

Impulse Control and Callous-Unemotional Traits Distinguish Patterns of Delinquency and Substance Use in Justice Involved Adolescents: Examining the Moderating Role of Neighborhood Context

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Abstract Both callous-unemotional (CU) traits and impulse control are known risk factors associated with delinquency and substance use. However, research is limited in how contextual factors such as neighborhood conditions influence the associations between these two dispositional factors and these two externalizing behaviors. The current study utilized latent class analysis (LCA) to identify unique classes of delinquency and substance use within an ethnically diverse sample ($n=1216$) of justice-involved adolescents (ages 13 to 17) from three different sites. Neighborhood disorder, CU traits, and impulse control were all independently associated with membership in classes with more extensive histories of delinquency and substance use. The effects of CU traits and impulse control in distinguishing delinquent classes was invariant across levels of neighborhood disorder, whereas neighborhood disorder moderated the association between impulse control and substance use. Specifically, the probability of being in more severe substance using classes for those low in impulse control was stronger in neighborhoods with fewer indicators of social and physical disorder.

Keywords Callous-unemotional traits · Impulse control · Delinquency · Substance use · Neighborhood context

Research has documented several important dispositional and environmental factors that can increase risk for externalizing behavior problems (Frick and Viding 2009). Impulse control and CU traits are two important dispositional factors that are associated with more severe patterns of externalizing behavior (Frick et al. 2014; Lynam 1996). It is likely that these two dispositional factors influence how one interacts with and responds to the environment, making a child more or less susceptible to its harmful effects. Neighborhood disorder has been identified as an important contextual factor in the development of externalizing behavior (Cleveland et al. 2010). Thus, neighborhood context may be an important factor influencing the association between impulse control and CU traits on various externalizing outcomes. In the current paper, we investigated whether the influences of CU traits and impulse control on patterns of two types of externalizing behaviors (i.e., delinquency and substance use) were moderated by neighborhood disorder. The theoretical basis for this moderational test is based on a number of lines of research.

First, CU traits are characterized by developmentally inappropriate levels of guilt and empathy, deficits in concern over performance in important activities, and restricted or shallow affect (DeLisi et al. 2014; Frick and Ray 2014). These traits are a consistent predictor of various types of externalizing behaviors. The majority of this research has focused on the association between CU traits and a severe, aggressive, and stable pattern of antisocial behavior. Specifically, Frick et al. (2014) reviewed 118 studies (70 cross-sectional and 48 longitudinal) in which CU traits specifically ($n=91$), or CU traits studied as part of the broader construct of psychopathy ($n=$

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27), were correlated with antisocial, delinquent, and aggressive behavior. A total of 125 studies (89 %) reported results indicating that CU traits were associated with antisocial outcomes, with the strength of the association varying greatly (r 's ranging from -0.15 to 0.84) and with an average correlation of 0.33 . Further, within adjudicated adolescents, CU traits are a risk factor for aggression that results in substantial harm to others (Flexon 2015; Kruh et al. 2005; Lawing et al. 2010) and for antisocial behavior that persists into adulthood (Byrd et al. 2012; McCuish et al. 2014). Research has also indicated that youth with CU traits are more likely to be risk-seeking and to engage in behaviors that potentially provide rewards, regardless of the negative consequences (Frick and White 2008). Because of such tendencies, youth with high levels of CU traits are also more prone to engage in risky substance use. Although there is much less work focusing on this type of externalizing behavior, CU traits have been found to be associated with recurrent and impairing substance use in adolescents (Hillege et al. 2010; Howard et al. 2012; Wymbs et al. 2012).

Second, low impulse control is also a well-documented risk factor for various types of externalizing behavior, including delinquency and substance use. Impulse control is the tendency or ability to resist temptations or urges and suppress potentially harmful behavior (Weinberger and Schwartz 1990). Research consistently finds an inverse relation between impulse control and delinquency (Bechtold et al. 2013) and substance use (White et al. 1987). Similar to CU traits, low impulse control has also been found to be associated with a particularly severe pattern of antisocial behavior, including the earlier onset of delinquency (Carroll et al. 2006; Sibley et al. 2013), higher rates of sexually aggressive behavior (Yeater et al. 2012), and more violent forms of delinquency (DeLisi et al. 2013; Sibley et al. 2011).

Third, research has consistently documented that neighborhoods differ substantially in their rates of delinquency and substance use by youth (Sampson and Groves 1989; Shaw and McKay 1942). These findings led Sampson et al. (1997) to suggest that negative structural characteristics of neighborhoods impede social cohesion among residents, reduce informal social control (i.e., collective efficacy), and increase opportunities for delinquent behavior. In support of this contention, neighborhoods characterized by low levels of collective efficacy as evidenced by both physical (e.g., graffiti, abandoned buildings, and excessive trash in public spaces) and social (e.g., fighting, drug/alcohol use, and gangs) disorder have higher rates of juvenile crime (Odgers et al. 2012; Sampson and Raudenbush 1999) and adolescent drug use (Jang and Johnson 2001).

