of tasks that individuals are typically competent to perform (Broadbent, Cooper, Fitzgerald, & Parkes, 1982). Individuals prone to cognitive failures have been described as having an inflexible attentional style that can impair their ability to evaluate and manage new incoming information (Larson & Merritt, 1991). Risky behaviors and negative outcomes associated with cognitive failures include initiation of drug use, externalizing behaviors in youth, affective disorders, and hyperactivity (Romer et al., 2009; Sullivan & Payne, 2007; Wallace, Kass, & Stanny, 2002). Cognitive failures are also related to unsafe workplace behaviors (Wallace & Vodanovich, 2003). Additionally, previous research demonstrated a significant correlation between cognitive failures and increased driving accidents (Larson, Alderton, Neideffer, & Underhill, 1997; Larson & Merritt, 1991).

Though previous research has examined the roles of inattention, impulsiveness, and cognitive failures in relation to dangerous driving individually, no comprehensive analysis of the relationships and interrelationships exists. The current study employed multiple methods of measurement. Specifically, self-report methods were used in the assessment of inattention, impulsiveness, cognitive failures, and dangerous driving, and additional behavioral measures were used in the measurement of attention, impulsiveness, and dangerous driving. The goal was to determine the abilities of attention, impulsiveness, and cognitive failures assessments to predict self-reported and simulated dangerous driving behaviors.

Measures of Interest

Dangerous Driving. As noted above, self-report measures of dangerous driving are a commonly used assessment technique in driving research. One such measure is the Dula Dangerous Driving Index (3DI) (Dula & Ballard, 2003). This 28-item measure was created in an attempt to measure the domains of risky driving, negative affect and thoughts, and aggressive driving. Accordingly, the 3DI has three subscales that measure each of those components and it is due to its capacity to assess multiple domains of dangerous driving, as well as its demonstrated reliability and validity, that it was chosen for the current study. The 3DI has been found to be reliable and valid in English speaking countries (Dula & Ballard, 2003) and across other cultures in translations (Willemsen et al., 2008). Scores on the 3DI have been shown to predict self-reported at-fault collisions, moving violations, and other risky, negative emotional, and aggressive driving occurrences (Dula, 2003; Dula & Ballard, 2003). Trait impulsiveness has also shown a significant correlation with 3DI scores (Fox et al., 2012). In tandem with performance on a driving simulator, 3DI scores can give researchers a more complete picture of driving behavior.

Also as noted above, simulated driving behavior has been very useful in being able to assess dangerous driving without actually putting anyone at risk. It has the advantage of some mundane reality in that the behaviors involved translate well to the real-world complementary behaviors. Though described below in much greater detail, the Systems Technology STISIM Drive™ Computer Simulated Driving Program was used to provide an actual behavior-based measure of the dependent variables. Simulated dangerous driving was operationally defined as speeding, traffic light infractions, collisions, and crossing the road center line during the simulated driving task, all events measured with precision by the simulator software.

Impulsiveness and Inattention. Several different measures of attention and impulsiveness are commonly used in research on risky behaviors, and each capture aspects of these complex and varied constructs. Diagnostic tools for ADHD are often relevant in assessment research regarding impulsiveness and problems with attention. In order to capture the clinically relevant aspects of impulsiveness and inattention, this study analyzed impulsive and inattentive endorsements of participants using the Attention-Deficit/Hyperactivity Disorder Rating Scale, Version IV (ADHD-RS). The ADHD-RS is a self-report measure in which participants endorse symptoms corresponding with DSM-IV criteria for a diagnosis of ADHD at differing levels of severity (DuPaul, Power, Anastopoulos, & Reid, 1998). The measure has demonstrated high predictive validity in research comparing clinical samples with control groups (DuPaul et al., 1998). There is also evidence of its reliability in multiple contexts and even across cultures (Dopfner et al., 2006; DuPaul et al., 1998). Despite its measurement of impulsiveness and inattention, the ADHD-RS only measures these constructs in a clinical sense and does not measure their direct impact on behavior.

Several techniques are currently used to assess impulsiveness, most of which are self-report measures (Caci, Nadalet, Bayle, Robert, & Boyer, 2003). One of the most researched and reliable self-report impulsiveness measures is the Barratt Impulsiveness Scale, Version 11 (BIS-11) (Patton, Stanford, & Barratt, 1995). High impulsiveness as measured by the BIS-11 has been found to be related to poor use of executive functions (Cheung et al., 2004), cognitive distortions (Mobini, Pearce, Grant, Mills, & Yeomans, 2006), alcohol use and problems (Dom, Hulstijn, & Sabbe, 2006; Magid et al., 2007), and risky behavior (Stanford et al., 1996), among other qualities. Impulsiveness is acknowledged as a diverse construct with multiple facets (Smith et al., 2007).

Though the BIS-11 has been demonstrated to be a valid measure, it may not be capturing all the features of impulsiveness. It has been suggested that there may be an important distinction between trait impulsiveness and state impulsiveness (Schmidt et al., 2004). The BIS-11, and other self-report measures like it, seem to be more sensitive to qualities of impulsiveness such as nonplanning and sensation seeking that are indicative of trait impulsiveness. It is difficult for a self-report measure to capture state impulsiveness, such as an inability to inhibit behaviors in some contexts. Problems with disinhibition may be important in understanding some aspects of dangerous driving. A self-report measure such as the BIS-11 must rely on a person's ability to remember and report past behaviors and current dispositions, which may sometimes be unreliable (Schatz, Ballantyne, & Trauner, 2001) and context dependent (Nordgren, van der Pligt, & van Haareveld, 2007). To capture all the features of impulsiveness and inattention, other measures are sometimes employed.

A continuous performance test (CPT) may be a more functional assessment technique due to its ability to measure actual impulsive and inattentive behaviors. A CPT is considered to be a neuropsychological assessment well-suited to gauge impulsiveness as well as sustained and selective attention abilities. CPTs have been used in driving research and have been used to demonstrate distractibility of subjects talking on a cell phone (Golden, Golden, & Schneider, 2003) and impaired processing speed and divided attention in older drivers (Ponds, Brouwer, & van Wolffelaar, 1988). The ability of CPTs to measure impulsive tendencies, inattention, and processing speed may potentially give driving researchers a clearer picture of the failures in executive functioning that are difficult to capture in self-report measures and are relevant to dangerous driving behavior. It also provides a means to capture the constructs of interest in a behavior-based manner as an adjunct to self-report data.

Cognitive Failures. Finally, cognitive failures were assessed using the Cognitive Failures Questionnaire (CFQ) (Broadbent et al., 1982). The CFQ has demonstrated good reliability across raters and over time (Broadbent et al., 1982; Broadbent, Broadbent, & Jones, 1986). More recently research has provided support that scores correlate with both self-reported and recorded errors and accidents (Wallace & Chen, 2005; Wallace & Vodanovich, 2003). It is also reported that individuals identified as being more vulnerable to stress report an increase in everyday mistakes in work settings as measured by the CFQ (Matthews, Coyle, & Craig, 1990; van der Linden, Keijsers, Eling, & van Schaijk, 2005). Related to driving, high scores on the

CFQ were significantly correlated to driver errors on a simulated driving task, including poor lane positioning, less time spent at a stop sign, and failure to notice an intersection (Kass et al., 2010).

Current Hypotheses

Research has guided some of the hypotheses regarding relationships examined in this study, but others are somewhat exploratory. With regard to the hypotheses below, where the 3DI is listed, the Dangerous Driving Total scale is the main variable of interest. The 3DI subscale scores will be examined in a post-hoc and exploratory fashion. Based on findings from previous research comparing self-report driving data with simulator performance (Deery & Fildes, 1999), it was hypothesized that 3DI scores would be correlated with risky behaviors on a simulated driving task (H_1). Similarly, CFQ scores have been related to dangerous driving behavior (Kass et al., 2010), so it was hypothesized that scores on the CFQ would predict scores on the 3DI (H_2) and errors on the simulated driving task (H_3). It was also hypothesized that scores on the BIS-11 would predict scores on the 3DI (H_4) as well as dangerous driving on the driving simulator (H_5).

As found in past studies examining ADHD and dangerous driving (Fischer et al., 2007; Thompson et al., 2007), it was hypothesized that higher scores on both subscales of the ADHD-RS (inattention and impulsiveness) would predict higher scores on the 3DI (H_6 ADHD inattention and 3DI; H_7 ADHD impulsiveness and 3DI) and dangerous driving behaviors on the simulated driving task (H_8 ADHD inattention and simulator; H_9 ADHD impulsiveness and simulator). Inattentive and impulsive errors on a CPT have been related to dangerous driving in past research (Golden et al., 2003; Ponds et al., 1988), and thus it was hypothesized that performance on the CPT, both inattentive and impulsive errors, would predict dangerous driving behaviors measured by the 3DI (H_{10} CPT Omission [inattention] and 3DI; H_{11} CPT Commission [impulsiveness] and 3DI) and driving simulator (H_{12} CPT Omission [inattention] and simulator;

H_{13} CPT Commission [impulsiveness] and simulator). Hypotheses are listed below in bulleted form for reference.

