

Attention Deficit Hyperactivity Disorder, Aggression, and Illicit Stimulant Use

Is This Self-Medication?

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Abstract: This study compares adults with and without attention deficit hyperactivity disorder (ADHD) on measures of direct and displaced aggression and illicit drug use. Three hundred ninety-six adults were administered the Wender Utah Rating Scale, the Risk Behavior Assessment, the Aggression Questionnaire (AQ), and the Displaced Aggression Questionnaire (DAQ). Those with ADHD were higher on all scales of the AQ and DAQ, were younger at first use of amphetamines, and were more likely to have ever used crack and amphetamines. A Structural Equation Model found a significant interaction in that for those with medium and high levels of verbal aggression, ADHD predicts crack and amphetamine. Follow-up logistic regression models suggest that blacks self-medicate with crack and whites and Hispanics self-medicate with amphetamine when they have ADHD and verbal aggression.

Key Words: ADHD, aggression, self-medication, crack, amphetamine

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Attention deficit hyperactivity disorder (ADHD) has been recognized as a major developmental problem for decades (Biederman, 2005). Most studies are concentrated on children and adolescents; however, adult ADHD has received extensive clinical attention only recently (Caci et al., 2008). Undiagnosed ADHD results in lifetime problems that can be pervasive in a person's ability to succeed. ADHD is characterized by “a pattern of behavior, present in multiple settings... that can result in performance issues in social, educational, or work settings” (American Psychiatric Association, 2013, p 1). Symptoms from two group types: a) inattention and b) hyperactivity-impulsivity manifest in behaviors such as excessive talking, disorganization, failure to complete tasks, and poor performance (American Psychiatric Association, 2013). ADHD begins in childhood and there must be symptoms present before the age of 12 years (American Psychiatric Association, 2013).

Self-Medication Hypothesis

The Self-Medication Hypothesis (SMH) has been used to explain substance use because drugs of abuse ameliorate psychological suffering (Khantzian, 1997). Another aspect of the SMH is that different disorders are associated with specific types of illicit drugs because of a pharmacological specificity (Khantzian, 2003). When someone with a disorder experiments with different illicit drugs, they will find that certain drugs relieve emotions or affective states that cause them

problems (Khantzian, 1997). It turns out that stimulants, including amphetamine and cocaine, can paradoxically calm and counteract the problematic affective states associated with ADHD (Khantzian, 2003). The SMH holds that psychiatric disorders precede substance abuse. However, it is not the psychiatric diagnosis that is being self-medicated, instead it is the psychological suffering described by the diagnosis (Mariani et al., 2014).

At the same time that Khantzian was putting forward his SMH rooted in the psychoanalytic tradition, a different version of the SMH based on learning theory and the epidemiological triangle was being presented (Duncan, 1975). The best predictor of drug use is use by peer group in that acquisition of drug use is social and usually means that the novice is introduced and trained in the drug use by experienced users. Drug users usually begin their drug use in a period of high stress in their lives (Duncan, 1974; Duncan, 1975). Whereas the initial acquisition of drug use may have been motivated by curiosity and a positive reinforcement mechanism, the stronger motivation that produces dependence is negative reinforcement, which is the relief from the stress or unpleasant state. This negative reinforcement of Duncan is similar to the relief in the Khantzian model.

Duncan continues his model by invoking the epidemiological triangle from public health (Duncan, 1975). The host is the potential drug user, and the host description includes describing “those individual characteristics which effect his or her susceptibility to the condition” (Duncan, 1975). The host susceptibility is increased by the presence of the ADHD and poor coping skills. The agent is the drug, which in the case of ADHD is a stimulant. The environment refers to the probability of the presence of the agent. The vector is the drug using peer group.

The association between ADHD and psychoactive substance use disorders has been fairly well established. For instance, in a study, 120 adults with ADHD were compared with 268 controls, and the ADHD adults had significantly higher rates of drug use disorders as compared with the controls (Biederman et al., 1995). A later comparison of these same groups found that the ADHD group had earlier onset of substance disorders independent of psychiatric comorbidity (Wilens et al., 1997). The literature on ADHD and substance abuse goes back at least to 1985 with a New York study that found that those with ADHD were more likely to have a drug abuse disorder (Gittelman et al., 1985). A Pittsburgh, PA, study also found that those with ADHD had a significantly greater proportion with illicit drug use, which included cocaine and nonprescribed stimulants (Molina and Pelham, 2003). A study in Milwaukee found that the hyperactive participants (both with and without conduct disorder) were significantly higher on frequencies of cocaine and amphetamine use (Barkley et al., 2004).