Fourth, it is possible that youth with certain dispositions, including CU traits and low impulse control, may be more susceptible to the reduction in social control and increased opportunities for delinquent behavior and substance use

afforded by neighborhoods with high levels of physical and social disorder. Several studies have examined the potential moderating role of neighborhood on the association between dispositional factors and externalizing behaviors but the results have been inconsistent (Barker et al. 2011; Dupéré et al. 2007; Jones and Lynam 2009; Kroneman et al. 2011; Lynam et al. 2000; Meier et al. 2008; Neumann et al. 2010; Trentacosta et al. 2009; Vazsonyi et al. 2006; Zalot et al. 2007; Zimmerman 2010). For example, some studies find that the association between low impulse control and self-reported delinquency is much stronger among youth in economically disadvantaged neighborhoods or neighborhoods characterized with lower levels of collective efficacy (Lynam et al. 2000; Meier et al. 2008; Zalot et al. 2007). However, Zimmerman (2010) found that the associations between low impulse control and two forms of delinquency (i.e., violent and property) only emerged among neighborhoods with *high* socioeconomic status and *high* collective efficacy. In contrast, other studies have reported that the association between impulse control and antisocial behavior is invariant across neighborhood context (Barker et al. 2011; Neumann et al. 2010; Vazsonyi et al. 2006). Studies investigating the potential moderating role of neighborhood context in the association between CU traits and delinquent behavior are similarly inconsistent. Specifically, CU traits have been more strongly associated with delinquency in neighborhoods high on measures of disorganization in some studies (Dupéré et al. 2007; Markowitz et al. 2014; Meier et al. 2008), but have demonstrated strong associations with delinquency across neighborhood types in others (Kroneman et al. 2011; Trentacosta et al. 2009).

Thus, the potential moderating role of neighborhood disorganization in the association between externalizing behavior and either CU traits or impulse control is inconsistent and in need of further study. One potential reason for these inconsistencies could be the failure to consider different patterns of externalizing behavior. For example, there are clear differences in the trajectories of delinquent behavior, with some adolescents exhibiting high, severe, and stable patterns of behavior and others demonstrating less severe and more transient patterns of delinquent behavior (Broidy et al. 2003; Odgers et al. 2008). Further, there is both theoretical and empirical precedent for taking into account the existence of distinct classes or patterns of externalizing behavior in order to identify and understand the unique causal pathways leading to each class or pattern (DeLisi 2013). It is possible that these unique causal pathways are related to different dispositional and contextual factors or that it requires a combination of individual and contextual factors for a youth to exhibit the rarer but more severe and stable pattern of delinquency, whereas social influences alone could lead to the less severe and more transient patterns (Frick and Viding 2009; Moffitt 2006). In support of this possibility, Markowitz et al. (2014) reported that neighborhood income moderated the association

between CU traits and delinquency, but only for violent delinquency (e.g., serious physical fight) and not instrumental delinquency (e.g., theft). That is, CU traits were only significantly associated with violent delinquency in low income neighborhoods.

Another possible reason for inconsistencies in the findings from past research is that much of the past work has examined substance use and delinquency together (e.g., Vaughn et al. 2011a, 2014). Although there is evidence for overlap in these externalizing behaviors, there is also evidence that these behaviors may be associated with different risk factors (Vaughn et al. 2011b; Willoughby et al. 2004). Further, like delinquency, there is evidence that adolescents can show very different patterns of substance use and these patterns may be associated with distinct risk factors. To illustrate this, in a study of 521 middle school students, CU traits did not contribute to low levels of alcohol and marijuana use but did contribute to the prediction of more severe recurrent use and to the prediction of the level of impairment associated with this use (Wymbs et al. 2012).

Based on this past research, we tested whether neighborhood disorganization moderated the association of important dispositional characteristics (i.e., CU traits and impulse control) with patterns of externalizing behaviors (i.e., delinquency and substance use). That is, we tested the hypothesis that neighborhood characteristics would moderate the association of CU traits and impulse control with both outcomes, with the association expected to be stronger in neighborhoods characterized by more disorganization and lack of social cohesion. This hypothesis was tested in a large and ethnically diverse sample of justice-involved adolescents. Using this population is important for obtaining a sample with substantial variation in all of the variables of interest. Importantly, we utilized Latent Class Analysis (LCA) to identify distinct patterns of both delinquency and substance use, given the possibility that the influence of dispositional (i.e., impulse control and CU traits) and contextual (i.e., neighborhood disorder) variables may differ depending on the specific pattern of externalizing behaviors displayed by the youth.

Method

Participants

The current sample of 1216 adolescents includes all of the participants from the baseline interview of the Crossroads Study, which draws from the juvenile justice systems of Jefferson Parish, LA ($n=151$); Orange County, CA ($n=532$); and Philadelphia, PA ($n=533$). The general aim of the study was to compare outcomes of informally and formally processed youth. To be eligible for the Crossroads Study, juveniles have to be first time male offenders, be English speakers

between the ages of 13 to 17 ($M=15.29$; $SD=1.29$) at the time of arrest, and have an eligible offense. Eligible charges were mid-range offenses, such as theft of goods, simple battery, and vandalism. Across all three locations, 72.32 % of individuals eligible to participate enrolled in the study. The sample is predominately White-Latino (45.8 %) and Black (36.9 %), followed by White-non-Latino (14.8 %), and Other (2.5 %). Participants' average Wechsler Abbreviated Scale of Intelligence (WASI-II; Wechsler 1999) Full-Scale Intelligence Quotient (FSIQ), as estimated by two sub-tests (Vocabulary and Matrix Reasoning), was 88.50 ($SD=11.87$).