- H_1. 3DI scores would be correlated with risky behaviors on a simulated driving task.
- H_2. CFQ scores would predict scores on the 3DI.
- H_3. CFQ scores would predict risky behaviors on the simulated driving task.
- H_4. BIS-11 scores would predict scores on the 3DI.
- H_5. BIS-11 scores would predict dangerous driving behaviors on the simulated driving task.
- H_6. ADHD-RS Inattention scores would predict scores on the 3DI.
- H_7. ADHD-RS Impulsiveness scores would predict scores on the 3DI.
- H_8. ADHD-RS Inattention scores would predict risky behaviors on the simulated driving task.
- H_9. ADHD-RS Impulsiveness scores would predict risky behaviors on the simulated driving task.
- H_{10}. CPT Omission (Inattention) scores would predict scores on the 3DI.
- H_{11}. CPT Commission (Impulsiveness) scores would predict scores on the 3DI.
- H_{12}. CPT Omission (Inattention) scores would predict risky behaviors on the simulated driving task.
- H_{13}. CPT Commission (Impulsiveness) scores would predict risky behaviors on the simulated driving task.

CHAPTER 2

METHOD

Participants

Participants for this study were 75 undergraduate students enrolled in psychology courses who volunteered to respond to self-report measures in an online database and received course credit for doing so. Participants who completed these measures were then eligible to schedule a date and time to complete the continuous performance test and driving simulator tasks. The sample consisted of 19 males (25.3%) and 56 females (74.7%). The mean age was 21.40 years old (*SD* = 4.59), and ranged from 18 to 41. The sample consisted of 67 (89.3%) participants who identified as Caucasian, 3 as African American, 1 as Hispanic, 1 as Asian, 1 as "other," where 2 did not respond. Though university undergraduates may not be representative of all ages in a general population typically, this sample represented an age group that has been identified as high risk in the area of driving (Stanford et al., 1996). A sample size of 75 is fairly large for a simulator study (compare to Kass et al., 2010; Deery and Fildes, 1999).

Participants had an average of 5.84 years of experience driving (*SD* = 4.61), and ranged from 0.5 years to 25 years. The reported mean number of crashes in which the driver was reported to insurance companies in the past 6 years was 1.20 (*SD* = 1.74; range 0 to 9), with 40 (53.3%) reporting at least one crash. The reported mean number of crashes where the participant was deemed at-fault, or partially at-fault, in the past 6 years was 0.66 (*SD* = 1.03), with 29 (38.7%) reporting at least one crash. The reported estimated mean number of times that one drove intoxicated (DUI) in the previous month, was 0.65 (*SD* = 1.86; range from 0 to 10) with 11 (14.7%) reporting at least one episode during that period. For the previous year, the reported estimated mean number of DUI episodes was 3.36 (*SD* = 9.43; range from 0 to 65) with 22

(29.3%) reporting at least one episode during that period. The reported mean number of moving violations citations (nonsafety belt warnings/tickets) received in the past 5 years was 1.03 (*SD* = 1.43; range from 0 to 7), with 38 (50.7%) reporting at least one citation.

Materials

Dula Dangerous Driving Index (3DI). The Dula Dangerous Driving Index (Dula & Ballard, 2003) is a self-report questionnaire containing 28 items measuring dangerous driving behaviors in three subcategories: Aggressive Driving (AD, 7 items), Negative-Emotional Driving (NE, 9 items), and Risky Driving (RD, 11 items). Responses to each item are arranged on a Likert scale, with 1 = *Never*, 2 = *Rarely*, 3 = *Sometimes*, 4 = *Often* and, 5 = *Always*. Examples of items include: "I deliberately use my car/truck to block drivers who tailgate me" and "I feel that most traffic laws could be considered as suggestions" (see Appendix A for complete instrument). Subscale scores are calculated by adding the items within each scale and a Dangerous Driving Total score is derived by summing all items. A total score serves as a rating for overall dangerous driving behaviors and higher scores correspond with higher report of dangerous driving behaviors. The 3DI has been shown to be valid (Dula & Ballard, 2003; with cross-cultural validity demonstrated by Willemsen et al., 2008), with high internal consistency (α = .94 in Dula & Ballard, 2003) and solid stability across time (α = .92; Dula & Ballard, 2003). The 3DI as a whole had an alpha of .92, where the alphas for the Aggressive Driving, Negative Cognitive/Emotional Driving, and Risky Driving subscales were .85, .81, and .84, respectively.

Cognitive Failures Questionnaire (CFQ). The CFQ (Broadbent et al., 1982) consists of 25 items measuring the frequency of making sensory, perception, and motor errors. Examples of questions include: ‘‘Do you forget appointments?" or ‘‘Do you fail to notice sign posts on the road?" (see Appendix B for complete instrument). Participants rate the frequency of these errors in the past 6 months from *Never* = 0 to *Very Often* = 4. Solid reliability has consistently been demonstrated for the CFQ, with the coefficient alpha being .79 in its initial development and where it has been reported as high as .92 (Broadbent et al., 1982; Larson et al., 1997). The alpha for the current sample was also .92.

Attention-Deficit/Hyperactivity Disorder Rating Scale, Version IV (ADHD-RS). The ADHD-RS (DuPaul et al., 1998) contains the 18 *DSM-IV* criteria for ADHD, where participants rate frequency of symptoms on a 4-point scale (0 = *Never/Rarely*, 1 = *Sometimes*, 2 = *Often*, 3 = *Very often*). This scale can yield two types of symptom scores: endorsements and severity. To calculate endorsements, each “2” or “3” rating is considered one symptom endorsement. The total number of “2” or “3” ratings is summed for a total symptom endorsement score. Scores range from 0 to 9 for both sets of symptoms, as there are nine inattentive and nine hyperactive-impulsive symptoms. Symptom severity scores are calculated by summing ratings ranging from 0 to 3 for inattention and hyperactivity-impulsivity. Symptom severity scores can range from 0 to 27 for both inattention and hyperactivity-impulsivity. Example items include: “I fail to give close attention to details or make careless mistakes in schoolwork,” and “I avoid tasks (e.g., schoolwork, homework) that require sustained mental effort” (see Appendix C for complete instrument). Reliability has been demonstrated with high levels of test-retest stability (α = .92) and internal consistency (Cronbach’s α = .84) (Zhang, Faries, Vowles, & Michelson, 2005). Convergent validity with other ADHD measures has also been demonstrated consistently (DuPaul et al., 1998; Zhang et al., 2005). The ADHD-RS had an alpha of .86 in the current sample.

Barratt Impulsiveness Scale, Version 11(BIS-11). The Barratt Impulsiveness Scale (Patton, Stanford, & Barratt, 1995) is a self-report questionnaire containing 30 items concerning control of thoughts and behavior on a 4-point scale, ranging from “rarely/never” through “almost always.” A score of 4 on an item indicates the most impulsive response; therefore, the higher the summed score, the higher level of impulsiveness. Examples of items include: “I spend or charge more than I earn,” and “I do things without thinking” (see Appendix D for complete instrument). Test-retest reliability has been demonstrated (r = .80) as well as convergent validity with constructs related to impulsiveness (Patton et al., 1995). The BIS-11 had an Cronbach’s alpha of .84 in the current sample.

Vigil Continuous Performance Test (CPT). The Vigil Continuous Performance Test (Cegalis, 1991) is a computerized assessment that measures responses to visual stimuli. Stimuli in this task are uppercase white letters on a black background presented one by one, sequentially. Participants are directed to hit the spacebar each time the target stimulus is presented. Stimuli are presented in 4 trial blocks of 120 stimuli each, with 36 targets per block. Stimuli remain on the screen for a period of 85ms with an interstimulus interval of 900ms. The program uses uncued (K) and cued (AK) tasks to measure attention and impulsiveness. Participants in this study were given the cued (AK) task. In this condition the participant is directed to hit the spacebar when a K is presented but only when it appears immediately after an A. Standard instructions provided in the program manual were read to each participant before the task. The task lasts 8 minutes. Variables collected include omission errors, commission errors, and reaction time for responses, which correspond to inattention, impulsivity, and speed of processing, respectively.

STISIM Drive™ Computer Simulated Driving Program. A simulator produced by Systems Technology Inc. (STISIM) was used to examine driving behavior of participants. The program displays a virtual driving environment on a high-definition television, giving the driver a field of view of 135 degrees. The setup employed a NVIDIA GeForce 7300 GS graphics card with 32-bit color quality, a screen resolution of 1024 x 768 pixels and 96 DPI, and a refresh rate of 60 Hz. The bucket seat, steering wheel, and pedals were stable and securely fastened but could be adjusted to maximize participant comfort. The room containing the simulator has no windows and is free from distracting external stimuli.

The simulator allows design of a variety of driving environments including pedestrians, buildings, natural surroundings, road signs, traffic signals, and interactive vehicles on all lanes. The virtual environment contains corresponding audio effects for acceleration and braking, as well as for other driving events. Standardized instructions to drivers (e.g., lane change, turn left, turn right, etc.) are cued by the program and played through the system speakers that are placed behind the driver's head.

