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The Role of Executive Functioning on Alcohol and Illegal Substance Use Among Adolescent Offenders

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Abstract

The aim of the study was to examine the role of executive functioning on both alcohol and illegal substance use among a longitudinal sample of adolescent offenders. Time spent involved in the justice system places individuals at risk for substance use disorders, along with housing issues and an increased risk for future delinquent behavior. Executive function, or our decision-making processes, plays a critical role in high-risk behaviors and justice involvement; however, this has been minimally studied among the adolescent offenders. Statistical analyses were conducted with Mplus 8 utilizing generalized linear mixed modeling to examine the relationship between the independent variable (executive functioning), covariates (race, lifetime PTSD, lifetime alcohol misuse, and lifetime drug misuse) on the dependent variables (alcohol use post baseline and illicit substance use post baseline). Analysis used the Stroop Word/Color Test to examine the role of executive function on alcohol use and illicit substance use within a 1-year post-baseline period. Results showed alcohol use post baseline was significantly impacted by executive functioning. No significant effect was found between executive functioning and illicit substance use post baseline. Recommendations are made that enhanced education for adolescent offenders regarding decision-making skills and the need for increased prevention programs for the population. Additionally, research is needed to explore and develop effective treatment strategies that consider executive functioning for adolescent offenders.

Keywords Executive functioning · Substance use · Alcohol use · Juveniles · Juvenile justice involvement

Recent estimates show delinquency cases involving juveniles to be on a continued downward trend with 722,600 cases in 2019, a 56% decline from 2005 (Hockenberry, 2022). While the total number of cases has decreased over this timeframe, the proportion that were formally petitioned and ultimately adjudicated has remained consistent (Hockenberry, 2022). The current study focuses on those juveniles that have been adjudicated as guilty for a range of serious offenses. Juveniles involved with the criminal justice system are typically defined as individuals under the age of 18 who are considered not old enough to be held responsible for criminal acts (OJJDP, 2013). The needs of youth involved in the justice system are varied, however many struggle with mental health complications, substance misuse, and difficulties with employment and housing as well as continued delinquent behavior (Baillargeon et al., 2010; Development Services Group, Inc., 2015; Visher, 2015).

Executive functioning plays an important role in engagement in high-risk behaviors and delinquency (Cauffman, et al., 2005; Casey et al., 2008; Human Impact Partners [HIP], 2017), but the relationship between executive functioning and high-risk behaviors has been minimally studied among adolescent offenders. Research is warranted with this population, as these youth have typically been underserved by other social service agencies but exhibit complex needs (HIP, 2017; Zajac et al., 2015). Further, the cycle of the criminal justice system is well known and has shown that once involved, it is difficult to escape further justice involvement, putting these youth at risk for adult involvement and potential incarceration. Additionally, research is needed to better understand the relationships between bio-psychosocial constructs, such as executive functioning, and the engagement of high-risk behaviors that are associated with

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delinquency. Thus, to understand and respond to those needs could potentially end continued involvement in the justice system and take a high-risk population to one that is thriving in their communities. To that end, this study aims to explore the association of executive functioning with engagement in alcohol use and drug use among court-involved youth.

Executive Functioning

Executive functioning captures the cognitive functions that control and regulate behaviors (Alvarez & Emory, 2006). In terms of physiology, Gorenstein (1982) found the frontal lobe is associated with executive functioning, specifically the cognitive skills of decision making and behavior engagement. Research in neuroscience has established that the human brain, specifically the frontal lobes, does not fully develop until age 21 (McNeely & Blanchard, 2009), making it more likely for adolescents with frontal lobe deficits to engage in risky behaviors particularly in emotionally-charged situations or in the presence of their peers (Chein et al., 2011; Cohen-Gilbert & Thomas, 2013; Grose-Fifer et al., 2013; HIP, 2017). The underdeveloped human brain is known to demonstrate poor executive functioning which often manifests through an individual's deficits in decision making and increased engagement in risky behaviors (Hughes et al., 2020; Reynolds et al., 2019).

