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ADHD and dangerous driving in emerging adults: The moderating role of family climate for road safety

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ABSTRACT

Dangerous driving accounts for 95% of driving fatalities among emerging adults. Emerging adult drivers exhibiting symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) are at greater risk for motor vehicle crashes and engaging in unsafe driving practices; however, not all individuals with ADHD symptoms exhibit such risk. Several studies have found that drivers' perceptions of their family's values and priorities related to driving practices predict driving outcomes among emerging adults; these factors have not been examined in the context of ADHD symptomology. We examined family climate for road safety as a moderator of ADHD symptoms and dangerous driving behaviors in a sample of college students. A total of 4,392 participants completed surveys measuring self-reported ADHD symptoms, dangerous driving behavior, and family climate for road safety. Results indicated that higher levels of parental feedback weakened the relation between ADHD symptoms and aggressive driving; higher levels of parental monitoring strengthened this relationship. Higher levels of parental monitoring strengthened the association between ADHD symptoms and negative emotion while driving. When participants perceived their parents as having high levels of noncommitment to road safety, the association between ADHD symptoms and self-reported risky driving increased. Higher levels of open communication about unsafe driving attenuated the relation between ADHD and risky driving. Overall, some but not all components of family climate for road safety appear to affect the relation between ADHD symptoms and dangerous driving in the expected direction.

1. Introduction

1.1. Emerging adult drivers and attention deficit-hyperactivity disorder

Approximately 1.35 million individuals die in motor vehicle crashes each year (World Health Organization [WHO], 2018). In 2018, emerging adults between the ages of 20 and 29 had the highest rate of new motor vehicle-related fatalities compared to any other age group (Center for Disease Control and Prevention [CDC], 2020). The economic burden of motor vehicle fatalities and injuries sustained by adolescents and emerging adults exceeded $4 billion in 2018 (CDC, 2020). The cumulative personal and economic impact of motor vehicle crashes make it a significant public health concern.

To better understand factors contributing to motor vehicle crashes among emerging adults, researchers have taken steps to identify individual factors that increase risk for motor vehicle crashes within this at-risk age group. Out of this line of research, clinical populations with attentional deficits have demonstrated a unique vulnerability to adverse driving outcomes (Aduen et al., 2015, 2018; Kastrup et al., 1978; Noyes, 1985). For over seven decades, studies have established a link between Attention-Deficit/Hyperactivity Disorder (ADHD) and issues of road safety (Tillmann and Hobbs, 1949). As a childhood onset neurodevelopmental disorder affecting 2.5 % of adults, ADHD symptoms of inattention, distractibility, disorganization, poor decision making,

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impulsivity, and hyperactivity contribute to higher rates of poor driving outcomes among this population (American Psychiatric Association [APA], 2013; Jerome et al., 2006). Given these problems in driving performance, it is not surprising that adult drivers with ADHD are 25 % more likely to experience a crash than those without ADHD (Vaa, 2014). Relatedly, Curry and colleagues (2017) calculated the probability of crash rates among 17- to 21-year-old drivers with and without ADHD and found that those with ADHD were 36 % more likely to have experienced a crash than their neurotypical peers. Further, researchers have found that drivers with ADHD had a 120 %-130 % increased likelihood of experiencing multiple crashes and multiple violations (OR = 2.2–2.3) based on self-report (Aduen et al., 2015), and a 46 % increased likelihood for a crash based on prospective monitoring of real-world driving using continuous monitoring (Aduen et al., 2018). In a sample of drivers with ADHD, individuals 18- to 25 years old reported more instances of driving errors, lapses, and violations on the Driving Behavior Questionnaire (DBQ) than those 26- to 55 years old (Reimer et al., 2005). Moreover, the influence of age on these outcomes is of particular interest given the evidence that emerging adulthood is a critical period for driving risk. For example, several studies have found that college students with ADHD, who tend to fall within the emerging adult years, report engaging in greater levels of unsafe driving practices compared to individuals without ADHD (Jerome et al., 2006; Richards et al., 2002). In addition, mood lability, irritability, and low frustration tolerance have been classified as associated psychological features of ADHD (APA, 2013). A recent systematic review exploring the mechanisms underlying unsafe driving behavior in those with ADHD pointed to mood dysregulation, specifically expressions of anger, as a potential predictor of risky driving behavior in this population (Deshmukh & Patel, 2019).

For example, a study investigating the influence of state dependent anger on poor driving outcomes in adults ($M_{age} = 31.61$, $SD_{age} = 11.59$) with and without ADHD found that individuals with ADHD had significantly higher scores on the Driving Anger Scale than controls (Richards et al., 2006). The authors went on to compare the group of adult drivers with ADHD with a normative college group to determine if the angry driving patterns observed in adult drivers with ADHD would surpass those of a sample known to report engaging in reckless and aggressive driving and experiencing more negative driving consequences. The findings indicated that the college group reported significantly more instances of verbal aggression, use of vehicle as a weapon, and physical aggression while driving than adult drivers with ADHD (Richards et al., 2006). In addition, college students experienced more moving violations and minor accidents than the adult ADHD cohort (Richards et al., 2006). Although the study did not include a sample of college students with ADHD, these results suggest that the intersection of emerging adulthood and ADHD status may lead to an increase in poor driving outcomes.

This speculation has been supported by the results of two research studies. In the first, Richards and associates (2002) sought to examine if college students with self-reported high and low symptoms of ADHD demonstrated differences in negative driving outcomes. Participants in the high ADHD symptom group reported that their ADHD symptoms interfered with their ability to operate a motor vehicle. This group also reported feeling significantly more anger toward police and slow drivers than the low ADHD symptom group. The high symptom group reported displaying their anger through gestures, their vehicle (e.g., honking horn), and physical aggression. Overall, the high ADHD group reported engaging in risky and unsafe behavior compared to their low ADHD counterparts. Moreover, the high ADHD group reported significantly higher levels of trait level negative emotionality and anger than the low ADHD group. The second study by Malta (2004) yielded similar results. Specifically, the author compared differences in the prevalence of psychiatric symptoms in a sample of aggressive and non-aggressive college drivers. Findings showed that aggressive drivers, who reported more motor vehicle crashes, tickets, and driving while intoxicated than nonaggressive drivers, also demonstrated a trend toward greater lifetime and childhood prevalence of ADHD. In sum, the literature exploring the relationship between angry driving and ADHD has largely focused on the role of individual factors that influence driving outcomes among individuals with ADHD and few studies have examined contextual factors (e.g., family).