Measures: Outcomes

Delinquency Items from the self-report of offending scale (SRO; Huizinga et al. 1991) were used as indicators of latent classes of delinquent behavior. The SRO is comprised of dichotomous items, which ask participants if they have ever engaged in 24 different types of crime. The SRO has demonstrated significant correlations with official reports of offending (Thornberry and Krohn 2000). Typically, the SRO is scored by summing items endorsed by the youth, to give a total number of different types of crimes. However, given that the individual items were used in the LCA analyses to form classes that differed in their level and/or type of delinquent behavior, items that were endorsed by less than 4 % of the sample were excluded because of their potential negative effects on the LCA (Vaughn et al. 2011a). Limiting the LCA to items with those with sufficient variability left a total of 15 items used in analyses: fighting (87.8 %), shoplifting (48.3 %), damaging property (37.2 %), receiving stolen goods (27.8 %), selling marijuana (23.9 %), hurting someone bad enough they needed a doctor (16.4 %), stealing with force without weapon (15.3 %), joyriding (13.8 %), carrying a gun (10.8 %), gang fighting (9.9 %), stealing from a car (9.2 %), driving while drunk or high (8.7 %), burglary (8.6 %), selling other drugs (7.8 %), and stealing with use of a weapon (4.5 %).

Substance Use Items used to identify latent classes of substance use were taken from the Substance Use/Abuse Inventory (Chassin et al. 1991). Fourteen items asked participants to report on the frequency of use of specific substances over the course of their lifetime. However, these items were dichotomized (i.e., 0 = never used and 1 = ever used) for use in LCA. Again, items that were endorsed by less than 4 % of the sample were not included for the identification of latent classes (Vaughn et al. 2011a, b). Thus, 10 remaining items were included in the LCA: marijuana (58.4 %), alcohol (54.4 %), cigarettes (43 %), someone else's prescription drugs (8.6 %), ecstasy (8.3 %), hallucinogens (7.6 %), sedatives and tranquilizers (6.9 %), one's own prescription drugs (5.8 %), inhalants (4.8 %), and cocaine (4.7 %).

Measures: Dispositional Characteristics

Callous-Unemotional Traits The Inventory of Callous-Unemotional traits (ICU; Kimonis et al. 2008) is a 24-item instrument derived from the Antisocial Process Screening Device (APSD; Frick and Hare 2001), which is a rating scale commonly used to assess CU traits in children and adolescents. Participants rated items on a four-point Likert scale from 0 (*Not at all true*), to 3 (*Definitely True*). The use of the total score on the ICU has been supported in factor analyses conducted with both detained (Kimonis et al. 2008) and community (Essau et al. 2006; Fanti et al. 2009) samples of adolescents. Further, the ICU correlates positively with antisocial behavior and negatively associated with prosocial behavior (Essau et al. 2006; Fanti et al. 2009; Kimonis et al. 2008). Within the current sample, internal consistency for the ICU total score ($M=26.67$, $SD=8.08$) was acceptable (Cronbach's $\alpha=0.76$).

Impulse Control An eight-item subscale of the Weinberger Adjustment Inventory (WAI; Weinberger and Schwartz 1990) was utilized to measure impulse control. Participants indicated on a five-point scale from 1 (*False*), to 5 (*True*) how true each statement is of them (e.g., "I should try harder to control myself when I'm having fun"). A total score is calculated after reverse scoring seven of the items, with higher scores reflecting more impulse control. Lower scores on this measure of impulse control have been associated with persistent antisocial behavior from ages 14 to 22 (Monahan et al. 2009). The internal consistency of this scale ($M=26.00$, $SD=6.85$) in the current sample was acceptable (Cronbach's $\alpha=0.74$).

Measures: Contextual Moderator

Neighborhood Disorder Neighborhood disorder (ND) was assessed using the 21-item Neighborhood Conditions Measure, which was adapted from Sampson and Raudenbush's (1999) measure of physical (e.g., cigarettes on the street or in the gutters, boarded up windows on buildings) and social (e.g., people drunk or passed out, adults fighting or arguing loudly) disorder. Participants endorsed the physical and social disorganization items on a 4-point Likert scale ranging from 1 (*Never*) to 4 (*Often*), such that higher total scores indicate more disorganization in the neighborhood. The neighborhood disorganization scale and self-reported offending were significantly correlated in a sample of serious juvenile offenders (Chung and Steinberg 2006). Within the current sample, the neighborhood disorganization scale ($M=43.33$, $SD=14.24$) demonstrated excellent internal consistency (Cronbach's $\alpha=0.94$).

Procedures

Institutional Review Board approval was obtained at each site before data collection began. Consent was obtained from the parent of the juvenile, and assent was obtained from the participant. The parent and youth were informed that the research project had obtained a Certificate of Confidentiality from the Department of Justice, which allowed the research information to be protected from being subpoenaed for use in legal proceedings. Interviews were conducted at a location convenient to the youth, which ranged from his home, a place in the community, or a private office at one of the universities conducting the research. The interview was administered using a laptop with an interviewing program that included all of the items and measures for convenience and standardized administration. The WASI was administered during the interview as well. To control for reading ability, interviewers read aloud all items to the participant. The participants were compensated for their time with \$50 in cash.

