



Developing a Younger Driver Assessment Tool Technical Memorandum #1

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Introduction

The trucking industry has faced challenges in recruiting and retaining sufficient numbers of truck drivers for many years. In a 2016 national survey, motor carrier executives ranked the driver shortage as the top industry issue (115). Overall, the driver shortage has been a top-ranked industry issue every year since 2005, with the exception of 2009, when the Great Recession drove freight demand down (115). In 2015, the truck driver shortage was estimated to be 48,000 and it was estimated that 890,000 truck drivers would need to be hired over the next decade to maintain the existing workforce (2, 27).

There are numerous factors that contribute to the truck driver shortage. Extended periods of time spent away from home, irregular schedules, and other demands of the profession create a lifestyle that may not suit the needs of many potential drivers (31). Additionally, industry growth and baby-boomer retirements of the current truck driver population are expected to exacerbate the driver shortage (27). Drivers in the over-the-road truckload segment are 49 years old on average, and it is estimated that replacing drivers who are retiring will account for nearly half of the new hires needed over the next decade (27).

Young drivers (18 to 25 years of age) represent a largely untapped age group for the trucking industry. This is primarily the result of federal regulations that require an individual to be 21 years of age before they can obtain a Commercial Driver's License (CDL) to operate across state lines. Therefore, individuals interested in becoming a truck driver before the age of 21 are restricted to operating intrastate – which may limit job opportunities and earning potential. As a result, drivers 20 to 24 years of age represent approximately five percent of individuals employed in the truck transportation sector, while for all industries this age group comprises 9.8 percent of employees (97).

As a group, the 18 to 25 year age group is characterized by elevated risk when compared to older age groups. Underlying factors of this heightened risk include immature cognitive function, a tendency to impulsively approach sources of pleasure, and high risk-taking behavior rates that are often associated with preventable negative consequences. While the 18 to 25 year age group is high-risk as a whole, there are likely to be individuals within this age group who are more similar to safe, experienced drivers than their peers.

In 2015, the American Transportation Research Institute's (ATRI's) Research Advisory Committee (RAC)¹ identified as a top research priority the investigation of whether younger drivers that are as safe as drivers in older age groups could be identified through some type of assessment tool. As a result, ATRI is undertaking a series of chronological tasks to assess whether "safer" drivers can be identified among 18 to 20 year olds. This report summarizes the background literature initially used to assess the feasibility of identifying and recruiting young individuals with low crash risk into the truck driver workforce based on existing scientific literature. Monica Luciana, a faculty member at the University of Minnesota and an expert in developmental neuropsychology, coauthored this report as an independent consultant.

¹ ATRI's RAC is comprised of industry stakeholders representing motor carriers, trucking industry suppliers, labor and driver groups, law enforcement, federal government and academia. The RAC is charged with annually recommending a research agenda for the Institute.

This report provides an overview of the psychology literature on adolescence and early adulthood, and how the characteristics of this age group relate to driving safety. Prior studies on driver safety have utilized a variety of methods, but were generally focused on determining the relationship between crash risk and a single predictive characteristic.

In the following phase of this research, ATRI will utilize multiple predictors to assess the relative crash risk of an individual driver. More specifically, the next phase of the research will investigate whether an Assessment Tool measuring individual difference factors in personality, health and cognition can reliably predict safe driving outcomes among a small sample of commercial drivers.

Younger Driver Characteristics

The 12 to 25 year age group has garnered considerable attention from developmental psychologists, public health experts, and neuroscientists due to the rise in risk-taking behaviors (often associated with quantifiable negative consequences) that occurs in this age range. The inclusion of those in the 18 to 25 year age range when conceptualizing adolescent risk is a relatively recent trend, with this age range often depicted as an extension of adolescence or “emerging adulthood,” where the brain and behavior are still maturing (59, 85). The age range of interest for recruiting younger truck drivers, 18 to 20 years of age, coincides with the “emerging adulthood” development phase.

The risky behaviors of teens and young adults are highly relevant to roadway safety. Teens and young adults are overrepresented in fatal motor vehicle crashes (77), have the lowest observed seat belt use of any age group and regularly use cell phones and other electronic devices while driving (48, 51, 79, 105).