To date research has explored the connection between poor executive functioning and the risky behaviors of unprotected sex and drug and alcohol use in a general adolescent population (Casey et al., 2008). Furthermore, previous studies have shown that the perception of risk and benefit is starkly different between adolescents and adults making it harder to engage in goal-oriented behaviors and increasing the likelihood of engagement in risky behaviors (Casey et al., 2008; McNeely & Blanchard, 2009). Greater involvement with risky behaviors in turn increases the likelihood of criminal justice involvement (Puzzenchara, 2020; Renn et al., 2017). Research performed in the 1980s through the 1990's found a connection between diminished executive functioning and juvenile offending (Seguin et al., 1995; Yuedall et al., 1982), but research is scant linking executive functioning to substance use in the juvenile justice population. Literature reviews conducted in more recent years have found that impaired executive functioning, coupled with other risk factors (i.e., poverty and abuse), can make youth more inclined to engage in criminal behavior (Development Services Group, Inc., 2015; HIP, 2017). A focus on executive functioning is warranted as executive functioning is amenable to intervention and provides a modifiable factor to intervene upon to reduce engagement in high-risk health behaviors and potentially reduce further justice-involvement.

Substance Use and Juvenile Justice

Recent national statistics show 20.3 million Americans aged 12 or older met diagnostic criteria for a substance use disorder [Substance Abuse and Mental Health Services Administration (SAMHSA), 2019]. Alcohol is the leading substance for substance use disorders (SAMSHA, 2019) with up to 90% of adolescent drinking qualifying as binge drinking, and the quantity of drinking continues to rise with age (National Institute of Alcohol Abuse and Alcoholism [NIAAA], 2020). Additionally, early substance use is associated with an increased risk for lifetime substance use disorder, as well as putting adolescents at an increased risk for a range of negative outcomes like sexually transmitted disease, physical injury, and increased mortality (CDC, 2012). Alcohol and illicit substance use has remained relatively stable for adolescents (12–20) over the last 20 years. In 2003, illicit use rate was 37.5% and in 2022 it was 28.4% for adolescents- with a recent drop occurring in 2021. Over a majority of the 20 years illicit drug use for adolescents ranged 37.5% to 32.6% demonstrating a stability of use patterns. It is important to mention, that while illicit substance use rates may have dropped there has been a significant increase in overdose deaths per year over the last 20 years with rates of overdose nearly doubling (Eflein, 2022). Using the National Survey on Drug Use and Health data from the last 20 years, it is evident that alcohol use for adolescents has remained stable over the years, with 31.9% reporting drinking alcohol in the which varies relatively little compared to 29.3% reporting alcohol consumption in the past 30 days (Newes-Adeyi et al., 2005; NIAAA, 2023).

While substance misuse is common among the general adolescent population, it occurs at an even higher rate for adolescent offenders. Bergeron and Valliant's (2001) study comparing adults and adolescents in the criminal justice system to their peers without justice involvement found substance use to be more prevalent among those with criminal justice experience. Nationally, drunkenness and drug misuse violations led to 13% of all juvenile arrests in 2018 (Puzancherra, 2020), however rates of drug and alcohol use and misuse among youth that are arrested are estimated to be much higher. Approximately 75% of arrested and detained adolescents reported involvement with drugs or alcohol (Belenko et al., 2003) and in a sample of 372 incarcerated adolescent males, almost 95% of the sample reported using drugs in their lifetime, with most reporting daily use (Racz et al., 2016).

Executive Functioning and Substance Use

Identification of factors contributing to the likelihood to use alcohol and drugs during adolescence is important due to the age of experimentation and that the process of

addiction frequently begins at the same time as the brain is undergoing dramatic developmental changes, particularly in the frontal lobes (Koob & Volkow, 2016). Given that poor executive function is linked to risky behaviors and both are commonly found within the developmental stages of adolescence, this may help explain why substance use is increased among the juvenile justice population (Romer et al., 2009). Research has shown that in adolescence, the brain rewards itself and experiences more emotional satisfaction when engaging in risky behaviors, such as substance use (HIP, 2017; Casey et al., 2008). The likelihood of engaging in risky behavior for youth who use alcohol and drugs is cumulative, meaning the more substances that are used the more likely it is they will experience a negative outcome, such as criminal justice involvement (Development Services Group, 2015; Green et al., 2008). Moreover, the younger a child is at the time of initial substance use will further increase the chances of prolonged engagement in risky behaviors, which in turn will increase a youth's chance of criminal justice involvement (Development Services Group, 2015).