Data Analyses

The current study first identified latent classes of delinquency and substance use by employing a Latent Class Analysis (LCA) procedure in Mplus software version 5.1 (Muthén and Muthén 2008). Multiple fit indices were used to determine the best fitting model (i.e., the optimal number of latent classes that best represent the data). These fit indices included the Lo-Mendel-Rubin Adjusted Likelihood Ratio Test (LMRT), Bayesian Information Criteria (BIC), sample-size adjusted BIC (ABIC), the Akaike Information Criteria (AIC), entropy values, and the mean posterior probabilities (Nylund et al. 2007; Lo et al. 2001). Additionally, the size of the class and the item probabilities for each model were examined to determine if substantively important classes were identified. Once the best-fitting model was identified, the individuals included in the analyses were assigned the class for which they had the highest probability of belonging based on their posterior probability values.

These classes were then utilized in separate analyses to test the moderating role of neighborhood on the associations between impulse control and CU traits and latent classes of each form of outcome (i.e., delinquency and substance use). It is important to note that research has identified problems with this approach (i.e., assigning individuals to classes based on highest probability); however, it has also been noted that this approach is acceptable when entropy values reach 0.80 or greater (Clark and Muthén 2009). For the moderation analyses a series of regression models were conducted in Stata version 13. Because class-membership was the outcome, a series of binary logistic models were conducted to compare each identified class on predictor variables. For significant interactions the average marginal effects of the predictors (i.e., impulse

control or CU traits) on the probability of being in a given class were plotted across the range of scores on the moderator variable (i.e., neighborhood disorder) in order to identify at what levels of the neighborhood disorder the interaction occurred. Also, collinearity diagnostic (Variance Inflation Factor; VIF) was assessed for all interactions. In cases where the VIF exceeded a value of 1 the variables used in the interaction terms were standardized (i.e., Z scores) for the analyses as recommended by Aiken and West (1991). Age, race/ethnicity (White-Latino, Black, White-non-Latino, and Other), IQ, and site (LA, PA, and CA) were included as covariates in the regression models.

Results

Identifying Latent Classes of Delinquency and Substance Use

Table 1 presents the fit indices for 2- through 5-latent class models for both outcomes (self-reported delinquency and substance). For delinquency, the AIC, BIC, ABIC, and LMRT favored the 3-class model over the 2-class model. When comparing the 3- to the 4-class model the AIC favored the 3-class model; however, BIC, ABIC, entropy, and LMRT values favored the 4-class model but these differences were marginal. More importantly, the 4-class model identified an additional, smaller class ($n=32$) that had slightly higher probabilities on delinquency items than the group with the highest probabilities in the 3-class model. A 5-class model was estimated, but none of the fit indices were better compared to the 4- or 3-class

models. Thus, the 3-class model was chosen as the best fitting solution in order to favor parsimony. A similar pattern emerged for the fit indices for the LCA of substance use. That is, the 3-class model was clearly favored over the 2-class based on all indices with the exception of the entropy (0.79 vs 0.81). However, the AIC and BIC values favored the 4-class compared to the 3-class, but again these differences in fit indices were marginal. The entropy and LMRT suggested that the 3-class model was the better fitting model. Substantive examination of the 4-class model revealed a smaller ($n=40$) class that was only distinguished by having slightly higher probabilities of endorsing substance use items. Thus, the 3-class substance use model was identified as the most parsimonious, best-fitting model.

Figures 1 and 2 present the plots of the mean posterior probabilities for indicators of class membership for the 3-class models for delinquency and substance use, respectively. Figure 1 clearly shows the largest class ($n=821$; 67 %) had a high mean probability of self-reporting having ever gotten into a fight, but very low probabilities of any other form of delinquency. As such, this class was termed the Fighter-only class. The second largest class ($n=328$; 27 %) had probabilities above 0.5 for engaging in shoplifting, damaging property, receiving stolen goods, and selling marijuana in addition to fighting and was, thus, labeled the Minor class. Finally, the smallest class ($n=67$; 6 %) had probabilities above 0.5 for engaging in every type of delinquency with the exception of burglary and was therefore termed the Varied class.

Figure 2 shows the mean probabilities for responding affirmatively to each type of substance use for the identified classes. The largest class was comprised of individuals with very low probabilities of ever having used any of the substances and, thus, this class was termed the Abstainer class. The second largest class ($n=489$; 40 %) had high probabilities of engaging in the “softer” types of substance use including alcohol, marijuana, and cigarettes and, thus, this class was termed the Soft drug class. Finally, the smallest class ($n=144$; 11 %) had relatively high probabilities of using all forms of drugs including some of the “harder” substances (e.g., ecstasy, cocaine, and prescription drugs) and was termed the Hard drug class.

Assessing the Moderating Role of Neighborhood Disorder

Self-Reported Delinquency Table 2 presents the results of the binary logistic regression models with the delinquency classes as outcomes. The top portion of the table presents results for the main effects model (i.e., no interaction term) and the bottom portion presents the results when the interaction terms for impulse control and neighborhood disorganization and for CU traits and neighborhood disorganization were entered into the model separately. For models 1 and 2, age, neighborhood disorder, impulse control, and CU traits had