1.2. Family factors and risky driving in drivers with ADHD

Families that include a child with ADHD are often characterized as having more familial conflict overall (Barkley et al., 1991; Markel & Wiener, 2014). These conflictual relationships may also impact the family climate around safe driving. In a longitudinal analysis of driving outcomes in an ADHD sample, low levels of parental monitoring and increased parental stress during childhood predicted risky driving in adolescence and emerging adulthood (Johnson et al., 2017). Additionally, parents of adolescents with ADHD generally engage in more negative and ineffective parenting behaviors such as ineffective commands, low levels of verbal praise, and inconsistent discipline compared to parents of children without ADHD (Ellis & Nigg, 2009; Wirth et al., 2017). These general parenting strategies seem to translate to the area of driving as well, though this literature is in its nascence. In a study examining parenting behaviors during driving in a sample of adolescents with ADHD, Schatz et al. (2014) found that parents engaged in little positive parenting (e.g., labeled praise, coaching) whether the adolescent driver was demonstrating safe or poor driving. Additionally, parents exhibited more anger and negative talk when the adolescents were driving poorly.

One family factor that influences the driving behavior and outcomes of young drivers that has yet to be explored in the context of ADHD is family climate for road safety. Family climate for road safety consists of parental attitudes toward driving safety and parental involvement in the driving process of young drivers (Burns et al., 2020; Taubman - Ben-Ari & Katz-Ben-Ami, 2013). Previous work using family climate for road safety has focused on adolescent populations (Taubman – Ben-Ari, 2014; Taubman - Ben-Ari & Katz-Ben-Ami, 2013). However, because of the developmental nature of driving, family climate during the learning to drive period likely has downstream effects on the driving behavior and outcomes of emerging adults as individuals continue to build driving habits. Using a measure of family climate for road safety, Taubman - Ben-Ari and Katz-Ben-Ami (2013) found that showing a parental commitment to safe driving and parental setting of clear messages regarding safe driving were predictive of less reckless driving, less angry driving, and more careful driving. In another study, a parental lack of commitment to road safety predicted an increase to young drivers' risk score and increased parental monitoring predicted lower risk scores, above and beyond other parenting factors and parents' risk scores (Taubman – Ben-Ari, 2014).

As highlighted above, ADHD presents as a significant risk factor for involvement in motor vehicle crashes and engaging in dangerous driving. However, not all individuals with ADHD exhibit this increased risk. Exploring the conditions under which this risk is greater and those under which risk is buffered, can help elucidate potential targets for intervention (Garner, 2019). Some contextual variables that have been previously identified as moderators of the relationship between ADHD and driving risk include vehicle transmission type, texting while driving, and the monotony of the drive (Garner, 2019). At least one study has examined parenting behavior in the context of driving and ADHD (Schatz et al., 2014); however, no study has explored the role of family factors as a moderator of the relation between ADHD and driving risk. Further, the only study examining the main effects of family factors and parenting on driving outcomes in an ADHD population focused on broad parenting and family factors rather than those specific to the driving context (Johnson et al., 2017).

1.3. Present study

The present study examines the role of family climate for road safety

in moderating the relation between ADHD symptoms and three aspects of dangerous driving: aggressive driving, negative emotionality while driving, and risky driving. While ADHD symptoms and family climate each contribute uniquely to dangerous driving in emerging adults, they likely interact in a way that increases risk of, or buffers against, dangerous driving behavior. Participants in the present study were college students who retrospectively reported on their family climate for road safety during the learning to drive period and their current driving behavior. We hypothesized that higher ADHD symptoms would be associated with higher levels of aggressive driving, negative emotion while driving, and risky driving (Deshmukh & Patel, 2019; Jerome et al., 2006; Richards et al., 2002). The main effects of family climate on dangerous driving in this sample have been analyzed in a separate psychometric validity study (Burns et al., 2020), however, that paper did not explore the role of ADHD on family climate for road safety. Consistent with that analysis, we hypothesized that higher levels of perceived parental noncommitment to safe driving and lower levels of perceived parental modeling of safe driving during the learning to drive period would predict higher levels of current aggressive driving. Additionally, it was expected that lower levels of perceived parental modeling and feedback during the learning to drive period would predict higher levels of current negative emotion while driving. It was also expected that higher levels of current risky driving would be predicted by higher levels of perceived parental noncommitment and lower levels of monitoring, communication, and modeling during the learning to drive period. The present study is novel in that we assess the interaction between ADHD symptoms and domains of family climate for road safety. We hypothesized that the positive relationship between ADHD symptoms and dangerous driving (i.e., aggressive driving, negative emotion while driving, risky driving) would be weaker when parents exhibited a higher level of modeling, monitoring, feedback, and communication, and stronger when parents exhibited a higher level of noncommitment to road safety.

2. Methods

2.1. Participants

The data were derived from a subsample of undergraduates (N = 4,392) from six universities in the United States that were enrolled in a larger study focused on evaluating and validating a measure of a psychological construct, cognitive disengagement syndrome, formerly known as sluggish cognitive tempo. A full description of the larger study can be found elsewhere (Becker et al., 2018). Participants in the present study were licensed drivers between ages 18 to 29 years ($M = 19.08$, $SD = 1.36$), and were predominantly female (68.8 %). The racial and ethnic composition of the sample was 83.5 % White, 6.1 % Black/African American, 5.1 %, Asian, 4.6 % Biracial/Multiracial, 0.4 % American Indian/Alaskan Native, and 0.2 % Pacific Islander/Hawaiian Native. The majority of the sample was comprised of students in their first year of college (58 %); with the remaining participants identifying as second years (21.9 %), third years (12.7), fourth years (7.2 %), and other (0.2 %). Nearly-one-fourth ($n = 1,125$) of the sample indicated that they had been previously diagnosed with a formal psychiatric diagnosis from a mental health profession. A breakdown of reported diagnoses is as follows: anxiety (14.4 %), depression (12.4), ADHD (9.2 %), learning disability (2.0 %), Bipolar Disorder (0.9 %), alcohol and substance use disorder (0.6 %), personality disorder (0.4 %), and Autism Spectrum Disorder (0.2 %). On average, participants had 3.01 years of driving experience ($SD = 1.43$, min = 0, max = 19). Traffic violations were reported by 32.1 % of the sample, with 0.55 ($SD = 1.07$, min = 0, max = 18) being the average number of tickets received since obtaining licensure. Involvement in a motor vehicle crash while operating a motor vehicle was reported by 45.1 % of the sample, with 0.70 ($SD = 0.98$, min = 0, max = 18) being the mean number of crashes reported. This sample is the same sample used in Burns et al. (2020) to establish the psychometric validity of the Family Climate for Road Safety Scale described below.