The suggestion that illicit stimulant use is being used by those with ADHD to self-medicate has been suggested in the case of cocaine use (Carroll and Rounsaville, 1993). A study of 14- to 16-year-old students found that those with symptoms of ADHD were significantly more likely to take cocaine, and the suggestion was that the students were using the cocaine to self-medicate their ADHD symptoms

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(Gudjonsson et al., 2012). The SMH has also been invoked to explain illicit amphetamine use, and the subjective responses to the illicit amphetamines have been reported to make those with ADHD feel calm, to enable them to accomplish everyday tasks, and to feel normal (Van Meer, 2014). There are also reports of illegal use of prescription ADHD medications by college students who seem to be self-medicating their ADHD, but they had never been diagnosed or prescribed the medications by a health care provider (Rabiner et al., 2009). The illegal use of methylphenidate, which is a drug that is used to treat ADHD, has been reported among methadone maintenance patients who also had higher scores on the Wender Utah Rating Scale (WURS), and the suggestion was that they were using the methylphenidate to self-medicate (Peles et al., 2015). Studies clarifying the role of self-medication by those who have symptoms of ADHD have been called for (Wilens et al., 2007). One of the issues being raised is what are the other comorbidities or personality characteristics that seem to increase the likelihood of self-medication by those with ADHD symptoms. In the Duncan model, it is these characteristics that increase the susceptibility of the host. One personality factor that may be relevant is trait aggressiveness.

Aggression and ADHD

Aggressiveness is a persistent trait that possesses cross-situational constancy (Huesmann et al., 1984). Early aggressiveness has been shown to be predictive of later antisocial behavior. The level of aggression at age 8 years predicts adult aggressiveness (Huesmann et al., 2002). There have been consistent reports of associations between ADHD, usually as measured with the WURS, and various measures of aggression such as the Aggression Questionnaire (AQ), which is a well-validated measure of trait aggressiveness (e.g., Bushman and Wells, 1998; Garcia-León et al., 2002; Giancola, 2002, etc.). For instance, an Italian study found a positive correlation between the WURS and the AQ total score (Carlotta et al., 2013). A Greek study found significant correlations between the WURS and the total and all subscale scores of the AQ (Giotakos et al., 2005). A Hungarian study measured ADHD with the Adult Self-Report Scale and found significant differences between the ADHD- and ADHD+ groups on the AQ total, physical, anger, and verbal, but not the hostility subscales (Bacskaï et al., 2012), and an Australian study that measured ADHD with the Brown Attention-Deficit Disorder Scales found a significant correlation with the AQ total score (Byrne et al., 2015). A study of college students with and without ADHD found that the ADHD group had significantly higher levels of both trait and state anger. They also expressed their anger inappropriately (Ramirez et al., 1997). A study of adults with ADHD found that those with ADHD reported more driving anger and aggressive expression through the use of their vehicles than those without ADHD (Richards et al., 2006).

Furthermore, the AQ was used in a study of current illicit drug users in California that found that the AQ contributed to a latent aggression factor that was associated only with amphetamine use (Jaffe et al., 2009). A study of substance-abusing veterans recovering from chronic substance use found that those veterans with post traumatic stress disorder had more aggression as reflected by higher scores on the AQ (Freeman and Roca, 2001). Substance-dependent inpatients with pathologic dissociation had higher scores on the AQ when compared with nondissociative patients (Evren et al., 2013). Detoxified cocaine-dependent inpatient had elevated levels of aggression compared with a control group as measured by the AQ (Roozen et al., 2011).

There are two different types of aggression: direct and displaced. Direct aggression is aggressive behavior aimed at the original source of the provocation. The AQ has been the measure that is typically used to assess for direct aggression. In contrast, displaced aggression occurs when an individual is provoked, does not retaliate against the original provocateur, but instead directs their aggression toward another target

(Pedersen et al., 2000). The Displaced Aggression Questionnaire (DAQ) has been the measure that is used to assess for displaced aggression. An example of displaced aggression might be to imagine a man who is berated by his superior at work. If he, in turn, yells at his boss, then he is engaging in direct aggression because the target of the man's aggressive behavior is the original provocateur (*i.e.*, the boss). If the man does not retaliate against his superior (for fear of losing his job), but instead goes home that night and kicks his dog, then he has just committed an act of displaced aggression. There are several potential reasons why an individual might engage in displaced aggression rather than direct aggression. For example, the provocateur might be unavailable, the original provocateur could be intangible, or a person is fearful of retaliation or punishment from the provocateur (Marcus-Newhall et al., 2000).