While examining executive functioning and drug use in a sample of adolescent boys, Shoal and Giancola (2001) found a significant correlation between the disruption in executive function and drug use severity and frequency among the higher risk for substance use disorder group. Moreover, Casey et al. (2008) neurological model explains why risky behaviors, such as substance use, are more prevalent with adolescent populations. The neurological model postulates that due to their cognitive development inhibiting the proper weighing of the risks and/or benefits of their behaviors at the same level as an adult, adolescents are more likely to be impulsive which could explain their propensity towards risky behaviors and poor decision making (Casey et al., 2008). Further, an important aspect that differentiates adults from adolescents, in addition to differences in the brain with respect to areas involved in reward and decision-making, is motivational salience (e.g., Galvin et al., 2018). Neurobiological changes may increase vulnerability towards potentially harmful incentives, such as substance use, but it may also contribute to adaptive motivations relevant to positive social development (Crone & Dahl, 2012).

As Paschall and Fishbein (2002) have noted, the implications of executive functioning and substance use research will impact the public health of society and, thus, it is imperative that more research be conducted to properly tailor interventions to such an at-risk population for poor executive functioning *and* high rates of substance use. Therefore, the research reviewed in this section underscores the importance of the current investigation into the relationship between executive functioning and risky behaviors, such as substance misuse, among adolescent offenders.

Current Study

The purpose of this study is to explore the association of executive functioning with engagement in alcohol use and drug use for adolescent offenders. Specifically, this study will answer the following questions: (1) Is there a relationship between an individual's executive functioning and their alcohol use post baseline? And (2) Is there a relationship between an individual's executive functioning and their illicit substance use post-baseline? It is expected that individuals with lower executive functioning will have an increased likelihood of alcohol and illicit substance use across time.

Methods

Participants and Procedure

The data in this study comes from the *Pathways to Desistance Study* and is comprised of 1354 youth between the ages of 14 to 17 years old who were adjudicated for serious offenses and then followed for 7 years. Participants were enrolled between November 2000 and January 2003 from juvenile and adult court systems located in Maricopa County, Arizona and Philadelphia County, Pennsylvania (Pathways to Desistance, n.d.). The youth were found guilty by the courts for serious offenses, mainly felonies, however a few exceptions in the data included misdemeanor property offenses, sexual assault, and weapons offenses (Pathways to Desistance, n.d.; Schubert et al., 2004). Drug charges were also included within the data, however, there were restrictions on the sampling in order not to have a disproportionate number of male participants adjudicated for drug offenses (see Schubert et al., 2004).

Baseline interviews were completed after youth and their parents/guardians gave informed consent and agreed to participate in the study. Baseline interviews were completed within 75 days after their adjudication or 90 days after their decertification hearing in Philadelphia or an adult arraignment in Phoenix. For this current study, all ten interview waves were used that ended at 84-months post-baseline. The first six interviews occurred 6-months apart, and the remaining four waves were 1-year apart. The baseline interviews were broken into two, 2-h sessions to account for the comprehensive nature of the questions and the length of time needed. The follow-up interviews were completed in one 2-h session and assessed changes within either the past 6-months or past year from the previous survey time-point (Schubert et al., 2004). For information on study design, methodology, and sample description

please refer to publications by Mulvey et al. (2004) and Schubert et al. (2004). Table 1 presents the descriptive characteristics of the sample.

Measures

Executive Functioning

The measure of executive functioning assessed general impairment of the frontal cortex as measured by Golden's (1978) Stroop Color and Word Test—a 20-item neurological performance test appropriate for both children and adults. While there are three parts to Stroop Test (word, color, and word-color), the word-color score was chosen for the executive functioning variable given that the word-color score is measuring cognitive performance. Scores of 40 and above on the word-color score indicate better cognitive performance (Pathways to Desistance, n.d.). The representation of executive functioning through cognitive performance is confirmed through research (Alvarez & Emory, 2006; Gorenstein, 1982; Stuss et al., 2000). Previous research has identified the Stroop Color and Word Test to have among "the most sound psychometric properties" for assessments measuring personality and temperament (Kindlon et al., 1995, p. 655). Specifically, psychometric analyses of the word-color section indicate a "moderate" level of temporal stability ($pr^2 = .47$, $p < .001$; Kindlon et al., 1995, p. 653) and acceptable reliability for correct and incorrect color-word responses (Kindlon et al., 1995).