A number of teen and young adult characteristics may explain the increased propensity for risky behavior observed in this age group, including:

- Teenagers have a higher “reward sensitivity” relative to early childhood or later adulthood, resulting in an increased interest in activities with the potential for positive emotions (63, 104). Peers are a particularly salient source of reward – the presence of peers increases the likelihood of risky behavior in numerous driving simulations and substitutes (23, 45, 81, 86, 101).
- Impulsivity, i.e. acting without planning or forethought (37), is often invoked as an explanation for poor judgment observed in teens and young adults (25, 29).
- Several major mental disorders first present symptoms in adolescence and young adulthood, such as depression and schizophrenia (82).
- Circadian rhythm shifts may impact alertness and result in daytime fatigue (18, 19).
- Surges in testosterone, for both men and women, into young adulthood may result in sensation-seeking and risk-taking behaviors (13).
- Executive function development, which regulates planning, inhibitory control, and behavioral flexibility, continues into the mid-20s (62, 99) supported by brain-based changes (10, 59). While younger individuals (16 to 17 years of age) are capable of adult-level executive function, this often differs from what is observed in day-to-day life (62, 98, 99).

Individual differences play a significant role in whether a given person is more similar to an adolescent or an adult with regard to judgment and risk-taking tendencies. In addition to individual differences, context and environment are relevant to risk-taking behavior in young adults.

Predictive Factors

In addition to the driver qualification standards established by federal regulations, scientific analyses suggest that a number of individual characteristics are likely relevant to driving safety (58, 75). Relevant factors identified in this literature review include age, experience, personality traits, health, and cognitive abilities. In the ATRI research, drivers will be screened for the personality traits, health, and cognitive abilities, and statistically significant measures are being assembled to develop and test an Assessment Tool that predicts driver safety outcomes. However, given the nature of the analysis method the researchers plan to use, it is possible that not all of the characteristics discussed in this paper will be included in the final Assessment Tool.

Age and Driving Experience

The relationship between safety and age is well-established, and has been attributed to numerous age-related differences, including perception, decision-making, responses to stimuli, and physical differences.

Young drivers, irrespective of nationality or culture, tend to have higher crash rates than middle age adults (21, 67, 102). Age-related studies tend to focus on the general driving population rather than trucking due to interstate CDL age requirements. However, a review of scientific literature on the impact of age on heavy vehicle crash risk drivers concluded that younger drivers, as well as those older than 63 years of age have higher rates of crash involvement (40).

Numerous studies have concluded that young drivers and elderly drivers have elevated crash risk relative to middle age drivers (91, 109). Explanations for why young individuals and elderly individuals have elevated crash risk differ. Studies of younger drivers tend to focus on personality characteristics, experience, and driving style; studies of older drivers focus on the impacts of advanced age on driver health and cognitive abilities (92).

Differences in perception, such as the ability to identify potential roadway hazards, may distinguish younger drivers from older, more experienced drivers. Researchers also theorize that younger drivers overestimate their driving skills. When driving in hazardous conditions, young drivers may fail to understand the potential consequences of their actions and fail to adjust their driving behavior accordingly (14, 35). Finally, young drivers are more likely to react to dangerous situations with unsafe counter-strategies (64).

While age appears to be an obvious factor contributing to overconfidence and poor judgment in this group, inexperience also contributes to these tendencies (47), and may be more predictive of crash risk than age alone (71).

Conversely, youth confers numerous advantages to younger drivers as they are in their physical prime. For example, younger drivers are better able to recover from visual glare relative to older drivers (68). Some researchers suggest that driving skill is better in younger drivers, provided

sufficient experience has been obtained (42). Individual differences appear to influence stylistic approaches to driving, which includes elements such as propensity to commit traffic violations and choice of driving speed. These stylistic approaches may be influenced by personality traits.

This research seeks to find a combination of characteristics that are more predictive of driving safety than age to allow for younger drivers with the characteristics of a safe older driver to be identified. Age and driving experience will be collected to assess the relative contributions each has to driver safety outcomes.

Personality Traits

Personality traits are individual differences in patterns of thinking, behaving, and feeling that are consistent within an individual and across situations. While personality traits may change with maturity, an individual’s relative ranking amongst peers is not likely to change (20, 26, 89).

Personality traits can be refined to a set of trait areas or domains, typically conceptualized as three to five domains that are present in all age groups and cultures (38). Table 1 displays the typical five-domain model, and examples of personality characteristics that represent the high- and low-end of each of the five domains. In five-domain personality models, individuals with low agreeableness and low conscientiousness are at higher risk for crash involvement (24). Five-domain models can also dependably predict safety for both commercial and non-commercial driver populations (56). Therefore, the proposed Assessment Tool will include a five-domain personality assessment.