Denson et al. (2006) developed the DAQ, which is the first measure to assess trait displaced aggression (TDA) (*viz.*, individual differences in the propensity to engage in displaced aggression). Subsequent investigations revealed that individuals with high levels of TDA not only engaged in more displaced aggression in laboratory and real-world environments, but they also experienced increased stress levels and decreased overall life satisfaction. Furthermore, increases in TDA were associated with a host of negative physical health symptoms including cardiovascular, respiratory, and gastrointestinal problems. These symptoms are in addition to a host of risky behaviors such as increased alcohol dependence, unhealthy diet, and unsafe sex practices (Denson et al., 2008). TDA has never been assessed in relation to ADHD. The DAQ has been found to have high levels of internal consistency as well as test-retest reliability (Denson et al., 2006). In addition, the DAQ is correlated to measures of theoretical relevance (*i.e.*, neuroticism, trait aggressiveness, agreeableness, social desirability, and anger expression), all of which help support the measure's convergent validity (Denson et al., 2006). The DAQ has also been shown to be a reliable predictor of displaced aggression in laboratory studies as well as indicators of real-world displaced aggression (*i.e.*, self-reported domestic abuse and road rage [Denson et al., 2006]). Furthermore, TDA (as measured by the DAQ) predicts negative physical and mental health outcomes in addition to decreased life satisfaction (Denson et al., 2008).

Purpose of the Study

The purposes of the study are to a) determine the likelihood that illicit stimulant use is associated with ADHD and is possibly being used to self-medicate ADHD symptoms, b) determine the association between ADHD and not only direct aggression, but also displaced aggression and other characteristics of the host, c) develop an overall model of aggression and ADHD showing a predictive relationship to drug use, d) assess for moderator effects (interactions) among ADHD and aggression and present what the temporal sequence leading to illicit stimulant use is.

METHODS

Participants

Three hundred ninety-six participants were recruited at a community clinic in a low-income area that provides human immunodeficiency virus (HIV) and sexually transmitted infection testing services located in Los Angeles County, California. The clinic is also a food distribution site for the Foodbank of Southern California. Clinic staffs who were enrolled at California State University, Long Beach (CSULB) administered instruments described in the following sections. All protocols were approved by the CSULB Institutional Review Board, and all data were protected under a Certificate of Confidentiality awarded by the federal government. Data were entered in Viking Data Entry and were analyzed in SAS 9.4 (TS1M2) on a Windows 2008 R2 server. SAS was also used to construct the logistic regression models. Mplus

version 7 was used to estimate a Structural Equation Model (SEM) with two binary outcomes using maximum likelihood (ML) estimation (Muthén and Muthén, 1998–2015).

Measures

In WURS (Ward et al., 1993), *DSM-4-TR* criteria for adult diagnoses of ADHD include a childhood history of ADHD symptoms dating back to at least age 7 years. Without a finding that an individual likely would have been diagnosed with ADHD as a child, an adult diagnosis cannot be confirmed. The WURS is a 25-item assessment instrument that is commonly used in clinical and research settings to make retrospective diagnoses of ADHD in adults. Using the WURS, participants report symptoms of inattention, hyperactivity, and impulsivity that they may have experienced during childhood. Recent investigations have found this measure to have high internal consistency (Retz-Junginger et al., 2007) and more robust psychometrics and validity than 14 other scales (Taylor et al., 2011). The WURS had the highest sensitivity to correctly diagnose ADHD and has been recommended as the best instrument for screening purposes (Dakwar et al., 2012). Severity of the 25 items on the WURS were rated using a 5-point Likert-type scale with a range from 0 (“not at all or very slightly”) to 4 (“very much”). Total scores on the WURS can range from 0 to a maximum of 125.