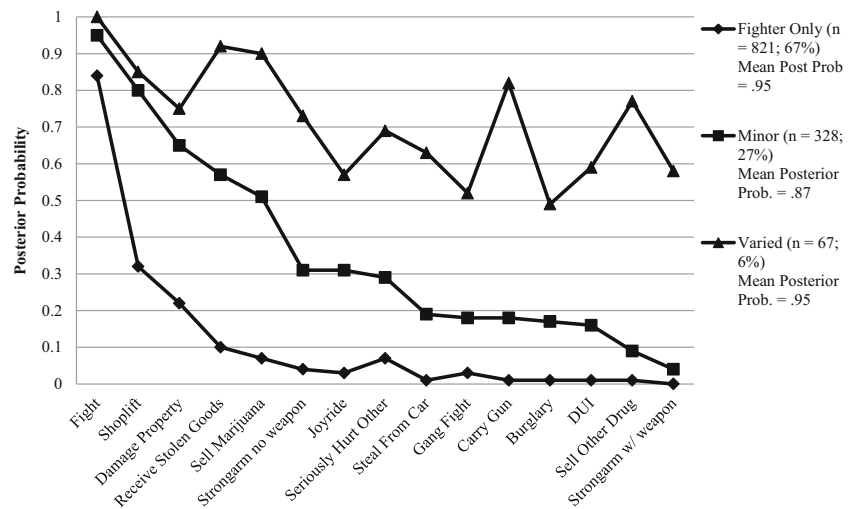
Table 1 Fit indices for latent class models of self-reported delinquency and substance use

	2 class	3 class	4 class	5 class
SRO				
AIC	12,948.99	12,688.44	12,633.24	12,608.00
BIC	13,107.20	12,928.29	12,954.75	13,011.17
ABIC	13,008.73	12,779.00	12,754.63	12,760.23
Entropy	0.88	0.83	0.86	0.73
LMR	2064.00***	290.01***	86.44*	65.10*
Substance use				
AIC	7474.59	7088.42	7063.10	7055.07
BIC	7581.75	7251.70	7282.50	7330.60
ABIC	7515.04	7150.06	7145.92	7159.07
Entropy	0.81	0.79	0.78	0.80
LMR	1665.59***	403.01***	46.73	29.65

SRO self-reported offending; AIC akaike information criteria; BIC Bayesian information criteria; ABIC adjusted Bayesian information criteria; LMRT Lo-Mendel-Rubin adjusted likelihood ratio test

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Fig. 1 Mean posterior probabilities for latent classes of delinquency



significant main effects; being older, reporting higher neighborhood disorder, lower impulse control, and higher CU traits increased the probability of being in the Minor and Varied offending classes compared to the Fighter-only class. However, in model 3, there was no main effect of impulse control, whereas being older, reporting more neighborhood disorder, and having higher levels of CU traits increased the probability of being in the Varied compared to the Minor offending class. Of most relevance for the test of moderation, the interaction terms for impulse control and CU traits with neighborhood disorder were not significant, suggesting that neighborhood context did not moderate the associations between these dispositional factors and being in a given delinquency class.

Substance Use Table 3 presents the results from three binary logistic regression models contrasting each of the identified

substance use classes. The models examining main effects showed significant effects for age, impulse control, CU traits, and neighborhood disorder. Similar to the delinquency findings, being older, reporting higher neighborhood disorder and CU traits, and having lower impulse control increased the likelihood of being in the Soft and Hard substance use classes compared to the Abstainer class, as well as increased the probability of being in the Hard compared to the Soft substance use class. There was also a consistent finding for race, such that being White-non-Latino compared to being White-Latino increased the probability of being in the Soft and Hard classes compared to the Abstainer class, as well as being in the Hard class compared to the Soft substance use class. The models including the interaction terms revealed significant interactions for impulse control and neighborhood disorganization when comparing the Abstainer class to the Soft class, as well as comparing the Abstainer to the Hard substance use class.

Fig. 2 Mean posterior probabilities for latent classes of substance use

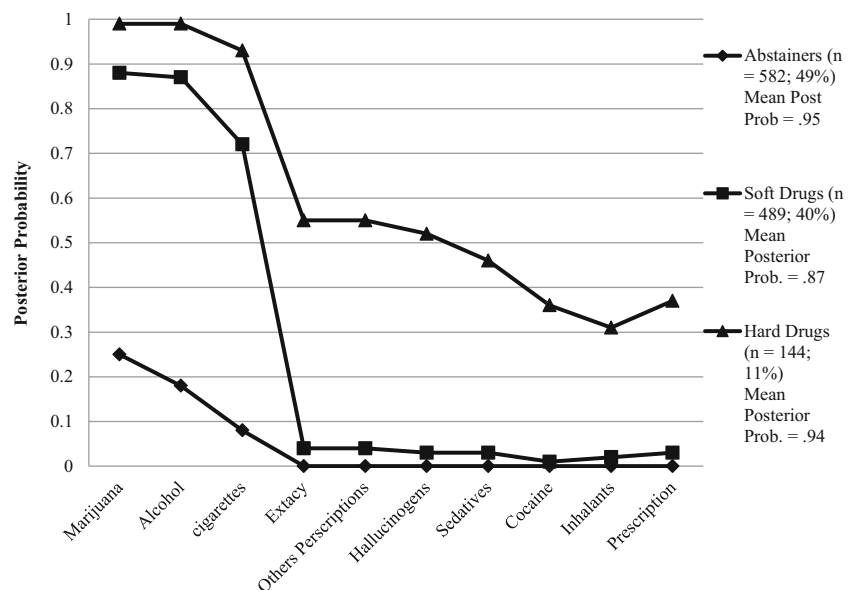


Table 2 Binary logistic regression models predicting delinquency class membership for main effects and interactions between impulse control and callous-unemotional traits with neighborhood disorder