2.2. Procedures

The present study was approved by the Institutional Review Board (IRB) of each participating university. Procedures across sites varied slightly based on standard practices at each institution. Specifically, for five of the sites, participants were recruited through an electronic participant recruitment system used by each of the universities (SONA) and directed to complete the study in Qualtrics. There, participants were provided a description of the study and contact information for the IRB, principal investigator, and student counseling center specific to their given university. Upon providing consent to continue, they were directed to complete a series of surveys and rating scales. Those students that completed the battery received course credit for their participation. An alternate recruitment process occurred at the sixth site, in which participants completed the same Qualtrics surveys as subjects from the other universities were invited to the investigator's laboratory where they provided in-person informed consent and completed the surveys on their own. These students received course credit for their participation in the same fashion as students from other sites.

2.3. Measures

2.3.1. Demographic Questionnaire

Respondents completed a brief laboratory developed survey in which they provided demographic information such as age, sex, race/ethnicity, parent education/income, year in school, marital status, mental health diagnosis, current medication use, and current athletic sport involvement. For the present study, sex, age, and university site were used to describe the sample and as possible covariates in the analyses.

2.3.2. The Barkley Adult ADHD Rating Scale-IV (BAARS-IV)

The BAARS-IV is a Diagnostic and Statistical Manual of Mental Disorders- Fifth Edition (DSM-5) (American Psychiatric Association, 2013) oriented 18-item rating scale that is used to assess ADHD symptoms in adults (Barkley, 2011). Subjects provided ratings on a four-point scale (0 = *not at all* to 3 = *very often*) that best describes the frequency of the behavior outlined in the statement over the past six-months. The BAARS-IV is subdivided into two subscales to assess ADHD inattention symptoms (i.e., ADHD-IN) such as "difficulty sustaining my attention in tasks or fun activities" and ADHD hyperactive/impulsive symptoms (i.e., ADHD-HI) including "fidget with hands and feet or squirm in seat". A total ADHD severity score can also be created. Satisfactory test–retest reliability and internal consistency has been established for the subscales of the BAARS-IV (Barkley, 2011). In the current study, the total ADHD score was used as an independent variable ($\alpha = 0.89$).

2.3.3. DULA dangerous driving index (DDDI)

The DDDI is a 28-item measure used to evaluate the domains thought to be core to dangerous driving (Dula & Ballard, 2003). In the present study, the measure was modified to include items that assess the age at which the subject obtained their driver's permit and license, the number of attempts to pass the written and on-road exams, years of carrying a valid driver's license, and the total number of crashes and tickets since obtaining licensure. After providing information regarding their driving history, participants rated their adverse driving behavior using a 5-point scale (1 = *never* to 5 = *always*). The DDDI is composed of the following subscales: Aggressive Driving, Negative Emotions while Driving, and Risky Driving, which are summed into a DDDI Total Score. Good test–retest reliability and internal consistency have been demonstrated across each scale of this measure. The Aggressive Driving subscale includes 7 items used to determine the frequency with which the participant engages in behaviors intended "to annoy, irritate, or punish other drivers" (Dula & Ballard, 2003, p. 269), such as "I verbally insult drivers

who annoy me" (α = 0.84). The Negative Emotions subscale contains 9 items measuring negative emotionality toward other drivers (e.g., "I feel that *passive* drivers should learn how to drive or stay home"; α = 0.83). The Risky Driving subscale consists of 12 items evaluating the subject's willingness to participate in unsafe behaviors while driving (e.g., "I will drive when I am drunk"; α = 0.83). In the present study, the Cronbach's αs for Aggressive Driving, Negative Emotions, and Risky Driving were 0.85, 0.86, and 0.86, respectively, and these subscales were used as outcome variables.

2.3.4. Family climate for road safety scale (FCRSS)

The FCRSS was originally a 54-item measure that consisted of 7 subscales used to evaluate a respondent's views of their parents' participation in adolescent driving and the family's attitudes and practices (i.e., family climate) around driving safety (Taubman - Ben-Ari & Katz-Ben-Ami, 2013). However, a factor analysis of the FCRSS conducted in the present sample found support for a 27-item, 5-dimension version of the scale (Burns et al., 2020). This version of the scale is used in the present study. Participants rated parental involvement and family climate on a 5-point scale (*1 = not at all* to *5 = very often*) across the following domains: Noncommitment (e.g., my parents ignore when I drive dangerously; α = 0.87), Monitoring (e.g., whenever I take the car I have to tell my parents where I am going; α = 0.91), Feedback (e.g., my parents compliment me for my driving safety; α = 0.93), Communication (e.g., we talk about how to avoid or prevent dangerous situations on the road; α = 0.81), Modeling (e.g., my parents set an example by obeying traffic laws; α = 0.88). In the present study, mean scores for each of these subscales were used as moderators of the relationship between ADHD symptoms and dangerous driving.

3. Analytic strategy

Data analysis was conducted using SPSS Version 27 and the 'psych' (Revelle, 2021), 'sjPlot' (Lüdecke, Bartel, Schwemmer, Powell, & Djalovski, 2021), 'reghelper' (Hughes and Beiner, 2021), 'rockchalk' (Johnson & Grothendieck, 2022), 'dplyr' (Wickham et al., 2022), 'haven' (Wickham & Miller, 2021), and 'emmeans' (Lenth et al., 2022) packages in the R statistical program (The R Foundation, 2022).