AQ (Buss and Perry, 1992) was specifically developed with the goals to update the Hostility Inventory (Buss and Durkee, 1957) and to ensure adequate reliability and validity as a psychometric instrument. The current AQ consists of 29 items. It uses a self-report format in which subjects rate each item on a 5-point scale ranging from 1 (extremely uncharacteristic of me) to 5 (extremely characteristic of me). AQ has four subscales: a) physical aggression (e.g., “Given enough provocation, I may hit another person”), b) verbal aggression (e.g., “My friends say that I’m somewhat argumentative”), c) anger (e.g., “I sometimes feel like a powder keg ready to explode”), and d) hostility (e.g., “I wonder why sometimes I feel so bitter about things”). Alpha coefficients (Cronbach, 1951) assessing internal consistency of the four subscales are fair-to-good using accepted rules of thumb (Cicchetti, 1994) and range from 0.72 to 0.85. Measures of 9-week test-retest reliability were 0.80 for physical aggression, 0.76 for verbal aggression, 0.72 for anger, and 0.72 for hostility. The reliability for the total score was 0.80. The subscales were correlated in the predicted fashion with various personality traits (e.g., emotionality, self-consciousness, etc.) (Buss and Perry, 1992). A smaller subset of the current study ($n = 183$) was administered the AQ.

DAQ (Denson et al., 2006) is a 31-item self-report measure that uses a 7-point Likert scale ranging from 1 (extremely characteristic of me) to 7 (extremely uncharacteristic of me). The DAQ consists of three subscales: 1) angry rumination (an affective component), 2) revenge planning (a cognitive component), and 3) behavioral displaced aggression (a behavioral component). The angry rumination subscale is made up of 10 items and assesses the tendency of an individual to focus on or relive a provoking event (e.g., “I re-enact the anger episode in my mind after it has happened”). The revenge planning subscale is composed of 11 items that are focused on an individual’s concern or need for retaliation in response to a provocation (e.g., “When somebody offends me, sooner or later I will retaliate”). The behavioral displaced aggression subscale consists of 10 items and is primarily concerned with the general tendency of an individual to displace his or her aggression (e.g., “When feeling bad, I take it out on others”). All three subscales are combined to create a composite score with higher values equating to greater likelihood that an individual will engage in displaced aggression. A smaller subset ($n = 274$) was administered the DAQ.

The Risk Behavior Assessment (RBA) (Dowling-Guyer et al., 1994; Edwards et al., 2007; Fisher et al., 2007; Napper et al., 2010; Needle et al., 1995) is a 20- to 30-minute structured interview

administered by trained interviewers. Developed by grantees of the National Institute on Drug Abuse (NIDA), the RBA collects demographic information as well as information on illicit drug use, drug abuse treatment, sexual activity, and sexually transmitted infections history. Drug use items include types of drugs used in lifetime, age of first use, and frequency of use in the last 30 days. The reliabilities of the ever in drug treatment item is $\kappa = 0.85$ (95% confidence interval [CI], 0.78–0.91); this item was worded “Have you ever in your lifetime been in a drug treatment or detox program?” The ever in outpatient drug-free treatment is $\kappa = 0.76$ (95% CI, 0.61–0.91) (Edwards et al., 2007). This item was worded “Have you ever in your lifetime been in an outpatient drug free program?” The conditional κ for the ever used crack is 1.0 (Dowling-Guyer et al., 1994). This item was worded as “Have you ever used crack (smokable cocaine)?” The reliability of the ever used amphetamine item is $\kappa = 0.79$ (95% CI, 0.71–0.87) and was worded “Have you ever used amphetamines?” The test-retest reliability of the age of first use of amphetamine is $r = 0.64$ (Napper et al., 2010). The question was worded “How old were you the first time you used amphetamine?”

Statistical Methods

A structural equation model (SEM) was estimated using ML estimation in Mplus version 7 (Muthén and Muthén, 1998–2015) to predict two binary outcomes, ever used crack and ever used amphetamines, from the predictors of ADHD, verbal aggression, and the interaction between ADHD and verbal aggression. The significance of the interaction term indicates whether verbal aggression is a significant moderator of the relation between ADHD and crack use, and ADHD and amphetamine use. If the interaction term is a significant predictor of crack and amphetamine use, this means that the strength of the relation between ADHD and crack and amphetamine use varies depending on the individual’s level of verbal aggression.

Following the SEM, logistic regression models were constructed using methods presented in Hosmer et al. (2013). There is one model using crack as the dependent variable and a separate model using amphetamine as the dependent variable. We did not have sufficient power to be able to modify the SEM to include ADHD, verbal aggression, and race simultaneously in a three-way interaction.