Main effects	Model 1			Model 2			Model 3		
	Fighter-only vs. minor			Fighter-only vs. varied			Minor vs. varied		
	OR	(SE)	95 % CI	OR	(SE)	95 % CI	OR	(SE)	95 % CI
Age	1.36***	(0.08)	1.22–1.54	2.06***	(0.31)	1.53–2.77	1.71**	(0.26)	1.26–2.31
Race									
Black	1.22	(0.28)	0.78–1.92	0.71	(0.33)	0.28–1.78	0.63	(0.29)	0.26–1.54
White-nL	2.31***	(0.50)	1.51–3.54	0.69	(0.39)	0.23–2.08	0.58	(0.30)	0.21–1.59
Other	2.21	(0.98)	0.93–5.26	0.27	(0.34)	0.02–3.12	0.24	(0.27)	0.03–2.10
IQ	1.01	(0.01)	<1.00–1.02	1.05**	(0.02)	1.02–1.08	1.03	(0.02)	<1.00–1.06
Site									
CA	3.04***	(0.68)	1.96–4.70	1.61	(0.73)	0.66–3.91	0.73	(0.31)	0.32–1.67
LA	2.24**	(0.57)	1.36–3.70	2.19	(1.42)	0.62–7.78	0.53	(0.35)	0.15–1.96
ND	1.04***	(0.01)	1.03–1.05	1.07***	(0.01)	1.04–1.09	1.04**	(0.01)	1.02–1.07
IC	0.94***	(0.01)	0.92–0.96	0.90***	(0.02)	0.86–0.95	0.95	(0.03)	0.90–1.01
CU traits	1.05***	(0.01)	1.03–1.07	1.14***	(0.03)	1.09–1.20	1.09***	(0.02)	1.05–1.14
Pseudo R ²	0.16			0.41			0.20		
Interactions									
IC×ND	1.11	(0.08)	0.96–1.28	1.20	(0.20)	0.87–1.65	0.97	(0.18)	0.67–1.40
Pseudo R ²	0.16			0.41			0.20		
CU×ND	1.01	(0.08)	0.87–1.17	0.79	(0.14)	0.56–1.13	1.06	(0.16)	0.79–1.42
Pseudo R ²	0.16			0.41			0.20		

Latino is comparison group for race; Philadelphia site is comparison groups for site; nL non-Latino; ND neighborhood disorder; IC impulse control; CU callous-unemotional; OR odds ratio; CI confidence intervals. Interaction terms were created from standardized (z-scores) of those variables used to create them

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

These significant interactions are plotted in Fig. 3a and b. In both cases the negative effect of impulse control was stronger in neighborhoods with low social and physical disorder. In fact, the negative association between impulse control and probability of being in the Soft drug class relative to the Abstainer class was only significant at low levels of neighborhood disorder. For example, a one unit increase in impulse control was associated with a -0.01 ($p = 0.003$) decrease in the probability of being in the Soft vs. the Abstainer when neighborhood disorder is at its lowest (i.e., score of 21 on the neighborhood disorder scale). However, when neighborhood disorder is at its highest (i.e., a score of 81) a one unit increase in impulse control was not associated with an increase in the probability of being in the Soft vs. the Abstainer class (0.006 ; $p = 0.28$). Additionally, the likelihood of being in a class that uses Hard drugs decreased at higher levels of impulse control and this relationship was significant only at low levels of neighborhood disorder. For example, a one unit increase in impulse control was associated with a -0.01 ($p < 0.001$) decrease in the probability of being in the Hard vs. the Abstainer when neighborhood disorder is at its lowest. However, when neighborhood disorder was at its

highest a one unit increase in impulse control was not associated with an increase in the probability of being in the Hard vs. the Abstainer class (0.002 ; $p = 0.74$). In summary, at high levels of neighborhood disorder, impulse control did not exert an effect on the probability of being in the Soft or Hard drug class relative to the Abstainer class.

Co-occurring Externalizing Behaviors Because delinquency and substance use often co-occur and this co-occurrence tends to delineate a particularly problematic group of youth (Elliott et al. 2012), we examined the overlap in the identified classes for substance use and delinquency. It was found that of those participants in the Varied delinquency class, 38 (56.7 %) participants were also in the Hard substance use class while 26 (38.8 %) participants and 3 (4.5 %) participants were in the Soft and Abstainer classes, respectively. Similarly, for those in the Hard substance use class 38 (26.4 %) participants were in the Varied delinquency class while 83 (57.6 %) participants and 23 (16 %) participants were in the Minor and Fighter-only classes, respectively.

In order to examine risk factors that might account for the co-occurrence of these two externalizing behaviors, groups

Table 3 Binary logistic regression models predicting substance use class membership for main effects and interactions between impulse control and callous-unemotional traits with neighborhood disorder