The participant was introduced to the simulator and positioned the equipment (i.e., seat, pedals, and wheel) where they were most comfortable. The scenario was presented on 52-inch high-definition monitor approximately three feet from participants' eyes. The driving scenario used in this study included rural and suburban roadways, 10 intersections with traffic signals, and four surprise obstacles: a dog walks into road, boxes fall off a truck, a pedestrian walks into the road, and a vehicle suddenly pulls into the road in front of the participant's vehicle. At one point a computerized voice instructed drivers to pass a slow-moving vehicle when it is illegal to do so (double yellow lines) and two different points the computer voice instructed drivers to make a turn at an intersection. The course was 6.44 miles in length and participants took an average of 20.25 minutes (*SD* = 4.08, ranging from 13.69 to 32.15 minutes) to complete the driving task.

Approximately the first third of the run consisted of rural two-lane roads with dotted center lines allowing for legal passing. Other traffic was sparse and several tight curves required reduced speed to remain in the lane. The next third was suburban in nature, where traffic increased and double yellow lines prevented legal passing. During this segment, the participant was presented with the computer voice attempting to induce an illegal pass, the dog walking out across the driver's path, and the vehicle pulling directly into the driver's pathway. The last third returned to rural roads, but roadway construction obstacles were now present and the participant was faced with a truck spilling boxes in front of the driver's vehicle and a pedestrian walking into the roadway.

Variables collected by the computer program include number of speeding events, percent of driving time spent speeding, number of collisions, number of center line crossings, and number of red light running violations.

Demographic Questionnaire (DQ). This measure consisted of questions regarding the participant's age, sex, and race in addition to select reports of recent driving consequences and risky driving behaviors. These questions asked participants about the number of crashes reported to an insurance company in the last 6 years, number of at-fault crashes in the last 6 years, number of tickets received in the last 5 years (not including tickets for seat-belt violations only), number of times driven intoxicated in the past year, and number of times driven intoxicated in the last month.

Procedure

Students in psychology courses were invited via an online participant pool management system to respond to several measures (DQ, 3DI, CFQ, BIS-11, and ADHD-RS) in an online study for modest course credit. Students who completed these measures were then contacted by email (using the system to maintain confidentiality as each student was contacted using his or her tracking number) and asked to participate in this study and were given equal opportunity to do so. Those who responded were able to schedule a time to come into the laboratory and complete the continuous performance task and driving simulator task. Simulator data were collected at a separate time from survey data. Time between survey completion and simulator task completion ranged from 1 day to 70 days.

Upon the participant's arrival, a researcher gave each participant a brief description of the experiment via an informed consent statement without disclosing information about the nature of the study or hypotheses. Following agreement to participate, directions were read for the CPT. Participants were given a chance to ask any questions about the CPT procedure before sitting at a computer and completing the 8-minute task. During this time, the researcher checked the driving simulator environment to ensure minimal distraction during the task.

Following the completion of the CPT, participants were seated at the driving simulator and read instructions for the driving task. It was stressed that they were to operate the simulator as if it was their own vehicle on a real road and to obey all traffic laws and use caution. They were told their safety performance would be compared to other drivers and a reward of an extra point of course credit would be given for scoring in the top 25% of safe drivers. This was done in an attempt to counter the lack of mundane realism (i.e., the similarity of a simulated environment to the real-world, see Berkowitz & Donnerstein, 1982) and enhance motivation to attend closely to the experimental task and take it seriously. All students received the extra point of course credit regardless of their performance after being debriefed.

As noted by Highhouse (2009), experiments of this nature are often critiqued for sample characteristics and a lack of mundane realism, but the validity, representativeness, and strength of the treatment manipulation are equally important. The STISIM simulator software and setup has a long history of providing realistic representations of physical environments in terms of proportions, angles, and placement of all scenario objects and roadways as well as of physics in terms of physical forces acting on the vehicle as it traverses the roadway (STISIM website for articles: http://www.systemstech.com/support/index.php/publications/viewcategory/10-ground-vehicles). Thus, participants are able to drive in a simulated environment without real-world consequences for their driving mistakes.

Participants were given an opportunity to ask any questions about the operation of the simulator and were asked to complete a short driving scenario to practice maneuvering the simulated vehicle. Researchers answered any other questions after the practice run and then allowed the participant to begin the actual experimental run. Participants were reminded of the reward of extra course credit for safe driving and were encouraged to use caution and obey all traffic laws. They were instructed to continue driving the simulated scenario until the program informed them that they were finished. Upon completion of the driving scenario, participants were debriefed regarding the nature of the study and given course credit. Four types of dangerous driving on the simulator were measured (all of the Risky Driving class): center line crossings, traffic lights run, collisions, speeding occurrences.

CHAPTER 3

RESULTS

For each participant the totals of each dangerous driving type on the driving simulator course were summed to create a total number of dangerous driving events on the driving simulator task (M = 20.09, SD = 6.13, ranging from 8 to 34 total events), but this score is unable to be compared to previous studies due to differences in driving scenarios employed. The mean time to complete the driving simulator task was 1,214.88 seconds, or 20.25 minutes (SD = 253.14 seconds), with a range of 821.28 to 1,929.26 seconds.

Descriptive statistics for the 3DI Total Scores (M = 64.15, SD = 15.51) were comparable to those reported in previous studies using nonclinical populations (Dula & Ballard, 2003) as were subscale scores for Aggressive Driving (M = 14.16, SD = 5.24), Negative-Emotional Driving (M = 22.80, SD = 5.26), and Risky Driving (M = 24.57, SD = 7.38). Scores for the CFQ (M = 43.05, SD = 15.01), ADHD-RS (M = 15.63, SD = 8.38), and BIS-11 (M = 66.20, SD = 11.24) were also similar to scores reported in previous research (DuPaul et al., 1998; Stanford et al., 1996; Wallace & Vodanovich, 2003). Descriptive statistics for the ADHD-RS impulsiveness subscale (M = 8.19, SD = 4.28) and inattention subscale (M = 7.44, SD = 4.86), also mirrored scores reported in previous research on nonclinical samples (DuPaul et al., 1998). Scores on the CPT were also comparable to past nonclinical samples with respect to errors of commission (M = 3.12, SD = 3.84), errors of omission (M = 2.35, SD = 4.22), reaction times (M = 417.65, SD = 32.60), and reaction time variability (M = 21.03, SD = 13.12) (Cegalis, 1991). Similarity for each of these scores compared to previous research was determined using the criteria that mean scores must fall within 1 standard deviation of previous research on a similar sample. See Table 1 for all main variable descriptive statistics.

Table 1

Descriptive Statistics for Scale and Subscale Scores Related to Dangerous Driving, Attention, Impulsiveness, and Cognitive Failures

	3DI-Total	Simulator Behaviors	CPT - Commission	CPT - Omission	BIS-11	ADHD - Impulsive	ADHD - Inattention	CFQ
M	64.15	20.09	3.12	2.35	66.20	8.19	7.44	43.05
SD	15.51	6.13	3.84	4.22	11.24	4.28	4.86	15.01
N	74	74	75	75	69	75	75	74

Note. 3DI = Dula Dangerous Driving Index; Simulator Behaviors = sum of all dangerous driving events during driving simulator task (total number of collisions, speed exceedances, traffic light infractions, and center line crossings); CPT Commission = Continuous Performance Task errors of commission (impulsive mistakes); CPT Omission = Continuous Performance Task errors of omission (inattentive mistakes); BIS-11 = Barratt Impulsiveness Scale, Version 11; ADHD – Impulse = Attention-Deficit/Hyperactivity Disorder Rating Scale - Impulsiveness subscale; ADHD – Inattention = Attention-Deficit/Hyperactivity Disorder Rating Scale – Inattention subscale; CFQ = Cognitive Failures Questionnaire

Independent sample t-tests were conducted to determine if there were significant sex differences on any of the independent or dependent variables. Each analysis passed Levene's test for equality of variance. No significant difference in scores was found for either of the dependent variables based on sex, including 3DI scores. The lack of significant sex differences on the 3DI Dangerous Driving Total score, as well as the Aggressive and Risky Driving subscales, failed to replicate previous findings (Dula, Adams, Miesner, & Leonard, 2010; Dula & Ballard, 2003; Willemsen et al., 2008). However, the low number of males in the sample likely accounts for the failure to find sex differences on 3DI variables. The only independent variable with significant sex differences based was the CFQ, where females reported significantly higher rates of cognitive failures compared to males, $t(72) = -2.24$, $p < .05$.

Pearson correlations were examined to quantify the relationships among scores on all instruments used in this study. The two instruments used to measure dangerous driving behavior, 3DI total scores and total number or risky driving behaviors on the driving simulator task, were not found to be significantly correlated. The total number of dangerous driving events on the driving simulator task was not significantly correlated with any of the 3DI scales. Also, age was not significantly correlated with total number of dangerous driving events on the driving simulator task or 3DI scores.

Scores on the 3DI were not found to be significantly correlated with CPT Omission scores, though the correlation with CPT Commission scores approached significance, $r(73) = .21$, $p = .07$. Consistent with previous research (Dula et al., 2011), 3DI scores were significantly correlated with BIS-11 scores, $r(66) = .35$, $p < .01$. Scores on the 3DI were also significantly correlated with CFQ scores, $r(71) = .33$, $p < .01$. It was found that 3DI scores were significantly correlated with ADHD-RS total scores, $r(72) = .28$, $p < .05$, and the ADHD-RS inattention subscale, $r(72) = .28$, $p < .05$, where the relationship with the impulsiveness subscale approached significance, $r(72) = .22$, $p = .06$.