Separate regression models were constructed to examine whether the effect of ADHD symptoms on each dimension of the DULA (i.e., aggressive driving, negative emotion, risky driving) was moderated by FCRSS domains after controlling for age, sex (0 = male, 1 = female), driving experience (i.e., time since licensure) and site (site 1 versus all others, site 2 versus all others, site 3 vs all others, site 4 versus all others, site 5 versus all others). Additionally, simple slopes were used to probe each moderation effect.

3.1. Data quality check

Careless responding was addressed using an instructional manipulation check (IMC; Oppehheimer, Meyvis, & Davidenko, 2009), trap questions (e.g., "Please click on the response 'sometimes'"), and questions regarding participants' effort were embedded within the battery. Participants were able to continue the survey only after correctly answering the IMC. Criteria for successfully completing the trap questions included answering more than 50 % of the questions correctly and rating effort as 5 or higher on a 10-point scale (0 = "Not Much Effort," 10 = "My Best Effort"). For additional details, see Becker et al. (2018).

4. Results

Bivariate correlations between variables of interest are presented in Table 1 and a summary of regression results is presented in Table 2.

4.1. Aggressive driving behaviors

Controlling for age, sex, time since licensure, and site, higher levels of ADHD symptoms ($\beta = 0.21$, $SE = 0.03$, $p \leq 0.01$) and Noncommitment ($\beta = 0.12$, $SE = 0.02$, $p \leq 0.01$) and lower levels of Modeling ($\beta = -0.12$, $SE = 0.02$, $p \leq 0.01$) were associated with higher levels of aggressive driving behaviors. There were no main effects of Communication, Feedback, or Monitoring on aggressive driving behaviors. There was a significant interaction between ADHD symptoms and Feedback ($\beta = -0.13$, $SE = 0.04$, $p \leq 0.05$); the positive association of ADHD symptoms with aggressive driving was weaker when parents engaged in a higher level of feedback regarding driving (Fig. 1). Additionally, there was a significant interaction between ADHD symptoms and Monitoring ($\beta = 0.02$, $SE = 0.03$, $p \leq 0.05$); the positive association of ADHD symptoms with aggressive driving was stronger when parents engaged in higher levels of monitoring (Fig. 2).

4.2. Negative emotion while driving

In addition, higher levels of ADHD symptoms ($\beta = 0.29$, $SE = 0.03$, $p \leq 0.01$), Monitoring ($\beta = 0.04$, $SE = 0.01$, $p \leq 0.01$), and Communication ($\beta = 0.08$, $SE = 0.02$, $p \leq 0.01$), as well as lower levels of Modeling ($\beta = -0.20$, $SE = 0.02$, $p \leq 0.01$) were associated with higher levels of negative emotion while driving. There were no main effects of Feedback or Noncommitment on negative emotion. The ADHD symptoms by Monitoring interaction ($\beta = 0.10$, $SE = 0.02$, $p \leq 0.05$) was significant; surprisingly, the positive association of ADHD symptoms with negative emotion while driving was stronger when parents engaged in higher levels of monitoring (Fig. 3).

4.3. Risky driving behaviors

Finally, higher levels of risky driving were associated with higher levels of ADHD symptoms ($\beta = 0.21$, $SE = 0.02$, $p \leq 0.01$) and Noncommitment ($\beta = 0.20$, $SE = 0.01$, $p \leq 0.01$), as well as lower levels

Table 1
Bivariate correlations among variables of interest

	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Sex			–										
2. Age	19.08	1.36	**−0.10**	–									
3. ADHD Total	1.68	0.46	−0.01	**0.04**	–								
4. Noncommitment	1.97	0.79	**−0.12**	0.00	**0.14**	–							
5. Monitoring	3.70	1.11	**0.16**	**−0.04**	**−0.10**	**−0.14**	–						
6. Feedback	3.60	1.08	**0.14**	**−0.07**	**−0.16**	**−0.18**	**0.43**	–					
7. Communication	3.87	0.98	**0.14**	**−0.07**	**−0.16**	**−0.22**	**0.42**	**0.63**	–				
8. Modeling	3.70	0.97	**0.07**	−0.02	**−0.21**	**−0.34**	**0.39**	**0.56**	**0.55**	–			
9. Aggressive Driving	1.76	0.73	**−0.10**	0.02	**0.25**	**0.21**	**−0.11**	**−0.14**	**−0.15**	**−0.22**	–		
10. Negative Emotion	2.37	0.73	−0.02	−0.01	**0.31**	**0.09**	**−0.04**	**−0.12**	**−0.08**	**−0.22**	**0.70**	–	
11. Risky Driving	1.56	0.59	**−0.18**	**0.04**	**0.27**	**0.29**	**−0.17**	**−0.19**	**−0.21**	**−0.26**	**0.71**	**0.63**	–

Notes: Sex (0 = Male, 1 = Female); ADHD Total = Total ADHD symptom report; **Bold** = $p \leq 0.05$.

Table 2
Summary of regression results with unstandardized regression coefficients.

	Aggressive Driving		Negative Emotion		Risky Driving	
	β	SE	β	SE	β	SE
Model 1						
ADHD Total	**0.21**	0.03	**0.29**	0.03	**0.22**	0.02
Noncommitment	**0.12**	0.02	0.00	0.02	**0.20**	0.01
Monitoring	−0.01	0.01	**0.05**	0.01	**−0.05**	0.01
Feedback	0.00	0.01	−0.03	0.01	−0.01	0.01
Communication	−0.01	0.02	**0.08**	0.02	−0.03	0.01
Modeling	**−0.12**	0.02	**−0.20**	0.02	**−0.10**	0.01
Model 2						
ADHD Total	**0.21**	0.03	**0.29**	0.03	**0.21**	0.02
Noncommitment	**0.12**	0.02	0.00	0.02	**0.20**	0.01
Monitoring	−0.02	0.01	**0.04**	0.01	**−0.05**	0.01
Feedback	0.01	0.01	−0.03	0.01	−0.01	0.01
Communication	−0.01	0.02	**0.08**	0.02	−0.03	0.01
Modeling	**−0.12**	0.02	**−0.20**	0.02	**−0.10**	0.01
ADHD*Noncommitment	0.00	0.03	−0.01	0.03	**0.19**	0.03
ADHD*Monitoring	**0.02**	0.03	**0.10**	0.02	0.01	0.02
ADHD*Feedback	**−0.13**	0.04	−0.02	0.03	0.00	0.02
ADHD*Communication	0.00	0.04	0.00	0.03	**−0.04**	0.03
ADHD*Modeling	0.00	0.04	0.00	0.03	0.00	0.03
Adjusted R^2	0.13		0.15		0.20	
ΔR^2	0.00		0.00		0.01	

Note: Controlling for age, sex, driving experience, and site; ADHD Total = Total ADHD symptom report; **Bold** = p ≤ 0.05.