Covariates

Previous research has indicated that a variety of factors may influence the relationship between executive functioning and substance use or be relevant when doing research among an adolescent offender population, such as race/ethnicity (Caldwell et al., 2010; Kakade et al., 2012; Loyd et al., 2019), lifetime PTSD (Sanders et al., 2018; Winningham et al., 2019), lifetime alcohol misuse, and lifetime drug misuse (Craig et al., 2019; Haynie & Osgood, 2005; Skeem et al., 2009). All statistical models control for these conceptually and empirically relevant constructs.

Race/ethnicity was comprised of the following categories: White, Black, Hispanic, and Other. Each race/ethnicity category was recoded into four dichotomous variables. Lifetime PTSD was measured using the posttraumatic stress disorder module from the Composite International Diagnostic Interview (CIDI; World Health Organization, 1990). This PTSD measure is widely used in epidemiological studies of PTSD and has shown good reliability and validity with youth as young as 11 (Kimerling et al., 2014; Perkonigg et al., 2005; World Health Organization, 1990). Similarly, the lifetime alcohol misuse *and* the lifetime drug misuse

Table 1 Sample characteristics

	M/N	*SD/%*
Demographics (N = 1354)		
Age	16.04	1.14
Race		
Black	561	41.43
Hispanic	454	33.53
White	274	20.24
Other	65	4.80
Lifetime PTSD		
Yes	87	6.43
Missing	25	1.85
Lifetime alcohol misuse		
Yes	148	10.93
Missing	52	3.84
Lifetime drug misuse		
Yes	343	25.33
Missing	52	3.84
Executive functioning		
Stroop word-color	46.46	8.58
Outcomes (N = 1354)		
Alcohol 6-months		
Yes	97	7.16
Missing	93	6.87
Alcohol 12-months		
Yes	101	7.46
Missing	94	6.94
Alcohol 18-months		
Yes	111	8.20
Missing	126	9.31
Alcohol 24-months		
Yes	117	8.64
Missing	125	9.23
Alcohol 30-months		
Yes	122	9.01
Missing	121	8.94
Alcohol 36-months		
Yes	141	10.41
Missing	124	9.16
Alcohol 48-months		
Yes	142	10.49
Missing	144	10.64
Alcohol 60-months		
Yes	159	11.74
Missing	154	11.37
Alcohol 72-months		
Yes	189	13.96
Missing	185	13.66
Alcohol 84-months		
Yes	206	15.21
Missing	230	16.99

Table 1 (continued)

	M/N	*SD/%*
Illegal substances 6-months		
Yes	211	15.58
Missing	93	6.87
Illegal substances 12-months		
Yes	232	17.13
Missing	94	6.94
Illegal substances 18-months		
Yes	251	18.54
Missing	126	9.31
Illegal substances 24-months		
Yes	274	20.24
Missing	125	9.23
Illegal substances 30-months		
Yes	277	20.46
Missing	121	8.94
Illegal substances 36-months		
Yes	276	20.38
Missing	123	9.08
Illegal substances 48-months		
Yes	314	23.19
Missing	144	10.64
Illegal substances 60-months		
Yes	277	20.46
Missing	154	11.37
Illegal substances 72-months		
Yes	283	20.90
Missing	185	13.66
Illegal substances 84-months		
Yes	230	16.99
Missing	230	16.99

M mean, *SD* standard deviation

variables were also measured by the CIDI using the respective Alcohol Dependence and Drug Abuse modules (World Health Organization, 1990).

Dependent Variables

The dependent variables included in the models were alcohol use post baseline and illicit substance use post baseline. Alcohol use and illicit substance use were assessed over ten interview waves until 84-months post-baseline. Table 1 summarizes the mean, range, and standard deviation of covariates, independent variables, and dependent variables used in the models.

Rates of alcohol use and illicit substance use during the 84-months showed different trends. Alcohol use steadily increased in use from 7.16 to 15.21% by the final follow-up interview. Illicit substance use started with 15.58% reporting at baseline and increased use was reported up to the 48-month interview (23.19%), which then decreased to 16.99% at 84-months. While these rates are similar or slightly lower compared to national adolescent population drug and alcohol use [19.30% and 14.80% for past year alcohol and illicit drug use, respectively; National Institute on Drug Abuse (NIDA), 2019], recent reporting indicate juvenile arrest rates have declined over the past 40 years with a similar decline in observed drug misuse arrest rates over the past decade (Puzzanchera, 2020).