The total number of dangerous driving events on the driving simulator was not found to be significantly correlated with CPT Commission scores or CPT Omission scores. Dangerous driving simulator events were also not significantly correlated with ADHD-RS total scores nor with inattention subscale scores. A significant correlation was found between dangerous driving simulator events and ADHD-RS impulsiveness subscale scores, $r(72) = .28$, $p < .05$ as well as with BIS-11 scores, $r(66) = .32$, $p < .01$. CFQ scores were not found to be significantly related to simulator errors. See Table 2 for the correlation matrix containing each independent and dependent variable entered into the regression models.

Table 2

Pearson Correlations for Scale and Subscale Scores Related to Dangerous Driving, Attention, Impulsiveness, and Cognitive Failures

	1	2	3	4	5	6	7	8
1. 3DI Total	1	.14	.21	.06	.35*	.22	.28*	.33*
2. Simulator Behaviors	.14	1	.12	.18	.32*	.28*	.07	.12
3. CPT - Commission	.22	.12	1	.48**	.10	.15	.14	.04
4. CPT - Omission	.07	.18	.48**	1	-.01	.02	.13	-.05
5. BIS-11	.35*	.32*	.10	-.01	1	.53**	.64**	.52**
6. ADHD - Impulse	.22	.28*	.15	.02	.53**	1	.68**	.40**
7. ADHD - Inattention	.28*	.07	.14	.13	.64**	.68**	1	.62**
8. CFQ	.33*	.12	.04	-.05	.52**	.40**	.62**	1

Note. 3DI = Dula Dangerous Driving Index; Simulator Behaviors = sum of all dangerous driving events during driving simulator task (total number of collisions, speed exceedances, traffic light infractions, and center line crossings); CPT - Commission = Continuous Performance Task errors of commission (impulsive mistakes); CPT - Omission = Continuous Performance Task errors of omission (inattentive mistakes); BIS-11 = Barratt Impulsiveness Scale, Version 11; ADHD – Impulse = Attention-Deficit/Hyperactivity Disorder Rating Scale - Impulsiveness subscale; ADHD – Inattention = Attention-Deficit/Hyperactivity Disorder Rating Scale – Inattention subscale; CFQ = Cognitive Failures Questionnaire; *$p < .05$ **$p < .001$

A set of exploratory Pearson product-moment correlations were assessed with the independent variables along with the subscales of the 3DI (i.e., Aggressive Driving [AD], Negative Cognitive/Emotional Driving [NCE], and Risky Driving [RD]), the four types of simulator-based dangerous driving (i.e., number of centerline crossings [SCC], collisions [SCL], speeding events [SSO], percent of task spent speeding [SSP], and number of red traffic lights run [STL]), as well as with self-reported number of crashes reported to an insurance company in the previous 6 years (regardless of fault), the number of crashes in the previous 6 years where the participant was deemed partially or completely at-fault, the number of tickets received in the previous 5 years (excluding those only for seatbelt law violations), as well as the estimated number of times driving intoxicated (DUI) in the previous year and the past month.

The total number of dangerous driving events during simulation was also correlated with these variables and was found to be only significantly or nearly significantly (i.e., $p < .10$) related to the constituent elements which derive that total (SCC $r = .38$; SCL $r = .21$; SSE $r = .90$; SSP $r = .65$; and STL $r = .25$) and DUIs in the previous month ($r = .26$). CPT Commission Errors were significantly or nearly significantly correlated with 3DI NCE scores ($r = .26$), 3DI RD scores ($r = .20$), SCC ($r = .34$), all crashes ($r = .21$), and DUIs in the past month ($r = .41$). CPT Omission Errors were significantly or nearly significantly correlated with 3DI NCE scores ($r = .20$), SCC ($r = .43$), SCL ($r = .31$), STL ($r = .39$), and DUIs in the past month ($r = .23$). BIS-11 scores were significantly or nearly significantly correlated with 3DI AD scores ($r = .28$), 3DI NCE scores ($r = .26$), 3DI RD scores ($r = .42$), SSE ($r = .28$), SSP ($r = .30$), tickets received ($r = .29$), and DUIs in the past year ($r = .23$) and past month ($r = .27$). ADHD-RS Impulsiveness scores were significantly or nearly significantly correlated with 3DI NCE scores ($r = .20$), 3DI RD scores ($r = .21$), SSE ($r = .30$), SSP ($r = .26$), all crashes ($r = .32$), and at-fault crashes ($r = .27$). ADHD-RS Inattention scores were significantly or nearly significantly correlated with 3DI AD scores (r

= .23) 3DI NCE scores (*r* = .24), 3DI RD scores (*r* = .33), all crashes (*r* = .26), tickets received (*r* = .21), and DUIs in the past month (*r* = .22). CFQ scores were significantly or nearly significantly correlated with 3DI AD scores (*r* = .22), 3DI NCE scores (*r* = .48), and 3DI RD scores (*r* = .24). Table 3 summarizes the correlations between the predictors and dangerous driving variables and Table 4 summarizes correlations between 3DI scores and reported driving consequences (e.g., DUI, crashes, tickets received).

Table 3

Exploratory Pearson Correlations for All 3DI Scale Scores, Crashes, Tickets, DUI Episodes, Simulator Behaviors, Attention, Impulsiveness, and Cognitive Failures

	Simulator Behaviors	CPT Commission	CPT Omission	BIS-11	ADHD Impulse	ADHD Inattention	CFQ
3DI Total	.14	.21†	.06	.35**	.22†	.28*	.33**
3DI Aggressive	.10	.09	.01	.28*	.20†	.23*	.22†
3DI Neg. Cog./Emo.	.17	.26*	.20†	.26*	.19	.24*	.48***
3DI Risky	.14	.20†	.00	.42***	.21†	.33**	.24*
Sim. Center Crosses	.38**	.19	.43***	.10	.06	-.14	.10
Sim. Collisions	.21†	.34**	.31**	.11	-.01	.07	.01
Sim. Speed Events	.90***	-.03	-.05	.28*	.30**	.11	.10
Sim. Speed %	.65***	.09	.07	.30*	.26*	.03	-.01
Sim. Traffic Lights	.25*	.08	.39**	.09	-.08	-.16	.02
All Crashes	.10	.21†	.05	.17	.32**	.26*	.16
At-Fault Crashes	.17	.13	.04	.16	.27*	.17	.14
Tickets Received	.10	.12	-.03	.29*	.07	.21†	.17
DUI Past Year	.05	.05	-.05	.23†	-.03	.17	.06
DUI Past Month	.26*	.41***	.23*	.27*	.06	.22†	.07

Note. 3DI = Dula Dangerous Driving Index; 3DI Aggressive = 3DI Aggressive Driving Scale; 3DI Neg. Cog./Emo. = 3DI Negative Cognitive/Emotional Scale; 3DI Risky = 3DI Risky Driving Scale; Sim. Center Crosses = total number of center line crossings during simulated driving task; Sim. Collisions = total number of collisions during simulated driving task; Sim. Speed Events = total number of speeding occurrences during simulated driving task; Sim. Speeding % = total percent of simulated driving task spent speeding; Sim. Traffic Lights = total number of red traffic lights run; All Crashes = all crashes reported to insurance company in past 6 years; At-Fault Crashes = all crashes in past 6 years where driver was partially or completely at-fault; Tickets Received = all tickets received in last 5 years which did not simply involve seatbelt law infractions; DUI Past Year = estimated number of times driven intoxicated in past year; DUI Past Month = estimated number of times driven intoxicated in past month; Simulator Behaviors = sum of all dangerous driving events during driving simulator task (total number of collisions, speed exceedances, traffic light infractions, and center line crossings); CPT - Commission = Continuous Performance Task errors of commission (impulsive mistakes); CPT - Omission = Continuous Performance Task errors of omission (inattentive mistakes); BIS-11 = Barratt Impulsiveness Scale, Version 11; ADHD – Impulse = Attention-Deficit/Hyperactivity Disorder Rating Scale - Impulsiveness subscale; ADHD – Inattention = Attention-Deficit/Hyperactivity Disorder Rating Scale – Inattention subscale; CFQ = Cognitive Failures Questionnaire; †$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Table 4

Exploratory Pearson Correlations for All 3DI Scale Scores and Reported Crashes, Tickets, DUI Episodes

	3DI Total	3DI Aggressive	3DI Neg. Cog./Emo.	3DI Risky
All Crashes	.12	.09	.19	.09
At-Fault Crashes	.13	.14	.26*	.03
Tickets Received	.35**	.34**	.25*	.29*
DUI Past Year	.26**	.17	.02	.40***
DUI Past Month	.33**	.18	.22†	.40**

Note. 3DI = Dula Dangerous Driving Index; 3DI Aggressive = 3DI Aggressive Driving Scale; 3DI Neg. Cog./Emo. = 3DI Negative Cognitive/Emotional Scale; 3DI Risky = 3DI Risky Driving Scale; Sim. Center Crosses = total number of center line crossings during simulated driving task; Sim. Collisions = total number of collisions during simulated driving task; Sim. Speed Events = total number of speeding occurrences during simulated driving task; Sim. Speeding % = total percent of simulated driving task spent speeding; Sim. Traffic Lights = total number of red traffic lights run; All Crashes = all crashes reported to insurance company in past 6 years; At-Fault Crashes = all crashes in past 6 years where driver was partially or completely at-fault; Tickets Received = all tickets received in last 5 years which did not simply involve seatbelt law infractions; DUI Past Year = estimated number of times driven intoxicated in past year; DUI Past Month = estimated number of times driven intoxicated in past month; †$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

Two hierarchical linear regressions with simultaneous entry into blocks were conducted to better understand the roles that CPT Commission and Omission scores, BIS-11 scores, ADHD-RS impulsiveness and inattention scores, and CFQ scores had in predicting dangerous driving outcomes, while also accounting for the potential contributions of age and sex.