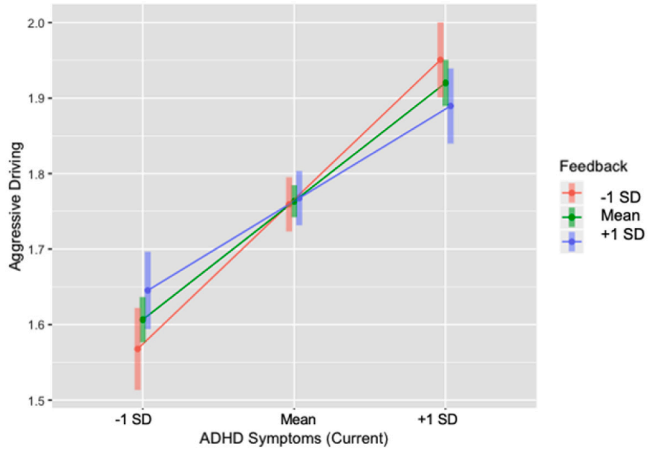

Fig. 1. Relation between ADHD symptoms and aggressive driving moderated by parental feedback.

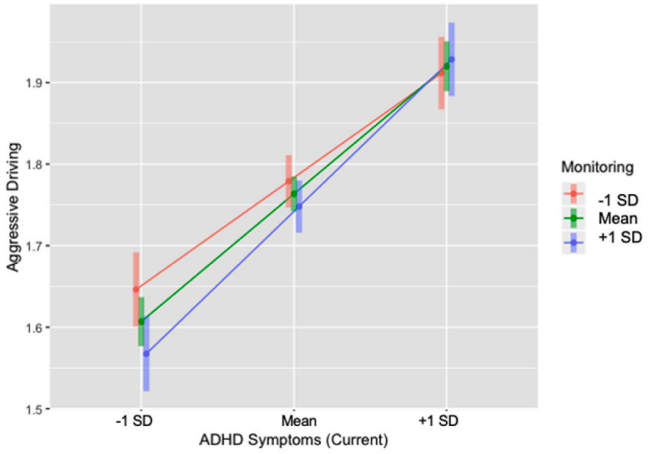

Fig. 2. Relation between ADHD symptoms and aggressive driving moderated by parental monitoring.

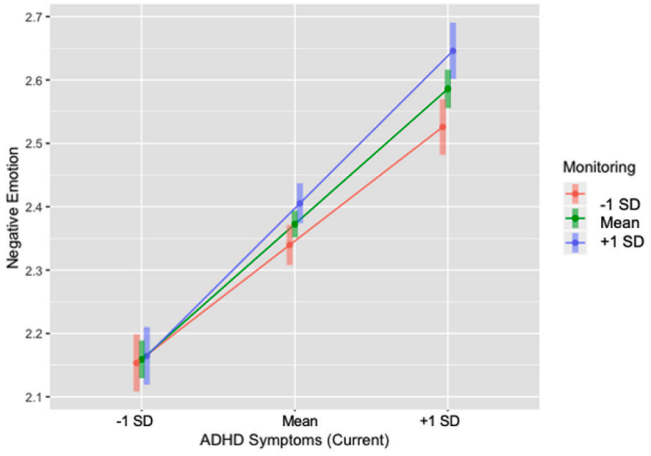

Fig. 3. Relation between ADHD symptoms and negative emotion while driving moderated by parental monitoring.

of Monitoring (β = -0.05, SE = 0.01, $p \leq 0.01$) and Modeling (β = -0.10, SE = 0.01, $p \leq 0.01$). There were no main effects of Feedback or Communication on risky driving behavior. There was a significant interaction between ADHD symptoms and Noncommitment (β = 0.19, SE = 0.03, $p \leq 0.01$); the positive association between ADHD symptoms and risky driving was stronger when parents demonstrated higher levels of noncommitment to road safety (Fig. 4). Additionally, the ADHD symptoms by Communication interaction (β = -0.04, SE = 0.03, p =.01) was significant; the positive association between ADHD symptoms and risky driving was weaker at higher levels of open communication between parents and children about driving (Fig. 5).

5. Discussion

Research has primarily examined individual factors as correlates of driving problems in emerging adults with ADHD with little attention paid to the role of family factors in these relationships. Moreover, given that not all drivers with ADHD exhibit driving problems, examination of moderating factors that increase or buffer against risk are needed (Garner, 2019). The current study is an initial step in filling this gap in

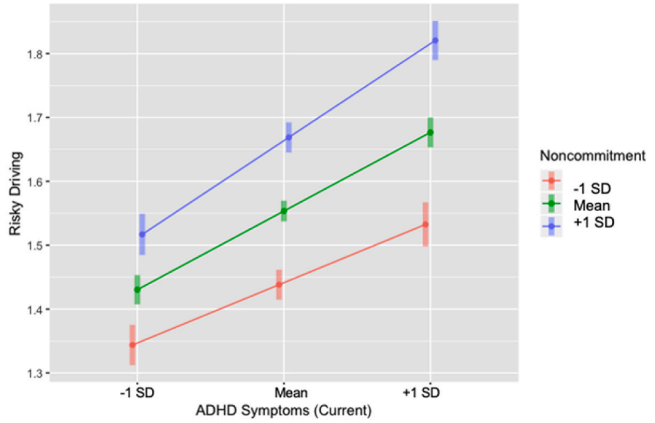

Fig. 4. Relation between ADHD symptoms and risky driving moderated by parental noncommitment to road safety.