Analysis Plan

All statistical analyses were conducted with IBM SPSS 25 and Mplus 8. Univariate analyses were conducted to assess variable frequencies and determine the viability of variables for further analysis. To identify the most parsimonious multivariate models, bivariate analyses were conducted to determine if there were significant differences in alcohol use and illicit substance use across the possible covariates. Preliminary analysis examined normality, multicollinearity, and missing data within the specified variables for inclusion in multivariate analyses. There were no issues with either normality or multicollinearity. Missing data was minimal across the independent variables with no variable having more than 3.84% of cases missing. Missingness on the outcome variable increased at each successive wave of the study beginning with 6.87% at 6-months and up to 16.99% at 84-months. The average rate of follow-up on the outcomes variables across all ten post-baseline interviews was 89.70%.

To account for the repeated measures of outcome variables and handle missing data, the present study used generalized linear mixed modeling to measure associations with alcohol and illicit substance use across time. This technique allows for the concurrent estimation of intercepts and slopes at the occasion level (Level 1) and individual level (Level 2; Ghisletta et al., 2015; Hox & Stoel, 2005; Laird & Ware, 1982). In the present study, time was treated as an individual level variable within a subject (Level 1) whereas executive functioning and included covariates were considered between level variables that are time invariant (Level 2) since they were assessed at baseline. Two generalized linear mixed models were run to examine the relationship of executive functioning and covariates (time, race, lifetime PTSD, lifetime alcohol misuse, and lifetime drug misuse) with (1) alcohol use and (2) illicit substance use in which time was treated as a random effect. Then, models were fitted with cross-level interaction terms between time and executive functioning. Model results are presented as log odds and standard errors, and parameter estimates are interpreted as the change in the log odds of experiencing the outcome for every unit increase in the predictor.

The following two hypotheses will be explored through modeling: (1) a decrease in a person's executive functioning, as measured by the Stroop Color and Word Test, is associated with an increased likelihood of alcohol use post baseline, and (2) a decrease in a person's executive functioning, as measured by the Stroop Color and Word Test, is associated with an increase of illicit substance use at post baseline.

Results

Model one was used to test the first hypothesis (Table 2). When adjusting for the effects of covariates (race, lifetime PTSD, lifetime alcohol misuse, and lifetime drug misuse), executive functioning (b = .02, SE = .01, p < .01) was significantly and positively associated with alcohol use post baseline. Participants who identified as Black (b = − 2.03, SE = .19, p < .001) and Latino (b = − .45, SE = .17) were significantly less likely to use alcohol compared to White participants. Those with a lifetime history of alcohol misuse (b = .87, SE = .18 p < .001), and lifetime illicit substance misuse (b = .43, SE = .15 p < .01) had a significantly higher likelihood of engaging in alcohol use post baseline. Time was also significantly and positively associated with alcohol use post baseline (b = .01, SE ≤ .001 p < .001).

The next model examined hypothesis two for associations of executive functioning with illicit substance use (Model 2). When adjusting for the effects of covariates, executive functioning was not significantly associated with illicit substance use (b = .01, SE = .01, p = .13). Latino participants had a significantly lower likelihood of illicit substance use post baseline relative to White participants (b = − .50, SE = .17, p < .01). Additionally, participants with a history of alcohol misuse (b = .53, SE = .18, p < .01) and illicit substance misuse (b = .64, SE = .13, p < .001) were significantly more likely to engage in illicit substance use. Time was not significantly associated with illicit substance use post baseline. No significant interaction effects were found between time and executive functioning in either model.

Discussion

Experts on child development in the Center on the Developing Child at Harvard University (2014) note that while we are not born with the critical functioning skills of executive function (i.e., decision making, impulse control, and cognition), these skills are modifiable from childhood through adolescence (and beyond) and can be strengthened via intervention. Executive functioning is important among adolescence during this critical period as the frontal lobes of the brain and associated functioning are still developing (McNeely & Blanchard, 2009). Further, an adolescent's perception of risk and reward are hindered (McNeely & Blanchard, 2009), which has the potential to help explain why illicit substance and alcohol use may be more common among juvenile justice populations (HIP, 2017; Romer et al., 2009). The present study is one of the first to explore the association between executive functioning and high-risk behaviors, such as alcohol and illicit drug use, among adolescent offenders.