In the first regression age and sex were regressed onto 3DI Dangerous Driving Total scores during the first step, and as no theoretical reasons were found in the literature to suggest a hierarchy of predictive utility, CPT Commission and Omission scores, BIS-11 scores, ADHD-RS impulsiveness and inattention scores, and CFQ scores were all added to the model together in the second step of the regression. Overall, the variables entered into the first step of this model did not account for a significant amount of the variance in 3DI scores. Overall, the variables entered into the second step did account for a significant amount of the variance in 3DI scores, Adjusted $R^2 = .20$, $F(6, 59) = 2.51$, $p < .05$. However, no predictors entered into this second step were found individually to contribute significantly to the variance, though BIS-11 scores approached significance at $p = .07$. See Table 5 for model summary and Table 6 for summary of individual predictors.

Table 5

Summary of Predictor Variables Regressed Stepwise onto 3DI Total Scores

Model	*R*	R^2	Adjusted R^2	*F*	*p*
Model 1 Age + Sex	.04	.00	-.03	.05	.95
Model 2 Model 1 + CPT Commission + CPT Omission + BIS-11 + ADHD Impulse + ADHD Inattention + CFQ	.54	.29	.20	2.51	<.01

Note. 3DI = Dula Dangerous Driving Index; CPT Commission = Continuous Performance Task errors of commission (impulsive mistakes); CPT Omission = Continuous Performance Task errors of omission (inattentive mistakes); BIS-11 = Barratt Impulsiveness Scale, Version 11; ADHD Impulse = Attention-Deficit/Hyperactivity Disorder Rating Scale - Impulsiveness subscale; ADHD Inattention = Attention-Deficit/Hyperactivity Disorder Rating Scale – Inattention subscale; CFQ = Cognitive Failures Questionnaire

Table 6

Regression Analysis Summary for Age, Sex, CPT Omission, CPT Commission, BIS-11, ADHD Impulsiveness, ADHD Inattentiveness, and CFQ Scores Predicting Total Score on the Dula Dangerous Driving Index

Variable	B	SEB	β
Model 1			
Age	-.12	.50	-.03
Sex	-.17	.50	-.05
Model 2			
Age	-.17	.50	-.05
Sex	-2.29	5.43	-.06
CPT Omission	-.18	.56	-.05
CPT Commission	.80	.58	.20
BIS-11	.36	.23	.25
ADHD Impulse	.05	.67	.01
ADHD Inattention	-.22	.76	-.07
CFQ	.24	.19	.23

Note. Model 1 Adjusted R^2 = -.03; Model 2 Adjusted R^2 = .20; CPT Commission = Continuous Performance Task errors of commission (impulsive mistakes); CPT Omission = Continuous Performance Task errors of omission (inattentive mistakes); BIS-11 = Barratt Impulsiveness Scale, Version 11; ADHD Impulse = Attention-Deficit/Hyperactivity Disorder Rating Scale - Impulsiveness subscale; ADHD Inattention = Attention-Deficit/Hyperactivity Disorder Rating Scale – Inattention subscale; CFQ = Cognitive Failures Questionnaire
*$p < .05$

Similarly, in the second regression, age and sex were regressed onto the total number of risky driving events on the simulator (e.g., centerline crossings, traffic lights run, collisions, speeding occurrences) during the first step, and CPT Commission and Omission scores, BIS-11 scores, ADHD-RS impulsiveness and inattention scores, and CFQ scores were all added to the model together in the second step. Overall, the variables entered into the first step of this model did not account for a significant amount of the variance in risky simulator driving behaviors. Overall, the variables entered into the second step were found to account for a significant amount of the variance in driving simulator errors, Adjusted $R^2 = .15$, $F(6, 60) = 2.91$, $p < .05$. Individually, two predictor variables were found to contribute a significant amount of variance in risky driving on the simulator: ADHD-RS impulsiveness scores, $t(65) = 2.16$, $p < .05$, $\beta = .36$, and BIS-11 scores, $t(65) = 2.22$, $p < .05$, $\beta = .34$. See Table 7 for model summary and Table 8 for summary of individual predictors.

Table 7

Summary of Predictor Variables Regressed Stepwise onto Total Number of Infractions During the Driving Simulator Task

Model	R	R^2	Adjusted R^2	F	p
Model 1 Age + Sex	.14	.02	-.01	.64	.53
Model 2 Model 1 + CPT Commission + CPT Omission + BIS-11 + ADHD Impulse + ADHD Inattention + CFQ	.50	.25	.15	2.91	.03

Note. CPT Commission = Continuous Performance Task errors of commission (impulsive mistakes); CPT Omission = Continuous Performance Task errors of omission (inattentive mistakes); BIS-11 = Barratt Impulsiveness Scale, Version 11; ADHD Impulse = Attention-Deficit/Hyperactivity Disorder Rating Scale - Impulsiveness subscale; ADHD Inattention = Attention-Deficit/Hyperactivity Disorder Rating Scale – Inattention subscale; CFQ = Cognitive Failures Questionnaire

Table 8

Regression Analysis Summary for Age, Sex, CPT Omission, CPT Commission, BIS-11, ADHD Impulsiveness, ADHD Inattentiveness, and CFQ Scores Predicting Total Number of Infractions on the Driving Simulator Task

Variable	B	SEB	β
Model 1			
Age	-.22	.20	-.15
Sex	-.11	1.92	-.08
Model 2			
Age	-.21	.20	-.14
Sex	-2.37	2.01	-.17
CPT Omission	.19	.21	.13
CPT Commission	.04	.22	.02
BIS-11	.17	.09	.34*
ADHD Impulse	.63	.26	.36*
ADHD Inattention	-.55	.28	-.34
CFQ	.04	.07	.10

Note. Model 1 Adjusted R^2 = .02; Model 2 Adjusted R^2 = .25; CPT Commission = Continuous Performance Task errors of commission (impulsive mistakes); CPT Omission = Continuous Performance Task errors of omission (inattentive mistakes); BIS-11 = Barratt Impulsiveness Scale, Version 11; ADHD Impulse = Attention-Deficit/Hyperactivity Disorder Rating Scale - Impulsiveness subscale; ADHD Inattention = Attention-Deficit/Hyperactivity Disorder Rating Scale – Inattention subscale; CFQ = Cognitive Failures Questionnaire
*$p < .05$

To relate the findings to specific hypotheses, the list below summarizes the support or lack thereof for each hypothesis.

H_1. 3DI scores would be correlated with risky behaviors on a simulated driving task.	Unsupported. No 3DI scales were related to simulated dangerous driving behaviors except for the 3DI Risky Driving scale's association with percent of time speeding.
H_2. CFQ scores would predict scores on the 3DI.	Partially Supported. The CFQ was significantly, or almost significantly, related to every 3DI scale. However, CFQ scores failed to emerge as a significant predictor of 3DI scores in regression analysis.
H_3. CFQ scores would predict risky behaviors on the simulated driving task.	Unsupported. CFQ scores and simulated dangerous driving behaviors were completely unrelated and CFQ scores were not a significant predictor in regression.
H_4. BIS-11 scores would predict scores on the 3DI.	Largely Supported. BIS-11 scores were significantly related to every 3DI scale. Regression analysis showed BIS-11 scores approached significance as a predictor.
H_5. BIS-11 scores would predict dangerous driving behaviors on the simulated driving task.	Partially Supported. Regression showed BIS-11 scores as a significant predictor of simulated dangerous driving. Yet, BIS-11 scores were significantly related only to the

	speeding behaviors in simulated dangerous driving.
H_6. ADHD-RS Inattention scores would predict scores on the 3DI.	Partially supported. ADHD-RS Inattention scores were not a significant predictor of 3DI scores. However, they were related significantly to every 3DI scale.
H_7. ADHD-RS Impulsiveness scores would predict scores on the 3DI.	Unsupported. ADHD-RS Impulsiveness scores were not a significant predictor of 3DI scores. However, they were positively related to every 3DI scale, though these relationships only approached significance.
H_8. ADHD-RS Inattention scores would predict risky behaviors on the simulated driving task.	Unsupported. ADHD-RS Inattention scores and simulated dangerous driving behaviors were completely unrelated and these scores were not a significant predictor in regression.
H_9. ADHD-RS Impulsiveness scores would predict risky behaviors on the simulated driving task.	Partially Supported. Regression showed ADHD-RS Impulsiveness scores as a significant predictor of simulated dangerous driving. Yet, these scores were significantly related only to the speeding behaviors in simulated dangerous driving.
H_{10}. CPT Omission (Inattention) scores would predict scores on the 3DI.	Unsupported. CPT Omission scores were not a significant predictor in regression and were

	only approaching significance with one subscale (3DI Risky Driving).
H_{11}. CPT Commission (Impulsiveness) scores would predict scores on the 3DI.	Unsupported. CPT Commission scores were not a significant predictor in regression and were only significantly related to the 3DI Negative Cognitive/Emotional scale, though relations to the 3DI Total and Risky Driving scales approached significance.
H_{12}. CPT Omission (Inattention) scores would predict risky behaviors on the simulated driving task.	Unsupported. Regression showed CPT Omission scores were not a significant predictor of simulated dangerous driving and there was no significant correlation related to total number of risky driving behaviors. Yet, these scores were significantly and relatively strongly related to the center line crossings and collisions in simulated dangerous driving.
H_{13}. CPT Commission (Impulsiveness) scores would predict risky behaviors on the simulated driving task.	Unsupported. CPT Commission scores were not a significant predictor in regression and were only significantly related to simulated driving collisions.