Table 1: Five Domain Personality Models (116)

Domain	High Level Characteristic Examples	Low Level Characteristic Examples
Extraversion	Outgoing, assertive	Reserved, contemplative
Neuroticism	Sensitive, anxious	Stable, calm
Agreeableness	Cooperative, compassionate	Suspicious, argumentative
Conscientiousness	Responsible, organized	Careless, impulsive
Openness	Imaginative, insightful	Consistent, inflexible

Other relevant personality traits are impulsivity, sensation-seeking and aggression. Impulsivity refers to acting without considering long-range consequences (37). Regardless of age, impulsivity is associated with numerous risky driver outcomes (83), and many motor vehicle crashes are associated with impulsive driver behaviors, such as unpredictable illegal maneuvers. Specifically, driver decision errors (e.g. following too closely, driving too fast for weather conditions) that could be attributed to impulsive behaviors account for 40.1 percent of

teen at-fault crashes (28).² With experience, the impact of impulsivity on driving behavior, and the associated safety risks, may lessen (111).

Sensation-seeking refers to "seeking of varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal, and financial risks for the sake of such experience" (112, 113, 114). Sensation-seeking measures are primarily self-report scales. The association between high sensation-seeking and risky driving has been demonstrated in a large number of studies (25, 34, 53, 95). In the U.S., studies suggest that sensation-seeking often changes with development, peaking in mid-to-late adolescence (49, 98). Engaging in speeding or other illegal maneuvers for the thrill of it are an example of sensation-seeking behaviors.

Tendencies toward aggression and psychopathy, unlike sensation-seeking and impulsivity, appear to be disposition-related rather than a function of incomplete development (61). Numerous studies have linked driver safety with aggression (56). While many assessments seek to measure aggression and related safety outcomes, the Driving Anger Scale (36) and Driver Behavior Questionnaire (88) have the strongest indications for validity. The Driver Anger Scale and Driver Behavior Questionnaire are self-report measures that rely on honest responses about a number of undesirable driving behaviors (e.g. excessive speed). Since the Assessment Tool can be used to screen drivers for employment purposes, prospective drivers may be reluctant to disclose risky driving behaviors in which they engage. So, while aggression is associated with driver safety, it may be difficult to assess reliably in this context.

Since personality traits, impulsivity, sensation-seeking, and aggression are associated with elevated crash risk, drivers will be screened for these characteristics to test their statistical significance in predicting driving safety.

Health

Health factors, in addition to the truck driver health requirements outlined in 49 CFR 391.43, also influence driver safety. Health factors relevant to driver safety identified in this literature review include: fatigue/sleep disorders, attention-related disorders, substance use, emotional instability, and obesity.

Attentional disorders, including attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD), are typically considered childhood disorders (1). A recent meta-analysis relates ADHD with greater risk for motor vehicle crashes (52) and observational studies connect ADHD with higher rates of driving-related citations (9). While these reports raise concerns, the impact of ADHD on safety outcomes may be over-estimated due its frequent association with younger individuals with little driving experience. In addition, driving-related risk tendencies in this population may be due to multiple conditions given that individuals with ADHD often also experience behavior problems (103). These concurrent conditions (i.e. comorbidities) are not always obvious, so ADHD is a condition that may need to be monitored. The safety risks of ADD and ADHD may be mitigated through treatment compliance (22).

² Despite the industry practice of characterizing crashes by preventability, much of the literature relates to "at-fault" crashes. At-fault determinations relate to legal culpability.

Fatigue and sleep disorders are considered to be a contributor to crashes (57), but it is difficult to determine the full extent of fatigue in causing crashes. Due to the difficulty of objectively assessing driver fatigue, estimates of truck-involved crashes associated with fatigued driving are extremely varied (76, 78). Sleep deprivation is common in the general population (39), although truck drivers may be more susceptible to fatigue than drivers in the general population due to driving for lengthy periods of time, Hours-of-Service (HOS) requirements, off-hour driving, and other characteristics of the profession. Moreover, young drivers may be particularly susceptible to these effects (70).

The impact of substance use on driving is widely recognized. Individuals aged 25 or younger have high substance use rates despite legal prohibitions (66). Additionally, substance use at a young age is associated with other forms of risk-taking behaviors (72). Individuals may avoid detection of substance use through short term abstinence, so hair testing has been recommended to index patterns over a longer period of time (117).

Affective, anxiety, and mood disorders are estimated to impact a portion of the general population (55); 9.5 percent of the population in the U.S. over a one-year period. A study of truck drivers found a number of issues impacting mental health, including depression (26.9%), chronic sleep disturbances (20.6%), anxiety (14.5%), and other emotional problems (13%) (96). These conditions may affect driving ability, and therefore increase crash risk in three essential areas: sleep disturbances impacting alertness (54); inattention impacting driving abilities; and side effects of medications (94).