Results suggested that a statistically significant relationship between executive functioning and alcohol use post baseline does exist, but a significant relationship between executive functioning and illicit substance use post baseline was not found. The significant relationship between

Table 2 Result from multivariable latent mixed models for alcohol and illegal substance use across time

	Model 1			Model 2		
	Alcohol use			Illegal substance use		
	Estimate	SE	p	Estimate	SE	p
Executive functioning	.02	.01	**< .01**	.01	.01	.13
Black	− 2.03	.19	**< .001**	− .24	.16	.14
Latino	− .45	.17	**< .001**	− .50	.17	**< .01**
Other race/ethnicity	− .08	.32	.80	− .66	.35	.06
Lifetime PTSD	.40	.27	.14	.24	.26	.35
Lifetime alcohol misuse	.87	.18	**< .001**	.53	.18	**< .01**
Lifetime illicit substance misuse	.43	.15	**< .01**	.64	.13	**< .001**
Time slope	.01	< .001	**< .001**	− .001	.002	.53
Intercept	− 3.97	.42	**< .001**	− 3.97	.42	**< .001**
Random intercept variance	3.53	.51	**< .001**	2.78	.35	**< .001**
Random slope variance	< .001	< .001	**< .001**	< .001	< .001	**< .001**

Unstandardized coefficients from multilevel models are presented with standard errors (SE) and p values
Boldface denotes statistical significance

executive functioning and alcohol use is counter to previous study findings in non-justice involved youth that established that deficits in executive functioning (i.e., one's inability to control impulses and increased use of autonomic responses) has been associated with increased alcohol use (Fernie et al., 2013; Peeters et al., 2015). In the current study, those who had higher levels of executive functioning were more likely to use alcohol. This finding did not support the research hypothesis, or previous research, but is alarming in a different way as preceding research has shown the alcohol use can impair executive functioning (Lees et al., 2020). Future work should consider exploring this relationship between alcohol use and the potential for diminished executive functioning among adolescent offenders.

Further, this finding with alcohol may have occurred due to alcohol being more convenient, and the perception that alcohol is a safer substance of choice with lower risk than illicit substances. Additionally, alcohol is established in the literature to be the drug of choice among adolescence (Swendsen et al., 2012). Post-adjudication is a significant period when youth often begin to re-engage in older risk behaviors, especially as time away from justice involvement lengthens. This is a time of heightened risk for re-engagement with the justice system and time when intervention delivery may be needed the most for adolescent offenders, with 55% of youth being re-arrested within 1 year of release (Office of Juvenile Justice and Delinquency Prevention, 2017; Snyder & Sickmund, 2006).

While executive functioning was not a predictor in many of the models, there is still evidence of alcohol and illicit substance use in this population that is critical to the broader discussion given its novelty and practical significance. These findings highlight continual use patterns of alcohol and illicit substance use, especially when further from the initial adjudication, which highlights the importance of treatment timelines and potential mandate guidelines for programs and interventions for justice-involved adolescents. Individualized care is one of the key treatment standards in drug and alcohol treatment [National Institute on Drug Abuse (NIDA), 2014], and thus, there is not a consensus on recommended treatment duration; however, past research has found that treatment is most effective when programming is at least 3 months long (Hser et al., 2001). However, in light of the descriptive findings of this study, treatment that lasts longer than 3 months may be warranted as an increase in alcohol use and illicit substance use gradually increased over time. In other words, mandates for treatment may need to span approximately a year or greater, with ongoing care following treatment, as post-adjudication is a critical time frame to promote positive outcomes in youth (ODJJP, 2017).

Additionally, presence of continued drug and/or alcohol use at these time points do not suggest failure of the person, but rather treatment that needs to be enhanced or adjusted to better serve individual needs (NIDA, 2014). These results also align with past research conducted on effective treatments for adolescent substance use among juvenile offenders. Tripodi and Bender (2011) found that juveniles in substance use treatment had better outcomes if interventions focused on cognition, involved family, and spanned environmental systems. These components of treatment should be heavily considered and incorporated into existing programming, while accounting for mandated timeframes for adolescent juveniles, and mechanisms of executive function.