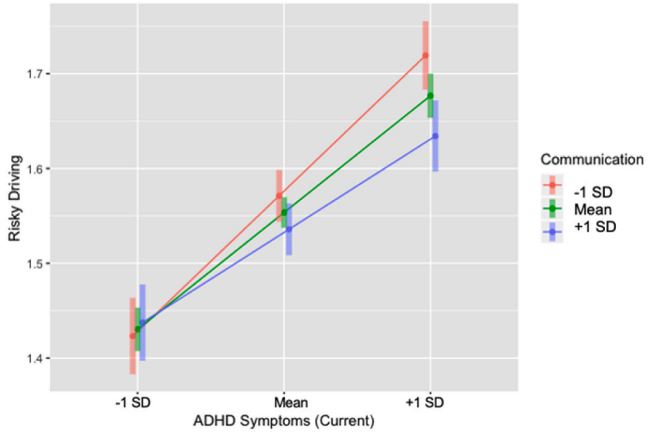

Fig. 5. Relation between ADHD symptoms and risky driving moderated by parent-adolescent communication.

the literature. We examined how family climate, specifically family climate for road safety, interacts with symptoms of ADHD in predicting dangerous driving among emerging adult college drivers. Consistent with previous literature, higher levels of ADHD symptoms were a unique predictor of higher levels of dangerous driving across subscales (i.e., aggressive driving, negative emotionality, risky driving). As expected from previous analyses with this sample (Burns et al., 2020), parent Noncommitment and Modeling were consistent predictors of risky driving and aggressive driving. Modeling also emerged as a significant predictor of negative emotion while driving.

In terms of the moderating effect of family climate on the relation between ADHD and dangerous driving, some expected, and some surprising results emerged. Higher levels of parent Feedback attenuated the positive relation between ADHD symptoms and aggressive driving. Additionally, lower levels of parent Noncommitment (indicating greater commitment) and higher levels of parent-adolescent Communication mitigated the positive association between ADHD symptoms and risky driving. These findings are consistent with some recommendations for reducing health risk behaviors in individuals with ADHD through improving parental communication about, and monitoring of, risky behavior (Schoenfelder & Kollins, 2016). This may be particularly important in the driving context where parents provide low rates of feedback to their child with ADHD overall (Schatz et al., 2014). Somewhat counterintuitively, the positive relation between ADHD symptoms and aggressive driving, as well as the relation between ADHD symptoms and negative emotion while driving, was stronger when there were higher levels of parental Monitoring. These results appear inconsistent with previous research that suggests that parental monitoring predicts less risky driving behavior in individuals with ADHD (Johnson et al., 2017). One explanation of the results of the current study is that parents of individuals high in negative emotion and aggressive driving recognize this risk and engage in more monitoring; high levels of monitoring may be a reaction to dangerous driving. This hypothesis is generally consistent with literature regarding academic outcomes of individuals with ADHD. Condo and colleagues (2022) found that parents of children with ADHD tend to be more involved when their children experience greater academic problems (Condo et al., 2022). They further concluded that increased parental involvement may not serve as a protective factor for academic performance, but rather could predict more negative academic outcomes. The same may be true for adolescents with ADHD engaging in dangerous driving.

Another potential explanation for the finding in the current study is measurement differences between studies for both family factors and driving outcomes. First, in the current study monitoring is operationalized broadly as the parent knowing who the youth is with while driving, where the youth is driving, and the timeline associated with the youth's use of the car (a full description on the FCRSS and the Monitoring subscale specifically can be found in Burns et al., 2020). However, in the Johnson and colleagues (2017) study, monitoring was operationalized as parent supervision across multiple domains (e.g., going to bed after bedtime, being home alone) and was assessed during childhood as opposed to the learning to drive period as in the current study. Second, the finding that the positive relation between ADHD symptoms and dangerous driving was stronger when there were higher levels of parental monitoring in the current study was only found for negative emotion and aggressive driving, which are operationalized as emotions felt while driving and driving behaviors meant to annoy or irritate other drivers, respectively. However, Johnson and colleagues (2017) measured risky driving operationalized as driving illegally, moving ticket violations, and traffic accidents. It should be noted that risky driving was measured in the current study as well (as a separate construct from negative emotion and aggressive driving) and operationalized more similarly to the way it was in the Johnson et al. (2017) study (e.g., driving illegally). With regard to this operationalization of risky driving, higher levels of parental monitoring was found to predict less risky driving as would be expected.

A final explanation for the relationship between ADHD symptoms, parental monitoring, and negative emotions and aggressive driving is the context of the parental monitoring and the subsequent perception by the youth. For example, high levels of monitoring may be perceived as controlling by the youth and could lead to higher negative emotion and aggressive driving. Ginsburg and colleagues (2009) concluded that while monitoring improved driving outcomes in adolescents, the best outcomes were found when monitoring was combined with a warm and supportive parent–child relationship. The current study did not assess for other broad family climate or parenting-child relational factors. Longitudinal studies measuring family climate for road safety, broad family climate, parent–child relationship, negative emotionality, and dangerous driving of youth with ADHD before they start driving independently are needed to better understand the nature of the associations between these constructs.

5.1. Implications

Overall, the current study shows the potential impact of family climate for road safety on improving driving outcomes for adolescents and young adults with ADHD. Interventions aimed at improving the driving outcomes of individuals with ADHD would likely benefit from incorporating components of family climate. An example of one such intervention is the Supporting a Teen's Effective Entry to the Roadway (STEER) program developed by Fabiano and colleagues (2016). The STEER program includes parent training that focuses on monitoring,

contingency management, and communication skills related to driving. The adolescent training component includes safe driving education and effective communication and social skills. There is also a driving practice component that is done in a simulator. This type of multifaceted intervention may be the most likely to have a positive impact because it addresses multiple factors that likely contribute to the driving problems experienced by individuals with ADHD. The parent training and communication skills training components of STEER are consistent with the results found in the current study suggesting that effective feedback and communication around driving can attenuate the relationship between ADHD symptoms and dangerous driving. It could further benefit from including psychoeducation around the importance of parents' showing commitment to safe driving behavior (e.g., explaining the importance of driving laws, following driving laws even when rushed), which was a unique predictor of risky and aggressive driving and was shown to attenuate the relationships between ADHD and risky driving; and modeling safe driving behavior (e.g., wearing seatbelts, following the speed limit), which uniquely impacted dangerous driving. Notably, interventions to increase modeling would likely be more impactful early in the child/teen's development.