The methods for the logistic regression models include both a plan for selecting variables and a method for assessing adequacy. Model building seeks to have the most parsimonious model that still reflects the outcome. Having a parsimonious model means that the model will be numerically stable, more easily adopted by others, and will have smaller standard errors. The first step in the Hosmer et al. purposeful selection method of model building is to start with a careful univariable analysis of each candidate independent variable. The top of Table 1 does this for categorical variables and uses the Pearson chi-square test, which Hosmer et al. says is acceptable. The bottom of Table 1 does this for continuous variables and uses the two-sample *t*-test, which Hosmer et al. say is acceptable for continuous variables in step 1. Step 2 involves fitting the multivariable model and eliminating variables that do not contribute. Step 3 involves adding back in variables that were eliminated in step 2 that turn out to be important because they provide a needed adjustment of those variables that remain in the model. Step 4 is to continue this process of adding and taking out variables until there is a preliminary main effects model. Step 5 is to check assumptions and to make sure that continuous variables are linear in the logit. This results in the main effects model. Step 6 is to check for interactions because an interaction implies that the effect of each variable is not constant over the levels of the other variable. This results in the preliminary final model. Step 7 is to check the model fit using methods such as the Hosmer-Lemeshow goodness-of-fit method (Hosmer and Lemeshow, 1980). This description reflects how we developed the model presented in Table 3.

TABLE 1. Associations by ADHD Status as Measured by the WURS

Variable	ADHD		χ^2	Phi
	Yes, <i>n</i> (%)	No, <i>n</i> (%)		
Sex				
Male	92 (70)	214 (81)	5.53*	0.1182
Female	39 (30)	51 (19)		
Ethnicity				
Black	46 (35)	93 (35)	3.19	
White	51 (39)	83 (31)		
Hispanic	24 (18)	61 (23)		
Other	10 (8)	28 (11)		
Ever in drug treatment, detox				
Yes	32 (24)	117 (44)	14.74***	0.1932
No	99 (76)	147 (56)		
Ever outpatient drug-free				
Yes	58 (58)	113 (77)	9.94***	0.2007
No	42 (42)	34 (23)		
Ever used crack				
Yes	105 (80)	159 (60)	15.68***	0.1993
No	26 (20)	105 (40)		
Ever used amphetamine				
Yes	92 (70)	151 (57)	6.48**	0.1280
No	39 (30)	114 (43)		
Variable	ADHD		<i>t</i>	<i>df</i>
	Yes, <i>M</i> (<i>SD</i>)	No, <i>M</i> (<i>SD</i>)		
AQ subscales				
Aggression total	2.75 (0.86)	2.33 (0.74)	3.47***	(181)
Physical aggression	2.61 (0.97)	2.25 (0.87)	2.57**	(181)
Verbal aggression	2.95 (1.04)	2.58 (0.90)	2.48**	(181)
Anger	2.62 (1.02)	2.11 (0.82)	3.66***	(181)
Hostility	2.91 (0.92)	2.45 (0.84)	3.39***	(181)
Displaced aggression subscales				
Displaced aggression total	96.34 (43.32)	76.29 (40.01)	3.75***	(272)
Displaced aggression subscale	30.60 (15.80)	23.94 (13.86)	3.55***	(275)
Revenge planning	30.36 (16.12)	23.96 (14.26)	3.33***	(274)
Angry rumination	36.38 (16.69)	28.45 (15.50)	3.85***	(274)
Age, yr	41.72 (9.84)	40.55 (11.44)	0.97	
Age of first use of amphetamines ^a	20.59 (8.85)	23.81 (7.93)	2.95**	(242)
Age of first use of crack	24.61 (8.64)	26.66 (8.93)	1.83	(261)
Highest grade of school ^b	4.09 (1.81)	4.75 (1.76)	3.31*** ^c	

Note: Wender-Utah cut point was, if greater than 45, = Yes ADHD.

^aOnly calculated on those who had ever used drug. ^bScale was 0 = no formal schooling, 1 = eighth grade or less, 2 = less than high school graduation, 3 = A GED, 4 = high school graduation, 5 = trade or technical training, 6 = some college, 7 = college graduation. ^cStatistic was *Z* for Wilcoxon two-sample test.

p* < 0.05, *p* < 0.01, ****p* < 0.001.

Given that we found an interaction in the model in shown in the figure, we wanted to develop the moderation further by putting the variables in a more theoretically logical time sequence. In this case, it made sense to have the interaction between ADHD (which begins in childhood and must have symptoms present before the age of 12 years) and trait verbal aggression (which has been shown to be present at the age of 8 years and persists into adulthood) predicting crack use, which our sample started using at about the age of 25 years. We produced a similar model for amphetamine use, which our sample started using at about the age of 23 years. We used meaningful levels of the

continuous variable of verbal aggression. This was done to identify the levels of verbal aggression at which having ADHD is predictive of crack use. For the race variable for the logistic regression models, we collapsed both native and Asian into “other” because of small cell sizes.