CHAPTER 4

DISCUSSION

Though results did not support most of the research hypotheses, there are some surprising and applicable conclusions to be drawn from these findings. One of the more surprising findings was that results did not show a significant relationship between 3DI scores and dangerous driving as measured by the driving simulator, failing to support H_1. Looking at the components of the simulated driving total, the only dangerous driving type measured that had any relation was percent of time speeding, which had a positive association with the 3DI Risky Driving scale ($r = .28$, $p < .05$). This is curious because self-report dangerous driving behavior has been linked to performance on a simulator in past research (Deery & Fildes, 1999), but several factors could have influenced this outcome. Research using a driving simulator to measure driving behavior is still somewhat new, and there may need to be more structure and standardization to promote consistent results. Though the driving scenario and protocol were modeled after those used in previous research, they were not identical and this variability can contribute to some of the inconsistency with previous findings. Even though the simulator scenario attempted to create realistic driving situations, there were likely more events in the 20 minute scenario (e.g., pedestrian crossings, dog walks into road, boxes spill off a truck, etc.) than a driver may encounter in a typical 20 minute drive.

Data measured and analyzed from the driving simulator program may not accurately encompass all the facets of dangerous driving behavior. In its definition, dangerous driving encompasses aggressive, negative-emotional, and risky driving, and the 3DI has subscales that address each of these. Though the driving simulator attempts to create a realistic driving environment, the output data (collisions, speed exceedances, traffic light infractions, center line crossings) appears to measure behaviors that correspond with risky driving only. Even given this observation, there were no significant correlations observed between dangerous driving behaviors on the driving simulator task and any of the subscales of the 3DI, including risky driving.

The dissimilar methods likely influenced this finding, though having multiple methods of assessment was part of the comprehensive design of this study. Had 3DI scores and errors on the simulator task been highly related, it might have been considered impractical to use two methods to essentially measure the exact same construct. Given the results, it appears 3DI scores measured the beliefs and predispositions of a participant's attitude towards driving, and the simulator attempted to measure actual performance as a driver, though these data may have been limited by realism. Efforts to create a realistic driving environment and eliminate the mundane realism of taking a computer simulation as seriously as driving a real vehicle on real roads were made, but may not have been fully successful. Though participants are highly encouraged and even offered extra incentives to perform safely and obey all traffic laws and use caution, it is still difficult to truly simulate the consequences of a real world driving error in a simulated environment.

Though there was a significant correlation found between CFQ scores and 3DI scores, results of the regression did not confirm the ability of the CFQ to predict 3DI scores, failing to support H_2. Likewise, H_3 was not supported as CFQ scores were not found to predict risky driving behaviors on the simulator (though there was no significant correlation between these two variables). The CFQ was significantly correlated with each of the other self-report measures (3DI, BIS-11, ADHD-RS subscales), which calls into question whether it was actually measuring a completely unique construct that the other instruments failed to measure in the context of this study. Though cognitive failures do not correspond with a clinical diagnosis like impulsiveness and inattention with ADHD, the CFQ was included to measure the nonclinical lapses in attention and processing that could impact driving behavior. Past research has identified the relationship between CFQ scores and certain driver errors, such as failure to notice an intersection or poor lane positioning (Kass et al., 2010), yet this effect was not observed during this study. This finding may not have been replicated due to the driving simulator output data measured for this study. The relatively minor lapses in attention associated with cognitive failures may not be captured in the output data from the driving simulator, which included more serious infractions such as collisions, speed exceedences, center line crossings, and traffic light infractions, instead of data that might be more related to these minor lapses such as poor lane positioning and braking reaction time. The correlations observed between CFQ scores and 3DI scales indicates that the 3DI captures a significant amount of risk associated with cognitive failures, particularly with the Negative Cognitive/Emotional subscale (r = .48, p < .001).

BIS-11 scores were found to be significantly correlated with 3DI Total and subscale scores and were approaching significance in their ability to predict 3DI Total scores in the regression equation, which largely supported H_4. Self-reported impulsiveness, particularly as measured by the BIS-11, has been linked to multiple other self-reported risky behaviors (Mobini et al., 2006; Stanford et al., 1996) and even self-reported dangerous driving (Dula et al., 2012; Fox et al., 2012), making this a replication of previous findings. Though it was approaching significance, its failure to be found as a significant predictor of 3DI scores may clarify this relationship. BIS-11 scores likely covary consistently with 3DI scores but may not have much unique predictive ability in this context, potentially due to the overlap of key features such as nonplanning, aggression, and venturesomeness.

It was also found that BIS-11 scores were significantly correlated with risky driving on the simulator, and there was a significant amount of predictive ability found for BIS-11 scores related to simulator performance, which supports H_5. Interestingly, BIS-11 scores were correlated with risky simulator behaviors as a whole but only correlated to speeding behaviors individually and not center line crossings, traffic light infractions, and collisions. This may suggest that trait impulsiveness does more to influence deliberate risky driving decisions (e.g., ignoring the speed limit) rather than immediate, unplanned risky driving responses (e.g., yellow light decisions, crossing the center line, responding to roadway obstacles). It would then follow that state impulsiveness may capture more of these unplanned and immediate responses, but those results are somewhat inconclusive and discussed more thoroughly in the context of predictive abilities of the CPT.

Though ADHD-RS inattention scores were significantly correlated with each 3DI subscale, these scores were not found to be a significant predictor of 3DI Total scores in the regression equation. These results partially support H_6 and raise some questions about clinical inattention and self-reported driving. The role of inattention, and particularly divided attention, has been a rising topic in recent research due to use of cell phones and driving, and has been demonstrated as an important factor in dangerous driving behaviors (Drews et al., 2008; Wilson & Stimpson, 2010). In the context of this study it appears that clinical inattention related ADHD is highly related to self-reported dangerous driving behavior but does not significantly predict 3DI scores. Similar to the results discussed in context of the CFQ and self-reported dangerous driving, the failure of ADHD-RS inattention subscale scores to be found as a significant predictor of 3DI scores may have been due to overlap in some of the constructs measured by each of these self-report instruments. The similarity of many of these measures may not have left enough unique variability to be explained in the regression analysis for each of these measures.

Scores on impulsiveness subscale of the ADHD-RS were not found to significantly predict 3DI scores and no significant correlations were found between ADHD-RS impulsiveness scores and any 3DI scales, failing to support H_7. These results seem to be in contrast with previously discussed results regarding relationships between BIS-11 scores and 3DI scores. As expected, ADHD-RS and BIS-11 scores were significantly correlated (r = .53, p < .001), but BIS-11 scores were correlated with all 3DI scales and approached significance as a predictor in the regression, and ADHD-RS impulsiveness scores were not correlated with any 3DI scales and were not a significant predictor of 3DI scores. It may be that clinical impulsiveness and trait impulsiveness impact driving in a different way. Trait impulsiveness appears to have a high overlap with self-reported dangerous driving, with common factors such as risk taking and aggression. It is possible that clinical impulsiveness relates more to constructs such as restlessness and hyperactivity that may have less to do with dangerous driving behaviors.

ADHD-RS inattention scores did not predict risky driving on the simulated driving task based on the regression analysis, which failed to support H_8. These scores were also not found to be significantly correlated to any of the risky driving behaviors on the simulated driving task. Clinical inattention as measured by the ADHD-RS was highly related to cognitive failures (r = .62, p < .001), and similar conclusions can be made about results. The sorts of errors measured on the driving task were more major errors (e.g., collisions, center line crossings, speed exceedences, and traffic light infractions) and not less severe driving errors that would be more prone to inattention, such as lane drifting or braking reaction time. Another explanation may be that participants were likely driving on a simulator task for the first time and the stimuli and driving situations were completely novel, which commanded more of their attention than a mundane, familiar driving situation. Most drivers have a high level of familiarity with the routes and stimuli they encounter in much of their daily driving. This familiarity may allow more opportunity for inattentive mistakes, as less attention may be allocated to driving when operating a vehicle in a familiar or routine situation.