Sedentary lifestyles and associated weight gain present risks for commercial drivers. Naturalistic studies of drivers have found obese drivers are more likely to be involved in crashes than drivers in the normal body mass index (BMI) range (3), and more likely to be objectively rated as fatigued (107). Obesity is associated with greater crash risk and risk of fatigue.

In summary, ADD/ADHD, sleep disorders, emotional/mood disorders, and obesity are associated with higher crash risk. To assess the effect of these conditions on driver safety, the proposed Assessment Tool will need to screen for these conditions.

Cognition

Cognition refers to patterns of thinking, understanding, and remembering. These patterns allow humans to acquire and use information to understand, react, and make decisions about the world around them. Driving is a complex task, requiring focus, rapid decision making, physical responses, and other cognitive tasks. This is supported by the numerous cognitive analyses of driving behavior that have found many elements that an individual must negotiate and control (84, 93), such as route planning, maintaining control over speed, and adhering to traffic regulations. Areas of cognition relevant to driving safety include general cognitive ability, executive function/decision-making, and attention.

General cognitive ability, or intellect, predicts multiple facets of job success for various occupations (16). For truck drivers specifically, intellect facilitates (56) general problem-solving demands and demands for adequate verbal skills. For example, problem solving allows drivers to determine how to best use available HOS to reach their destination.

Executive function is a high-level aspect of cognition often associated with safe driving behavior (8). Most studies on executive function relate to older drivers, as executive function is compromised with increasing age (5, 11, 30, 73). However, executive function is relevant to younger drivers as it is regulated by the brain's frontal lobe, a region that does not reach maturity until the mid-20s (32, 46, 59, 62, 98, 100, 108). Executive function is essential to performing numerous driving tasks by regulating behavior through processes such as attention, behavioral flexibility, working memory, and inhibitory control. These processes are most efficient when a person is able to process information quickly (3).

Attention is crucial for safe vehicle operation – drivers must actively monitor road signs, road conditions, and the actions of other drivers (92). Additionally, fast reaction times enable the rapid detection of road conditions and the actions of other drivers (15, 35). Attention test scores predict traffic infractions in driving simulations (106). Additionally, drivers who engage in inattentive driving behavior, such as cell phone use, are more likely to make impulsive decisions (50). Impulsive decision-making is also predictive of other risky driving behaviors (83).

Behavioral flexibility is the ability to adjust behavior in response to environmental feedback, which allows drivers to respond to unique circumstances such as changing behavior for driving in icy conditions or adjusting lane positioning to avoid an erratic driver. In addition to difficulties in adjusting behavior in response to risky road conditions (e.g. icy roads), young and inexperienced drivers may have difficulty detecting the risks (35). Practically speaking, difficulty detecting roadway risks lowers the amount of time a driver has to respond to a potential risk and underpins the importance of a driver's ability to adjust behavior quickly in response to roadway risks.

Working memory and "updating" refer to tracking information, then using the information to actively pursue goals. Working memory and updating facilitate a driver's ability to monitor the roadway for potential risks. When an actual hazard is encountered, drivers must use information about their surroundings to influence actions taken to avoid a crash. Numerous studies have found associations between driving safety and aspects of working memory (7, 15, 44, 51, 90, 92,).

Inhibitory control, the ability to regulate or stop one's emotions or responses, may be particularly salient to safe driving. For example, inhibitory control allows a driver to control their emotional response to being cut off by another vehicle. Inhibitory control improves throughout adolescence and completes development in mid-adulthood (108). Poor inhibitory control is related to crash involvement (15, 30, 69, 80) and poor driving performance (33).

In summary, driving requires executive function for multi-tasking, attention, and quick reactions (5, 7, 43). These cognitive demands may be negatively impacted by in-vehicle displays and sounds (12, 87), or when individuals are asked to drive in unfamiliar areas (60). In novel situations, the ability to monitor the environment for potential risks and subsequent identification of actual hazards is paramount and numerous executive functions are needed and utilized. The ability to respond to hazardous situations, especially in unfamiliar environments (90) is critical to crash avoidance.

As implied by this brief review, executive functions, including attention, are critical to driver safety. There are numerous measures used to assess these elements, only some of which have been applied to the study of driving behavior. Additionally, the assessment of executive

function and attention is complicated by the fact that performance is highly influenced by situational factors, and is not necessarily stable within individuals across varied situations. Capturing these variations in a laboratory setting to predict real-world behavior is a challenge. However, since executive function, attention, behavioral flexibility, working memory, and general intelligence are associated with driving safety, the proposed Assessment Tool will attempt to screen drivers for these characteristics.

Conclusion

As a group, younger drivers are at higher-risk than other age groups. However, by selecting for younger drivers with specific physical and psychological characteristics, it may be possible to identify young drivers with the same characteristics as a safe, veteran driver.