Both Tables 2 and 3 show the variable in the first column, the adjusted odds ratio of that variable in the second column, the 95% lower confidence level (LCL) below the odds ratio in the third column, and the 95% upper confidence level (UCL) above the odds ratio in the fourth column. The Wald confidence limits for the odds ratios are

TABLE 2. Logistic Regression Model of Ever Using Crack

Variable	Odds Ratio	95% LCL	95% UCL
Hispanic vs. black	0.331	0.117	0.906
Other vs. black	0.167	0.043	0.632
White vs. black	0.349	0.125	0.950
ADHD at level of verbal aggression			
1	0.393	0.061	2.552
2	1.436	0.508	4.057
3	5.243	1.470	18.702
4	19.140	1.995	183.653
5	69.878	2.330	999.999

Notes: Hosmer-Lemeshow goodness-of-fit χ^2 (8) = 9.1035, p = 0.3336.
Verbal aggression is the verbal aggression subscale of the AQ. Odds ratios whose CI does not include 1 are significant. CIs for the interaction are Wald CIs. CIs for race are profile likelihood CIs. Wald χ^2 (3) for race is 9.0052, p = 0.0292. Wald χ^2 (1) for the interaction of ADHD with verbal aggression is 4.3569, p = 0.0324.

computed using the values for the parameter, which is the log-odds ratio, and then exponentiating it (Hosmer et al., 2013). The Wald confidence limits are reported for the odds ratios of the interactions. The profile likelihood confidence limits are reported for the levels of race. The profile likelihood method is described as the interval of values for which the likelihood ratio test failed to reject the hypothesis $H_0: \beta = \beta^*$. The obtained value of the Wald chi-square that is the parameter estimate divided by the standard error of the parameter estimate is in the fifth column, and the significance level of the obtained value of the Wald chi-square that follows a standard normal distribution is in the last column.

RESULTS

Table 1 shows the bivariate relationships of ADHD as measured by the WURS with demographic characteristics of the sample and risk behaviors. A majority of the sample was male (n = 306, 77%) and mostly black (n = 139, 35%) and white (n = 134, 34%) with some Hispanics and other ethnicities. Those with ADHD were significantly more likely to be female, and there was no association between ADHD and

TABLE 3. Logistic Regression Model of Ever Using Methamphetamine

Variable	Odds Ratio	95% LCL	95% UCL
Hispanic vs. black	3.298	1.488	7.590
Other vs. black	2.409	0.739	8.238
White vs. black	5.808	2.538	14.285
ADHD at level of verbal aggression			
1	0.438	0.106	1.802
2	1.003	0.425	2.364
3	2.294	1.117	4.714
4	5.251	1.645	16.767
5	12.017	1.995	72.385

Notes: Hosmer-Lemeshow goodness-of-fit χ^2 (8) = 3.2319, p = 0.9190.
Verbal aggression is the verbal aggression subscale of the AQ. Odds ratios whose CI does not include 1 are significant. CIs for the interaction are Wald CIs. CIs for race are profile likelihood CIs. Wald χ^2 (3) for race is 19.0234, p = 0.0003. Wald χ^2 (1) for the interaction of ADHD with verbal aggression is 5.0298, p = 0.0249.

ethnicity. The mean age was 40.96 years (SD = 10.91), and there was no significant difference on age between those with and those without ADHD.

The first purpose of the study was to determine the likelihood that illicit stimulant use is associated with ADHD and is possibly being used to self-medicate ADHD symptoms. One way to do this is to show the relationship between the WURS and age of first use of illicit stimulants. Table 1 shows that although those with ADHD were not significantly different in age from those without ADHD at the time of participation in this study, those with ADHD were significantly younger at age of first use of amphetamines. In addition, Table 1 shows that those with ADHD were more likely to take illicit stimulants such as crack and amphetamine.

The second purpose of the study was to determine the association between ADHD and both direct and displaced aggression. The bottom of Table 1 shows that the total and all of the AQ subscales are significantly higher in those with ADHD compared with those without ADHD. The DAQ total and subscales are also significantly different between the ADHD group and the comparison group. For the AQ, the big effects are for the total, anger, and hostility scales. For the DAQ, the big effects are for the total and the angry rumination scales.