ADHD-RS impulsiveness scores were found to be significantly correlated and a significant predictor of risky driving on the simulator, which supported H_9. Similar to BIS-11 findings, ADHD-RS impulsiveness scores were only correlated to driving simulator speeding behavior (number of speeding occurrences and percent of time spent speeding) and not related to other risky driving behaviors measured by the simulator (center line crossings, collisions, and traffic light infractions). The finding that clinical impulsiveness as measured by the ADHD-RS was a significant predictor of risky driving on the simulator may be important in understanding risks associated with drivers living with ADHD as a clinical diagnosis. ADHD, and particularly the hyperactive/impulsive subtype, has a well demonstrated association with dangerous and risky behaviors (Cheung et al., 2004; Magid et al., 2007; Stanford et al., 1996), and these results indicate that this association may be applicable for driving as well. Though it was not a significant finding, ADHD-RS inattention scores were very nearly identified as a significant predictor for driving simulator performance ($\beta = -.34$, $p = .05$), indicating that clinical inattention is something worthy of future consideration in research on clinical factors and dangerous driving.

CPT inattention and impulsiveness scores did not contribute significantly to the variance of 3DI scores and were not significantly correlated to 3DI Total scores, failing to support H_{10} and H_{11}. Likewise, these factors were not found to be significantly correlated or a significant predictor of total number of risky driving errors on the simulator, which failed to support H_{12} and

H_{13}. Consistent with previous findings (Fox et al., 2012; Fox, May, & Yurasek, 2008), CPT scores were not significantly correlated with any their self-report analogs (ADHD-RS subscales or BIS-11 scores). It has been suggested that this is due to the difference between self-reporting predispositions related to impulsive or inattentive behaviors (trait impulsiveness and inattention) and quick neuropsychological decisions to attend or inhibit response to a novel stimuli (state impulsiveness and inattention). Though CPT scores were not significantly related to total number of risky behaviors on the simulator task, some individual categories of errors may guide future inquiries regarding the utility of a CPT in predicting driving behaviors. Impulsive mistakes on the CPT were significantly correlated with simulator collisions ($r = .34$, $p < .01$) and inattentive mistakes on the CPT were significantly correlated with center line crossings ($r = .43$, $p < .001$), collisions ($r = .31$, $p < .01$), and traffic light infractions ($r = .39$, $p < .01$). These are the risky driving behaviors that were not well accounted for by the self-report measures, as the BIS-11 and ADHD-RS impulsiveness subscale only had a significant relationship with speeding variables. It may be of value to future researchers to understand that CPT scores may have more of a relationship to nonspeeding risky driving behaviors than self-report impulsiveness and inattention measures.

Despite some exploratory findings, results largely indicated that CPT scores have minimal utility in predicting driving outcomes and relationships. One explanation may be that the CPT used in this study (*Vigil Continuous Performance Test*), only tests participants for an 8-minute time frame. Other CPT programs have a longer test period, creating more opportunity for factors such as boredom and cognitive strain to allow these impulsive and inattentive mistakes to be made. Also, *Vigil* and other continuous performance tasks have been shown to be valid and reliable clinical assessments in the past, but their utility in nonclinical research has not been well demonstrated. The use of CPT data in this study was somewhat exploratory, and it appears that the lack of demonstrated relationships to other major variables in this study and previous related studies (Fox et al., 2012; Fox et al., 2008) indicate that it may not be particularly useful outside its designated role as a supplemental diagnostic test for ADHD.

Participant age and sex were analyzed in the first step of each regression analysis due to the consistently demonstrated relationship with driving outcome variables, such as the 3DI scores and simulator performance. For this study these factors were not found to have any predictive ability for either of these driving measures. Their effects were very weak in the analyses and were not approaching significance. This seems to be opposed to previous research that has identified sex differences on several of the measures used for this study (Dula & Ballard, 2003; Kass et al., 2010; Lenné et al., 2010). One possible explanation may be the inequality of males to females in the sample (19 males to 56 females). Equal variances for sex were observed on all measures examined through t-tests, and the only variable that yielded a significant difference in scores based on sex was the CFQ. The failure to find age as a significant predictor of driving variables also seems to be opposed to previous research findings to the contrary (Dula & Ballard, 2003; Owsley et al., 2003). One of the identified limitations of the sample was the restricted age of the sample ($M = 21.40$, $SD = 4.59$). Though it may have been useful to study younger drivers as they have been identified as a group with more dangerous driving behaviors, the lack of variability in age may have limited the ability of this study to replicate previous findings of age as a predictor for dangerous driving.

The overall regression analysis examining the abilities of age, sex, both CPT scores, both ADHD-RS subscale scores, BIS-11 scores, and CFQ scores to predict 3DI scores was found to be significant and accounted for 20% of the variance in 3DI scores, though no individual predictors were found significant. As mentioned previously, there is likely significant overlap in several of the self-report measures used in this study as evidenced by multiple significant correlations between scores (see Table 2). This would explain the significant amount of variance accounted for in the regression equation with all eight predictors, but lack of any emerging individual predictor. Though each of these instruments and the constructs that they measure may be important to understanding dangerous driving behavior, it appears that the overlap between these factors may have been too large to allow any of these factors to individually claim a significant portion of the variance in predicting 3DI scores.

Despite the analyses only identifying two of the assessment measures (ADHD-RS impulsiveness and BIS-11) as a significant individual predictor for driving simulator performance, the overall model that included age, sex, both CPT scores, both ADHD-RS subscale scores, BIS-11 scores, and CFQ scores was found to be significant and accounted for 15% of the variance in driving simulator performance. In contrast to their predictive abilities related to the 3DI, these instruments (particularly the self-report instruments) likely had more ability to explain variance in driving data due to dissimilar methods and lack of overlapping constructs. While conclusions about individual predictive abilities can only be made about ADHD-RS impulsiveness and BIS-11 scores, these results indicate that each of these constructs likely have some role in understanding actual driving performance. It may be useful in guiding future research to be less inclusive of similar measures and have less exploratory analyses to make more robust conclusions about driving behavior and the impact of impulsiveness, inattention, and cognitive failures.

Future research may aim to improve some of the limitations of this study. Though this study examined a larger number of participants than most research using a driving simulator, a more representative and inclusive sample, particularly in the areas of age and sex, may produce more comprehensive and generalizable findings. The skewness in age and sex for this sample likely hindered the ability of analyses in this study to replicate results from previous research related to these factors. The use of a driving simulator to measure driving behavior is still a relatively new method in this field of research. It would be advisable for the field to create more standardization and consistency in methods, variables, programs used, and driving scenarios. Also, stepwise regression models were used for exploratory purposes to understand the relationship each of the measures had with the driving measures. The models used in this study may need to be refined if used for more explanatory or strictly predictive research. It was also found that there was a fair amount of overlap between several of the measures, particularly the self-report measures. Though the aim of this analysis was to be comprehensive and understand the role of all of these factors and methods together, future research may be better able to understand the impact these constructs have on driving behavior if studied individually or controlling for these interrelationships, so as not to diffuse variability between so many factors.

CHAPTER 5

CONCLUSION

Dangerous driving is a varied and complex construct. The lack of a relationship between 3DI scores and driving simulator performance is evidence of this, as well as the mixed results when comparing dangerous driving to other related constructs. The relationship between impulsiveness and dangerous driving was also found to be somewhat complicated. Impulsiveness did predict risky driving behavior on the driving simulator when examining clinical impulsiveness via the ADHD-RS and trait impulsiveness via the BIS-11 but not impulsiveness measured by CPT scores. It appeared through investigation of specific risky driving behaviors on the simulator that impulsiveness in general is more related to speeding than other risky driving behaviors.

Though no predictive relationships were observed for inattention or cognitive failures, their relationship to dangerous driving has been supported by previous research (Drews et al., 2008; Larson et al., 1997) and current results (e.g., correlations, near significant findings) warrant their continued study. Inattentive errors on the CPT were significantly correlated with simulator center line crossings, collisions, and traffic lights. These were errors that no other measure used by this study were found to be significantly related to and may indicate that inattentive neuropsychological errors lead to more serious risky driving behaviors. Scores on the CFQ and ADHD-RS inattention subscale were highly related to self-report dangerous driving measured by the 3DI, suggesting that there is a fair amount of overlap between problems with attention and self-reported dangerous driving.

Despite the lack of strong and definitive individual predictors for dangerous driving outcomes, both regression models indicate that impulsiveness, inattention, and cognitive failures do account for a significant amount of variance in dangerous driving behaviors. These factors have had mixed results when studied for their individual relationships in past studies, and individual analyses replicated these mixed results. It does appear that, on the whole, each of these constructs (impulsiveness, inattention, and cognitive failures) and their corresponding methods of measurement are important in understanding dangerous driving behaviors.

A better understanding of the essential features that each of these measures lends to the study of dangerous driving is essential. Further research detailing the specifics of these relationships and real world consequences is necessary to reduce the impact that driving infractions influenced by these cognitive problems have on social, health, and economic costs. The significant danger inherent to driving behavior warrants further study into these and other related factors that can lead to dangerous driving and its consequences, including collisions and death. While research, law enforcement, and public policy attention is often given to other factors that contribute to dangerous driving, such as anger or substance use, this study indicates that similar attention may also merited for impulsiveness, inattention, and cognitive failures related to dangerous driving.

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APPENDICES

Appendix A

Dula Dangerous Driving Index

Please answer each of the following items as <u>honestly</u> as possible. Please read each item carefully and then circle the answer you choose on the form. If none of the choices seem to be your ideal answer, then select the answer that comes <u>closest</u>. THERE ARE NO RIGHT OR WRONG ANSWERS. Select your answers quickly and do not spend too much time analyzing your answers. If you change an answer, erase the first one well.