The study's findings may suggest other several important items for discussion in addition to the relationship between executive functioning and alcohol and illicit substance use. First, during an age range where all acts of substance use are illegal, results confirm that alcohol is a critical substance to address and should continue to be a key focus of prevention efforts. The fact that alcohol is legal for individuals aged 21 and older may make it easier to access than perhaps other illicit substances within the household and, thus, indicates the need for interventions that promote increased and enhanced education for parents regarding the harm of alcohol use at an early age. Similarly, lifetime alcohol misuse and lifetime illicit substance misuse were statistically significant predictors for recent use for both alcohol and illicit substances. These results support the importance of alcohol specific prevention for adolescents as lifetime alcohol use impacts recent use of legal and illegal substances. Alcohol use in adolescence has immediate (i.e., academic and social issues) and long-term consequences for adolescent offenders (i.e., development of alcohol and drug use disorders and neurological impairment; Centers for Disease Control and Prevention [CDC], 2020; Federation of American Societies for Experimental Biology [FASEB], 2014). However, there do exist promising interventions that can help to prevent the escalation of negative consequences for youth. For example, a recent randomized control trial found a family based online alcohol use prevention program decreased teen drinking at 6 and 12 months by 27.5% among participants that had completed the alcohol module (Byrnes et al., 2019).

Moreover, model results also confirm that race *does* matter in relation to alcohol and illicit drug use and criminal justice involvement. Gaps in the literature exist relating to race and ethnicity within criminal justice populations, especially among adjudicated youth (Caldwell et al., 2010; Kakade et al., 2012; Piquero & Brame, 2008). A recent study examined the interaction effect of race and gender on time to reincarceration and found this interaction to significantly predict reincarceration; yet noted that more research is needed to understand the macro forces on risk for criminal justice re/involvement (Berry et al., 2018). This further confirms the need to identify and explore how system inequalities within legislation and criminal justice institutions

disproportionately impact the rates at which certain races and ethnicities are becoming involved with the criminal justice system.

Lastly, these findings are important due to the reinforcing nature of deficits in executive functioning and substance use. Research has previously established that substance use, both illicit substances and alcohol, increase the odds of suffering a loss in executive functioning across the lifespan—particularly in the area of behavior inhibition (Kim-Spoon et al., 2017). In addition, executive functioning through brain impairment occurs due to substance use specifically through harm to cognitive control systems which impact the ability to make decisions and regulate an adolescent's actions, emotions, and impulses (Allan et al., 2016).

Limitations

While the current research advances the literature on executive functioning and substance use there are limitations that should be addressed. First, the use of longitudinal data introduces methodological issues such as panel attrition—or the loss of participants over data collection time points. Panel attrition was minimal during the original data collection, ranging from 91 to 93% retention. With this study utilizing secondary data, there are limitations to the data. This includes the limited operationalization of executive functioning and substance use. In future research, executive functioning should be considered a latent variable to capture a more rigorous assessment of executive functioning among the sample, as well as continuous measurement of substance use that captures quantity and/or frequency of use. Another limitation of the current study is the use of self-recall measures, which raises concern around the reliability of the data due to reliance on participant recall. Lastly, the sample consisted of serious juvenile offenders in the two metropolitan areas of Philadelphia, Pennsylvania and Phoenix, Arizona; therefore, the study findings should not be generalized to youths from other communities or youth convicted of minor crimes or other community-based samples. Despite these limitations, the findings from this study advance research surrounding executive functioning and illicit substance and alcohol use among adolescent offenders.

Conclusion

Overall, this study moved our understanding forward on alcohol and illicit substance use patterns among adjudicated youth, while showing more research is warranted in the area of executive functioning and substance use. While all substance use (illicit and alcohol) is illegal for this age group, these findings highlight the specific importance of alcohol use with its relationship to executive functioning. The implications of these findings suggest a few areas of future research among youth involved in the justice system. Research should continue to explore the underlying cognitive processes associated with substance use, its potential relationship with executive functioning, and mechanisms and systems to facilitate positive development among youth historically marginalized. Additionally, future research should examine the cyclical relationship of substance use and executive functioning for adjudicated youth, as in the current study those who had high executive functioning were actually more likely to consume alcohol.

There has been promising evidence that suggests consistent and stronger effects of executive functioning on reward and punishment sensitivity (Kim-Spoon et al., 2017). Further, future research should explore the differences in use among illegal substances, such as isolating marijuana use. It is critical that this work on executive functioning be expanded to youth in the juvenile justice system as these adolescences are some of the most vulnerable to continuing on trajectories of risky decision making into adulthood. It is also imperative to consider the importance of continuity of care post-adjudication to prevent relapse or recidivism and mandating treatment follow ups and include key stakeholders in their environment (NIDA, 2014). Further, future research should consider how to design prevention research and interventions targeted towards treating and addressing problematic drug and alcohol use, thus impeding the addiction cycle for these marginalized and disadvantaged youth.

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