The third purpose of the study was to develop a more complex, but parsimonious, model of aggression, drug use, and ADHD. Figure 1 is such an overall model. What the model shows is that there is a significant interaction between ADHD and the verbal aggression subscale of the AQ that we discovered in step 6 of the Hosmer et al. model building procedure (Hosmer et al., 2013). The SEM is able to model both dependent variables of crack and amphetamine use simultaneously. The SEM shows that verbal aggression is a significant moderator of the relation between ADHD and crack use (p = 0.31) and amphetamine use

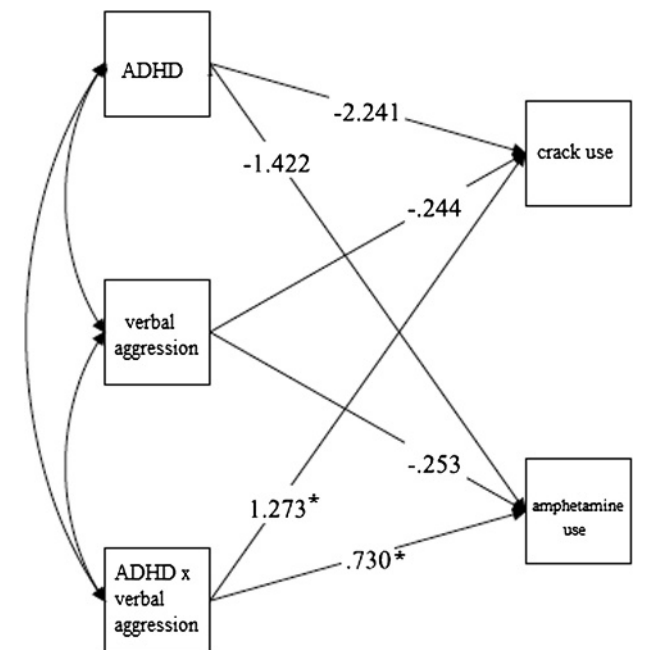


FIGURE 1. SEM with crack use and amphetamine use as outcomes and ADHD, verbal aggression, and the interaction between ADHD and verbal aggression as predictors. The numerical values indicate the estimates of the paths. The path between the interaction term and crack use was statistically significant (p = 0.031), and so was the path between the interaction term and amphetamine use (p = 0.034), thus indicating that verbal aggression was a significant moderator of the relation between ADHD and crack use, and between ADHD and amphetamine use.

($p = 0.034$). Thus, the strength of the relation between ADHD and crack and amphetamine use depends on the individual's level of verbal aggression.

We did not have sufficient power to include race in a three-way interaction in the SEM, so we ran crack and amphetamine separately using logistic regression. This way, we were able to adjust the odds ratios in the model by including race as a design variable in that white, Hispanic, and other were contrasted with black as the reference category. The verbal aggression subscale of the AQ that ranges from 1 to 5 and Tables 2 and 3 show that as verbal aggression increases, the simple odds ratio of using crack and amphetamine also increases. The verbal aggression scores of 1 or 2 are not significant because the CI for the simple odds ratio includes 1. When the CI includes 1, then the odds ratio is not significant. However, when the verbal aggression score is 3, 4, or 5, then the simple odds ratio increases dramatically and is significant. The upper confidence limit for a verbal aggression score of 5 shows that there is a lot of random error associated with this point of the interaction for crack. Table 2 shows that blacks are significantly more likely than whites or Hispanics to take crack when race is included in the model with the interaction between ADHD and verbal aggression. Table 3 shows that whites and Hispanics are significantly more likely than blacks to take amphetamines when race is included in the model with the interaction between ADHD and verbal aggression. There is less of a problem of a wide CI for the interaction when verbal aggression is 5 compared with the model for crack.

DISCUSSION

Several previous studies have reported associations between ADHD and use of illicit drugs, although in most of these reports the illicit drugs were combined together in a single variable (Biederman et al., 1998; Biederman et al., 1995; Downey et al., 1997; Gittelman et al., 1985). We wanted to specifically focus on the stimulants and their association with ADHD. In our low-income sample, we found associations with amphetamines and crack.