1. I drive when I am angry or upset.
   A. Never B. Rarely C. Sometimes D. Often E. Always
2. I lose my temper when driving.
   A. Never B. Rarely C. Sometimes D. Often E. Always
3. I consider the actions of other drivers to be inappropriate or stupid.
   A. Never B. Rarely C. Sometimes D. Often E. Always
4. I flash my headlights when I am annoyed by another driver.
   A. Never B. Rarely C. Sometimes D. Often E. Always
5. I make rude gestures (e.g., giving the finger, yelling curse words) toward drivers who annoy me.
   A. Never B. Rarely C. Sometimes D. Often E. Always
6. I verbally insult drivers who annoy me.
   A. Never B. Rarely C. Sometimes D. Often E. Always
7. I deliberately use my car/truck to block drivers who tailgate me.
   A. Never B. Rarely C. Sometimes D. Often E. Always
8. I would tailgate a driver who annoys me.
   A. Never B. Rarely C. Sometimes D. Often E. Always
9. I drag race other drivers at stop lights to get out front.
   A. Never B. Rarely C. Sometimes D. Often E. Always
10. I will illegally pass a car/truck that is going <u>too</u> slowly.
   A. Never B. Rarely C. Sometimes D. Often E. Always
11. I feel it is my right to strike back in some way, if I feel another driver has been aggressive toward me.
   A. Never B. Rarely C. Sometimes D. Often E. Always
12. When I get stuck in a traffic jam I get <u>very</u> irritated.
   A. Never B. Rarely C. Sometimes D. Often E. Always
13. I will race a slow moving train to a railroad crossing.
   A. Never B. Rarely C. Sometimes D. Often E. Always
14. I will weave in and out of slower traffic.
   A. Never B. Rarely C. Sometimes D. Often E. Always
15. I will drive if I am only <u>mildly</u> intoxicated or buzzed.
   A. Never B. Rarely C. Sometimes D. Often E. Always
16. When someone cuts me off, I feel I should punish him/her.
   A. Never B. Rarely C. Sometimes D. Often E. Always

17. I get impatient and/or upset when I fall behind schedule when I am driving.
A. Never B. Rarely C. Sometimes D. Often E. Always

18. Passengers in my car/truck tell me to calm down.
A. Never B. Rarely C. Sometimes D. Often E. Always

19. I get irritated when a car/truck in front of me slows down for no reason.
A. Never B. Rarely C. Sometimes D. Often E. Always

20. I will cross double yellow lines to see if I can pass a slow moving car/truck.
A. Never B. Rarely C. Sometimes D. Often E. Always

21. I feel it is my right to get where I need to go as quickly as possible.
A. Never B. Rarely C. Sometimes D. Often E. Always

22. I feel that passive drivers should learn how to drive or stay home.
A. Never B. Rarely C. Sometimes D. Often E. Always

23. I will drive in the shoulder lane or median to get around a traffic jam.
A. Never B. Rarely C. Sometimes D. Often E. Always

24. When passing a car/truck on a 2-lane road, I will barely miss on-coming cars.
A. Never B. Rarely C. Sometimes D. Often E. Always

25. I will drive when I am drunk.
A. Never B. Rarely C. Sometimes D. Often E. Always

26. I feel that I may lose my temper if I have to confront another driver.
A. Never B. Rarely C. Sometimes D. Often E. Always

27. I consider myself to be a risk-taker.
A. Never B. Rarely C. Sometimes D. Often E. Always

28. I feel that most traffic laws could be considered as suggestions.
A. Never B. Rarely C. Sometimes D. Often E. Always

Appendix B

The Cognitive Failures Questionnaire

The following questions are about minor mistakes which everyone makes from time to time, but some of which happen more often than others. We want to know how often these things have happened to you in the past 6 months. Please circle the appropriate number.

		Very often	Quite often	Occasion- ally	Very rarely	Never
1.	Do you read something and find you haven't been thinking about it and must read it again?	4	3	2	1	0
2.	Do you find you forget why you went from one part of the house to the other?	4	3	2	1	0
3.	Do you fail to notice signposts on the road?	4	3	2	1	0
4.	Do you find you confuse right and left when giving directions?	4	3	2	1	0
5.	Do you bump into people?	4	3	2	1	0
6.	Do you find you forget whether you've turned off a light or a fire or locked the door?	4	3	2	1	0
7.	Do you fail to listen to people's names when you are meeting them?	4	3	2	1	0
8.	Do you say something and realize afterwards that it might be taken as insulting?	4	3	2	1	0
9.	Do you fail to hear people speaking to you when you are doing something else?	4	3	2	1	0
10.	Do you lose your temper and regret it?	4	3	2	1	0
11.	Do you leave important letters unanswered for days?	4	3	2	1	0
12.	Do you find you forget which way to turn on a road you know well but rarely use?	4	3	2	1	0
13.	Do you fail to see what you want in a supermarket (although it's there)?	4	3	2	1	0

		Very often	Quite often	Occasion-ally	Very rarely	Never
14.	Do you find yourself suddenly wondering whether you've used a word correctly?	4	3	2	1	0
15.	Do you have trouble making up your mind?	4	3	2	1	0
16.	Do you find you forget appointments?	4	3	2	1	0
17.	Do you forget where you put something like a newspaper or a book?	4	3	2	1	0
18.	Do you find you accidentally throw away the thing you want and keep what you meant to throw away – as in the example of throwing away the matchbox and putting the used match in your pocket?	4	3	2	1	0
19.	Do you daydream when you ought to be listening to something?	4	3	2	1	0
20.	Do you find you forget people's names?	4	3	2	1	0
21.	Do you start doing one thing at home and get distracted into doing something else (unintentionally)?	4	3	2	1	0
22.	Do you find you can't quite remember something although it's "on the tip of your tongue"?	4	3	2	1	0
23.	Do you find you forget what you came to the shops to buy?	4	3	2	1	0
24.	Do you drop things?	4	3	2	1	0
25.	Do you find you can't think of anything to say?	4	3	2	1	0

Appendix C

Attention-Deficit/Hyperactivity Disorder Rating Scale, Version IV

Circle the number that <u>best describes</u> your behavior over the last 6 months

		never or rarely	sometimes	often	very often
1.	I fail to give close attention to details or make careless mistakes in schoolwork.	0	1	2	3
2.	I fidget with hands or feet or squirm in seat.	0	1	2	3
3.	I have difficulty sustaining attention in tasks or play activities.	0	1	2	3
4.	I leave my seat in the classroom or in other situations in which remaining seated is expected.	0	1	2	3
5.	I do not listen when spoken to directly.	0	1	2	3
6.	I run about or climb excessively in situations in which it is inappropriate.	0	1	2	3
7.	I do not follow through on instructions and fail to finish work.	0	1	2	3
8.	I have difficulty playing or engaging in leisure activities quietly.	0	1	2	3
9.	I have difficulty organizing tasks and activities.	0	1	2	3
10.	I am "on the go" or act as if "driven by a motor."	0	1	2	3
11.	I avoid tasks (e.g., schoolwork, homework) that require sustained mental effort.	0	1	2	3
12.	I talk excessively	0	1	2	3
13.	I lose things necessary for tasks or activities.	0	1	2	3
14.	I blurt out answers before questions have been completed.	0	1	2	3
15.	I am easily distracted.	0	1	2	3
16.	I have difficulty awaiting turn.	0	1	2	3
17.	I am forgetful in daily activities.	0	1	2	3
18.	I interrupt or intrude on others.	0	1	2	3

Appendix D

Barratt Impulsiveness Scale, Version 11

DIRECTIONS: People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and put an X on the appropriate circle on the right side of this page. Do not spend too much time on any statement. Answer quickly and honestly.

O Rarely/Never | O Occasionally | O Often | O Almost Always/Always

1	I plan tasks carefully.	O	O	O	O
2	I do things without thinking.	O	O	O	O
3	I make-up my mind quickly.	O	O	O	O
4	I am happy-go-lucky.	O	O	O	O
5	I don't "pay attention."	O	O	O	O
6	I have "racing" thoughts.	O	O	O	O
7	I plan trips well ahead of time.	O	O	O	O
8	I am self controlled.	O	O	O	O
9	I concentrate easily.	O	O	O	O
10	I save regularly.	O	O	O	O
11	I "squirm" at plays or lectures.	O	O	O	O
12	I am a careful thinker.	O	O	O	O
13	I plan for job security.	O	O	O	O
14	I say things without thinking.	O	O	O	O
15	I like to think about complex problems.	O	O	O	O
16	I change jobs.	O	O	O	O
17	I act "on impulse."	O	O	O	O
18	I get easily bored when solving thought problems.	O	O	O	O
19	I act on the spur of the moment.	O	O	O	O
20	I am a steady thinker.	O	O	O	O
21	I change residences.	O	O	O	O
22	I buy things on impulse.	O	O	O	O
23	I can only think about one thing at a time.	O	O	O	O
24	I change hobbies.	O	O	O	O
25	I spend or charge more than I earn.	O	O	O	O
26	I often have extraneous thoughts when thinking.	O	O	O	O
27	I am more interested in the present than the future.	O	O	O	O
28	I am restless at the theater or lectures.	O	O	O	O
29	I like puzzles.	O	O	O	O
30	I am future oriented.	O	O	O	O

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