5.2. Limitations

The current study has multiple limitations that should be noted. The current study used a homogenous sample in terms of the race (primarily White) and sex (primarily female) of the participants. The current study relied solely on self-report data which could result in biased reports of parental and driving behaviors. Additionally, the results may be subject to same-method bias. Similarly, participants were asked to retrospectively report on parents' behavior, this may impact the accuracy of the participants' reporting. Further, the cross-sectional design of the current study limits the ability to make causal or directional inferences. Finally, although family status of the participant and being a parent may influence the perception of previous parental behaviors, this information was not gathered for the current study.

5.3. Future directions

Future research should further explore the relation between ADHD symptoms, family climate for road safety, and driving outcomes. Specifically, the extent to which family climate moderates the association between ADHD symptoms and costly driving outcomes (e.g., motor vehicle crashes, moving violations) is yet to be examined. Additionally, future studies should use longitudinal designs to elucidate the casual mechanisms and possible bi-directional associations at play in the associations between ADHD symptoms, family climate, and driving behaviors and outcomes. Finally, driving interventions should be designed with innovative methods of addressing family climate and assessed for efficacy and effectiveness through intervention studies.

CRediT authorship contribution statement

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Aduen, P.A., Kofler, M.J., Cox, D.J., Sarver, D.E., Lunsford, E., 2015. Motor vehicle driving in high incidence psychiatric disability: Comparison of drivers with ADHD, depression, and no known psychopathology. Journal of Psychiatric Research 64, 59–66. https://doi.org/10.1016/j.jpsychires.2015.03.009.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). 10.1176/appi.books.9780890425596.

Aduen, P.A., Kofler, M.J., Sarver, D.E., Wells, E.L., Soto, E.F., Cox, D.J., 2018. ADHD, depression, and motor vehicle crashes: A prospective cohort study of continuously-monitored, real-world driving. Journal of Psychiatric Research 101, 42–49. https://doi.org/10.1016/j.jpsychires.2018.02.026.

Barkley, R.A., 2011. Barkley Adult ADHD Rating Scale—IV (BAARS-IV). Guilford Press.

Barkley, R.A., Fischer, M., Edelbrock, C., Smallish, L., 1991. The adolescent outcome of hyperactive children diagnosed by research criteria—III. Mother-child interactions, family conflicts and maternal psychopathology. Journal of Child Psychology and Psychiatry, and Allied Disciplines 32 (2), 233–255. https://doi.org/10.1111/j.1469-7610.1991.tb00304.x.

Becker, S.P., Burns, G.L., Garner, A.A., Jarrett, M.A., Luebbe, A.M., Epstein, J.N., Willcutt, E.G., 2018. Sluggish cognitive tempo in adults: Psychometric validation of the Adult Concentration Inventory. Psychological Assessment 30 (3), 296–310. https://doi.org/10.1037/pas0000476.

Taubman - Ben-Ari, O., & Katz - Ben-Ami, L. (2013). The contribution of family climate for road safety and social environment to the reported driving behavior of young drivers. *Accident Analysis & Prevention*, *47*, 1–10. 10.1016/j.aap.2012.01.003.

Burns, A.B., Garner, A.A., Chang, A., Becker, S.P., Kofler, M.J., Jarrett, M.A., Luebbe, A.M., Burns, G.L., 2020. Factor structure of the family climate for road safety scale in emerging adults in the United States. Accident Analysis & Prevention 142, 105563.

Centers for Disease Control and Prevention. (2021, December 2). *WISQARS (Web-based Injury Statistics Query and Reporting System)|Injury Center CDC*. https://www.cdc.gov/injury/wisqars/index.html.

Condo, J.S., Chan, E.S.M., Kofler, M.J., 2022. Examining the effects of ADHD symptoms and parental involvement on children's academic achievement. Research in Developmental Disabilities 122, 104156.

Curry, A.E., Metzger, K.B., Pfeiffer, M.R., Elliott, M.R., Winston, F.K., Power, T.J., 2017. Motor vehicle crash risk among adolescents and young adults with attention-deficit/hyperactivity disorder. JAMA pediatrics 171 (8), 756–763. https://doi.org/10.1001/jamapediatrics.2017.0910.

Deshmukh, P., Patel, D., 2019. Driving and road rage associated with attention deficit hyperactivity disorder (ADHD): A systematic review. Current Developmental Disorders Reports 6 (4), 241–247.

Dula, C.S., Ballard, M.E., 2003. Development and evaluation of a measure of dangerous, aggressive, negative emotional, and risky driving1. Journal of Applied Social Psychology 33 (2), 263–282. https://doi.org/10.1111/j.1559-1816.2003.tb01896.x.

Ellis, B., Nigg, J., 2009. Parenting practices and attention-deficit/hyperactivity disorder: new Findings suggest partial specificity of effects. Journal of the American Academy of Child & Adolescent Psychiatry 48 (2), 146–154. https://doi.org/10.1097/CHI.0b013e31819176d0.

Fabiano, G.A., Schatz, N.K., Morris, K.L., Willoughby, M.T., Vujnovic, R.K., Hulme, K.F., Riordan, J., Howard, M., Hennessy, D., Lewis, K., Hawk, L., Wylie, A., Pelham, W.E., 2016. Efficacy of a family-focused intervention for young drivers with attention-deficit hyperactivity disorder. Journal of Consulting and Clinical Psychology 84 (12), 1078–1093. https://doi.org/10.1037/ccp0000137.

The R Foundation. (2022). *R: The R project for statistical computing* [Computer Software]. https://www.r-project.org/.

Garner, A.A., 2019. Driving in adolescents with ADHD and the road to intervention. In: Becker, S.P. (Ed.), ADHD in adolescents: Development, assessment, and treatment. Guilford Press, pp. 255–277.