Regardless of age, driving safety outcomes can be reliably predicted by personality traits, health factors, and cognitive characteristics (Table 2). Additionally, driving experience is a significant predictor of crash risk. Many of these factors have been tested in non-commercial drivers, with some application to truck drivers. The primary goal of ATRI’s “Younger Driver Assessment Tool” research is to assess whether a test-based combination of risk-related characteristics can reliably predict driving safety outcomes above and beyond age in a sample of truck drivers.

Table 2: Summary of Safety-Relevant Driver Factors

Characteristic	Relationship with Driving Safety	Relationship with Age
Experience	More driving experience is typically related to lower crash risk.	Age influences experience due to minimum driver age requirements. Experience may contribute more to driver safety outcomes than age.
<i>Personality Factors</i>		
Five-Factor Personality Traits	Low measures of agreeableness and conscientiousness increase crash risk.	May mature with age, but typically does not impact rank amongst peers.
Impulsivity	Associated with risky driving behaviors and increased crash risk.	Peaks during adolescence and early adulthood.
Sensation-Seeking	Associated with risky driving behaviors.	Peaks during mid-to-late adolescence.
Aggression	Associated with risky driving behaviors.	
<i>Health Factors</i>		
ADD and ADHD	Possible association with crash risk and violation risk.	

Fatigue and Sleep Disorders	Associated with crash risk. Truck drivers may be more susceptible due to the demands of the profession.	Circadian rhythm shifts.
Substance Use	Associated with risk-taking behaviors.	Younger individuals have high rates of substance use.
Affective, Anxiety or Mood Disorders	May impact driving ability and therefore crash risk.	These disorders tend to emerge during adolescence and early adulthood.
Obesity	Associated with increased crash risk and fatigue risk.	
<i>Cognition</i>		
Executive Function	Compromised executive function is associated with increased crash risk. Executive function facilitates multi-tasking, attention, and quick reactions to risks.	Reaches maturation in mid-20s.

Next Steps

The literature review identified characteristics associated with safe driving in both the truck driver and general populations. The next step will be to investigate whether a test focused on these safety-related characteristics can identify “safe” truck drivers among a pool of entry-level applicants. ATRI is now moving forward with the development of an Assessment Tool to identify younger individuals with the characteristics of a safe, older driver. This will involve assembling the relevant measures of the predictive factors identified in the literature review, choosing how driving safety will be measured, and conducting a beta test – which will run the Assessment Tool on a small sample of both veteran and entry-level drivers to ensure that a larger scale study is warranted.

First, the ATRI research team will assemble the relevant measures of personality, health, cognition, and safety attitudes. It is possible that driving safety can be reliably predicted from a subset of measures identified in the literature review. However, to determine the measures most relevant to truck driver safety, a full battery of measures will be assembled and tested.

A measure of driving safety will also need to be selected. There are numerous objective measures of driver safety. Typically, safety is measured through crash metrics, by adherence to rules and regulations (e.g. observation of speed limits) or through driving-related citations. While crashes are an objective indicator, they are a relatively rare occurrence. A history of prior crash involvement and traffic violations is associated with future crash involvement (56, 65, 74). ATRI’s Crash Predictor Model for commercial drivers found that prior crash involvement was a statistically significant predictor of future crash involvement (65). However, crash *involvement* does not necessarily imply crash *causation*. Current reporting standards usually do not indicate whether truck-involved crashes could have been prevented by the truck driver (17). Therefore, a combination of safety-related measures will likely be utilized.

ATRI will conduct a beta test of the proposed Assessment Tool. The beta test will ensure that the expense and commitment of a larger study is warranted. The beta test phase will involve assessing approximately 50 truck drivers of varying ages and driving experience levels (i.e. safe, veteran drivers and young, entry-level applicants). Based on their safety records (including motor vehicle record data), the safe, veteran drivers' test scores will act as a surrogate and target for the younger driver test scores. The results from this limited sample will verify whether there are significant correlations between individual difference measures and driver safety outcomes as well as confirming that variability in these measures exists in a small truck driver sample. These results will guide modifications to the study design if needed prior to full study implementation.

If the beta test demonstrates strong correlations between measures and test scores among the safe, veteran drivers, and can identify similar scores among entry-level applicants, ATRI will execute a larger study with an expanded driver sample. Ultimately, this larger sample will allow researchers to determine what factors are statistically significant in predicting commercial driver safety, leading to the creation of a multivariate Assessment Tool that can predict if an individual, regardless of age, has the characteristics of a safe driver. At that point, the Assessment Tool could be used early in the employment process to facilitate driver selection.

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