Regarding amphetamines, both the lifetime use of amphetamines and a significantly younger age of first use of amphetamines were in evidence in our results. Those with ADHD have been reported to be more likely to use methamphetamine and to use it more frequently than those without ADHD (Jaffe et al., 2005; Obermeit et al., 2013). We also found major effects and interactions for crack use with ADHD. Although there is much literature on cocaine use and ADHD, there is very little literature that is specifically on crack use and ADHD. Several of the studies that mention crack use in relation to ADHD have combined crack and powder cocaine in their analyses so that it is not possible to differentiate one from the other (Miguel et al., 2016; Roux et al., 2016). We were only able to find one study that was predominately of crack users, and this study found that those crack users with ADHD were more likely to progress to dependence as compared with those without ADHD (Falck et al., 2008). One of the strengths of our study is that we were able to distinguish between crack and powder cocaine use, and ours is one of the few reports to focus specifically on crack use and ADHD. Not only did we find that those with ADHD were more likely to ever use crack, but crack use in interaction with verbal aggression was associated with ADHD. Table 2 shows a temporal order of the interaction of verbal aggression with ADHD predicting crack use. There has been a previous study that showed an interaction between hyperactivity and conduct disorder being associated with significantly higher levels of both cocaine and amphetamine use in a follow-up study of children (Barkley et al., 2004). What we have done in our study is to show analogous findings, but for adults. Instead of hyperactivity, we had ADHD as measured by the WURS, and instead of conduct disorder, we had aggression as measured by both the AQ and the DAQ. Our interaction was verbal aggression and ADHD leading to crack use and amphetamine use that is similar to the Barkley et al. study.

We were able to take advantage of more modern methods of analysis and produced an SEM that had both crack and amphetamine as dependent variables. This supports the notion that it is stimulants in general that are being used to self-medicate ADHD and verbal aggression. Our follow-up Table 2 included race and showed that blacks are significantly more likely to take crack than either whites or Hispanics. We suggest that when blacks have ADHD and verbal aggression, then they are more likely to self-medicate with crack. This is due mainly to availability in that crack is much more prevalent and available in the blacks in our sample. Table 3 is our follow-up table for amphetamine, which included the interaction of ADHD and verbal aggression, but also includes race similar to Table 2. For amphetamine, however, it is whites and Hispanics who are significantly more likely to take amphetamine, which suggests that when whites and Hispanics have ADHD and verbal aggression, they self-medicate with amphetamine rather than crack. Again, we infer that this is due to availability.

In terms of our theoretical model, the Khantzian version of the SMH fits our data in that stimulant use is the specific type of drug that relieves an affective state in those with ADHD that causes them problems (Khantzian, 1997). In terms of the Duncan model of the epidemiological triangle, there would be an increased susceptibility of those with ADHD to take drugs to relieve their problematic behaviors when their symptoms were particularly acute, which would result in a negative reinforcement mechanism to explain the drug use (Duncan, 1975). However, there is an interaction between ADHD and aggression, which suggests that a Duncan model would hypothesize that those people with ADHD who are high on aggression are the ones who are behaving in a maladaptive manner by having too much aggression, which then produces stress, which is then relieved by taking stimulants. The fact that those with ADHD were significantly higher on both direct aggression and displaced aggression on bivariate analysis as indicated in Table 1 may be an indication that those with ADHD realize that they cannot always retaliate against their primary target and that doing so is maladaptive, that is, they developed displaced aggression as a way of coping when they realized that direct aggression was maladaptive. We would hypothesize that the stimulant use facilitates their behavioral transition from direct to displaced aggression.

There were several limitations in the current study. All of our data were self-report, although most of the instruments have established fair-to-good reliability and validity. We did not have data collected during the childhood of the participants and were only able to use the WURS to collect recollection of previous symptoms. Our sample was an adult sample, which is both a strength and a weakness. Our research center's location was in a low-income area, and the data may not generalize to samples with different characteristics.

CONCLUSIONS

In conclusion, this article makes several contributions. First, it is one of the few to report on the different illicit drugs separately and does not combine them into a single variable. This enabled us to be the first to show an association between ADHD and crack use. Second, this is the first report to show an interaction between ADHD and verbal aggression being associated with both crack and amphetamine use. We were able to show that crack for the most part is being used by blacks, and that amphetamine is being used by whites and Hispanics, and we suggest that blacks use crack to self-medicate ADHD and verbal aggression, whereas whites and Hispanics used amphetamines to self-medicate them. Third, this article has extended Barkley's finding in children of an interaction between hyperactivity and conduct disorder being associated with amphetamine and cocaine use, to our finding of an interaction between ADHD and aggression being associated with crack use and amphetamine use in adults. Finally, this is the first presentation to explain the interaction between ADHD and aggression and illicit drug use using the SMH.

DISCLOSURE

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The authors declare no conflict of interest.

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