Main effects	Model 1			Model 2			Model 3		
	Abstainer vs. soft			Abstainer vs. hard			Soft vs. hard		
	OR	(SE)	95 % CI	OR	(SE)	95 % CI	OR	(SE)	95 % CI
Age	1.75***	(0.06)	1.58–1.97	2.22***	(0.25)	1.78–2.76	1.36**	(0.14)	1.11–1.66
Race									
Black	0.51**	(0.10)	0.34–0.75	0.46	(0.22)	0.18–1.16	0.99	(0.44)	0.41–2.36
White-nL	1.63*	(0.38)	1.04–2.57	4.17***	(1.45)	2.11–8.24	2.14**	(0.60)	1.23–3.72
Other	0.87	(0.38)	0.37–2.05	0.53	(0.41)	0.12–2.38	1.35	(0.88)	0.38–4.84
IQ	1.02**	(0.01)	1.01–1.03	1.03*	(0.01)	>1.00–1.05	1.01	(0.01)	0.99–1.03
Site									
CA	1.10	(0.22)	0.74–1.64	9.24***	(3.91)	4.03–21.18	7.82***	(2.88)	3.79–16.11
LA	0.68	(0.16)	0.43–1.09	1.10	(0.65)	0.35–3.47	1.77	(0.92)	0.64–4.92
ND	1.01*	(0.01)	>1.00–1.03	1.04***	(0.01)	1.02–1.06	1.02*	(0.01)	>1.00–1.04
IC	0.98*	(0.01)	0.97–0.99	0.90***	(0.02)	0.86–0.94	0.93***	(0.02)	0.90–0.97
CU traits	1.03**	(0.01)	1.01–1.05	1.06***	(0.02)	1.02–1.10	1.03*	(0.01)	>1.00–1.06
Pseudo R ²	0.14			0.42			0.17		
Interactions									
IC×ND	1.14*	(0.08)	1.01–1.69	1.39*	(0.18)	1.08–1.79	1.20	(0.13)	0.97–1.50
Pseudo R ²	0.15			0.43			0.17		
CU×ND	0.87	(0.06)	0.76–1.00	1.01	(0.11)	0.82–1.25	1.07	(0.11)	0.88–1.31
Pseudo R ²	0.15			0.42			0.17		

Latino is comparison group for race; Philadelphia site is comparison groups for site; *nL* non-Latino; *ND* neighborhood disorder; *IC* impulse control; *CU* callous-unemotional; *OR* odds ratio; *CI* confidence intervals. Interaction terms were created from standardized (z-scores) of those variables used to create them

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

were created based on the overlap in class-membership and used as an outcome in a multinomial logistic regression model (MLOGIT). That is, four groups were created that included individuals classified as being in: 1) both the Varied and Hard classes ($n=38$), 2) either the Varied or Hard classes but not both ($n=135$), 3) either in the Minor or Soft classes but not in the Varied or Hard classes ($n=530$), and 4) both the Fighter-only and Abstainer classes ($n=512$). In the MLOGIT model the group which categorized individuals who were in both the Varied and Hard classes was the comparison group. The findings were consistent with the previous models predicting class membership separately for delinquency and substance use classes. That is, CU traits and neighborhood disorder were the most consistent risk factors for being in both the Varied and Hard classes compared to the other three groups: Fighter-only and Abstainer ($\beta=-0.14$, $p < 0.05$ and $\beta=-0.09$, $p < 0.05$, respectively for CU traits and neighborhood disorder); either in the Minor or Soft classes (but not Varied or Hard; $\beta=-0.09$, $p < 0.05$ and $\beta=-0.06$, $p < 0.05$, respectively); and either Varied or Hard ($\beta=-0.05$, $p < 0.05$ and $\beta=-0.05$, $p < 0.05$, respectively). Impulse control was also a significant risk factor for being in both the Varied and Hard classes and those in the

Fighter-only and Abstainer classes ($\beta=0.11$, $p < 0.05$) and those in the Minor and Soft classes ($\beta=0.08$, $p < 0.05$). However, neither of the interaction terms between CU and neighborhood disorder or IC and neighborhood disorder were significant in these analyses.

Discussion

The goal of the current study was to test whether neighborhood disorder altered the associations between dispositional characteristics (i.e., impulse control and CU traits) and two important externalizing behaviors (i.e., delinquency and substance use) in an ethnically diverse sample of justice-involved adolescents. Different classes of delinquent and substance use behavior were identified and then used as outcomes in analyses. Consistent with past research, several discrete patterns of delinquent behavior emerged (Odgers et al. 2007). Specifically, the majority of the justice involved adolescents reported only fighting (67 %) or fighting as well as mild delinquent behavior (27 %). Only 6 % of the youth were engaged in a large number of different types of delinquent