Ginsburg, K.R., Durbin, D.R., García-España, J.F., Kalicka, E.A., Winston, F.K., 2009. Associations between parenting styles and teen driving, safety-related behaviors and attitudes. Pediatrics 124 (4), 1040–1051. https://doi.org/10.1542/peds.2008-3037.

Hughes, J., & Beiner, D. (2021). *reghelper: Helper Functions for Regression Analysis* (1.1.0) [Computer software]. https://CRAN.R-project.org/package=reghelper.

Jerome, L., Segal, A., Habinski, L., 2006. What we know about ADHD and driving risk: A literature review, meta-analysis and critique. Journal of the Canadian Academy of Child and Adolescent Psychiatry 15 (3), 105–125.

Johnson, P. E., & Grothendieck, G. (2022). *rockchalk: Regression Estimation and Presentation* (1.8.151) [Computer software]. https://CRAN.R-project.org/package=rockchalk.

Johnson, J.A., Jakubovski, E., Reed, M.O., Bloch, M.H., 2017. Predictors of long-term risky driving behavior in the multimodal treatment study of children with attention-deficit/hyperactivity disorder. Journal of Child and Adolescent Psychopharmacology 27 (8), 747–754. https://doi.org/10.1089/cap.2017.0025.

Kastrup, M., Dupont, A., Bille, M., Lund, H., 1978. Traffic accidents involving psychiatric patients. Characteristics of accidents involving drivers who have been admitted to Danish psychiatric departments. Acta Psychiatrica Scandinavica 58 (1), 30–39. https://doi.org/10.1111/j.1600-0447.1978.tb06917.x.

Lenth, R. V., Buerkner, P., Herve, M., Love, J., Miguez, F., Riebl, H., & Singmann, H. (2022). *emmeans: Estimated marginal means, aka least-squares means* (1.7.2) [Computer software]. https://CRAN.R-project.org/package=emmeans.

Lüdecke, D., Bartel, A., Schwemmer, C., Powell, C., Djalovski, A., & Titz, J. (2021). *sjPlot: Data visualization for statistics in social science* (2.8.10) [Computer software]. https://CRAN.R-project.org/package=sjPlot.

Malta, L. S. (2004). *Predictors of aggressive driving in young adults* (Publication No. 3125962) [Doctoral Dissertation, University at Albany, State University of New York]. ProQuest Dissertations and Theses Global.

Markel, C., Wiener, J., 2014. Attribution processes in parent–adolescent conflict in families of adolescents with and without ADHD. Canadian Journal of Behavioural Science / Revue Canadienne Des Sciences Du Comportement 46 (1), 40–48. https://doi.org/10.1037/a0029854.

Noyes, R., 1985. Motor vehicle accidents related to psychiatric impairment. Psychosomatics 26 (7), 569–580. https://doi.org/10.1016/S0033-3182(85)72820-4.

Oppenheimer, D.M., Meyvis, T., Davidenko, N., 2009. Instructional manipulation checks: Detecting satisficing to increase statistical power. Journal of Experimental Social Psychology 45 (4), 867–872. https://doi.org/10.1016/j.jesp.2009.03.009.

Reimer, B., D'Ambrosio, L.A., Gilbert, J., Coughlin, J.F., Biederman, J., Surman, C., Fried, R., Aleardi, M., 2005. Behavior differences in drivers with attention deficit hyperactivity disorder: The driving behavior questionnaire. Accident Analysis and Prevention 37 (6), 996–1004. https://doi.org/10.1016/j.aap.2005.05.002.

Revelle, W. (2021). *psych: Procedures for Psychological, Psychometric, and Personality Research* (2.1.9) [Computer software]. https://CRAN.R-project.org/package=psych.

Richards, T.L., Deffenbacher, J.L., Rosén, L.A., 2002. Driving anger and other driving-related behaviors in high and low ADHD symptom college students. Journal of Attention Disorders 6 (1), 25–38. https://doi.org/10.1177/108705470200600104.

Richards, T.L., Deffenbacher, J.L., Rosén, L.A., Barkley, R.A., Rodricks, T., 2006. Driving anger and driving behavior in adults with adhd. Journal of Attention Disorders 10 (1), 54–64. https://doi.org/10.1177/1087054705284244.

Schatz, N.K., Fabiano, G.A., Morris, K.L., Shucard, J.M., Leo, B.A., Bieniek, C., 2014. Parenting behaviors during risky driving by teens with attention-deficit/hyperactivity disorder. Behavior Therapy 45 (2), 168–176. https://doi.org/10.1016/j.beth.2013.08.003.

Schoenfelder, E.N., Kollins, S.H., 2016. Topical review: ADHD and health-risk behaviors: Toward prevention and health promotion. Journal of Pediatric Psychology 41 (7), 735–740. https://doi.org/10.1093/jpepsy/jsv162.

Taubman – Ben-Ari, O. (2014). The parental factor in adolescent reckless driving: The road ahead. *Accident Analysis & Prevention*, *69*, 1–4. 10.1016/j.aap.2014.02.011.

Tillmann, W.A., Hobbs, G.E., 1949. The accident-prone automobile driver; a study of the psychiatric and social background. The American Journal of Psychiatry 106 (5), 321–331. https://doi.org/10.1176/ajp.106.5.321.

Vaa, T., 2014. ADHD and relative risk of accidents in road traffic: A meta-analysis. Accident Analysis and Prevention 62, 415–425. https://doi.org/10.1016/j.aap.2013.10.003.

Wickham, H., François, R., Henry, L., Müller, K., & RStudio. (2022). *dplyr: A Grammar of Data Manipulation* (1.0.8) [Computer software]. https://CRAN.R-project.org/package=dplyr.

Wickham, H., code, E. M. (Author of included R., & RStudio. (2021). *haven: Import and Export "SPSS", "Stata" and "SAS" Files* (2.4.3) [Computer software]. https://CRAN.R-project.org/package=haven.

Wirth, A., Reinelt, T., Gawrilow, C., Schwenck, C., Freitag, C.M., Rauch, W.A., 2017. Examining the relationship between children's adhd symptomatology and inadequate parenting: The role of household chaos. Journal of Attention Disorders. https://doi.org/10.1177/1087054717692881.

World Health Organization. (2018). *Global status report on road safety 2018*. https://www.who.int/publications/i/item/9789241565684.