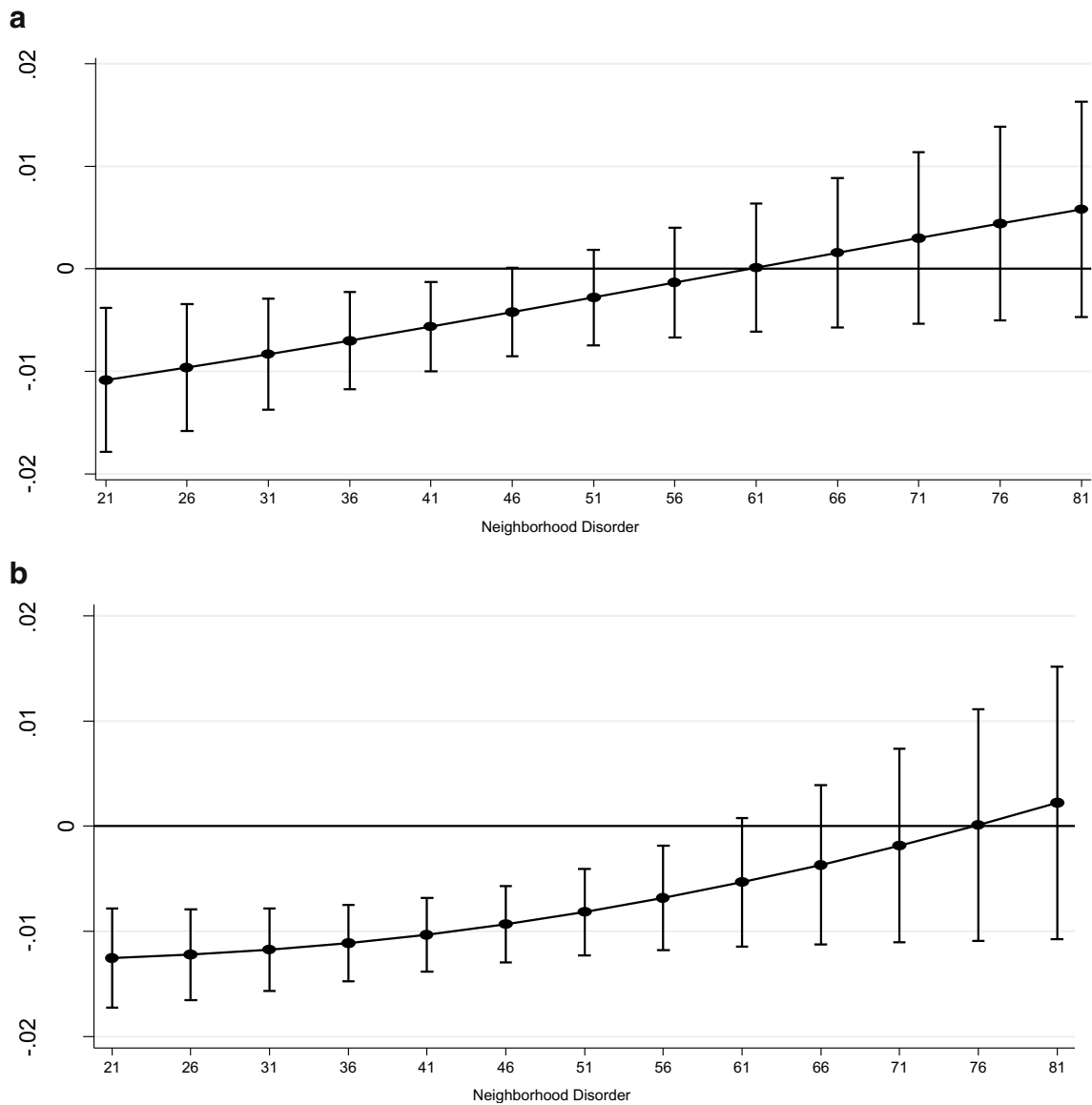


Fig. 3 a Average marginal effects of impulse control on the probability of being in abstainer (0) versus soft (1) substance class at various levels of neighborhood disorder with 95 % confidence intervals. **b** Average

marginal effects of impulse control on the probability of being in abstainer (0) versus hard (1) substance class at various levels of neighborhood disorder with 95 % confidence intervals

behaviors. Similarly, the majority of the youth reported very little substance use (49 %) or only soft drug use (40 %), with just 11 % of the sample reporting significant hard drug use. In the current sample, there was quite a bit of variation on both self-reported delinquency (range=0–15) and self-reported substance use behaviors (range=0–10). However, only a small portion of individuals reported varied engagement in each form of externalizing behavior. These findings are consistent with prior research in justice-involved adolescents that has identified a small class of offenders that is responsible for a disproportionate amount of externalizing behavior (e.g., Vaughn et al. 2011a, b, 2014). We also identified a class that seemed to specialize in a particular form of violence (i.e., fighting). The item assessing this was “Have you ever been

in a fight”. This wording likely led to somewhat normative levels of fighting and arguments being endorsed. In fact, 88 % of the sample reported “fighting” using this item, whereas only 10 and 16 % reported engaging in a “gang fight” or “hurting someone so badly they needed a doctor”, respectively. Thus, the fighter-only group seems to be engaging in relatively mild levels of externalizing behavior.

With regard to delinquency, our results suggest that impulse control, CU traits, and neighborhood disorder all contributed independently in distinguishing class membership. Further, this was relatively consistent across models distinguishing between juveniles who engaged mainly in fighting versus those who engaged in more varied delinquency, as well as between those whose delinquency was limited to

more minor offenses and those who reported more varied delinquent behaviors. The one exception to this pattern of findings was that impulse control did not distinguish between those in the varied delinquency class from those in the minor delinquency class. More importantly, the effects of impulse control and CU traits on delinquency were invariant across different levels of neighborhood disorder, as found in several previous studies (Barker et al. 2011; Kroneman et al. 2011; Neumann et al. 2010; Vazsonyi et al. 2006). Importantly, past research has found similar results using other definitions and measures of neighborhood disorder, such as defining impoverished neighborhoods based on census-track data (Barker et al. 2011) or defining high risk neighborhoods based on perceived neighborhood dangerousness (e.g., Kroneman et al. 2011).

In the analyses distinguishing substance use patterns, CU traits and neighborhood disorder again showed consistent main effects but no interactions. Thus, these variables seem to provide unique and additive information when distinguishing substance use class membership in justice-involved adolescents. However, neighborhood disorder did moderate the effects of impulse control on substance use in two of the three models. Contrary to expectations, the effect of impulse control was stronger when comparing class membership for both soft and hard drug users to abstainers, with the negative association between impulse control and substance use being largely found in youth from neighborhoods with low physical and social disorder.

Although somewhat unexpected, these findings for impulse control and neighborhood disorder are in line with those of Zimmerman (2010) and suggest that high neighborhood disorder promotes substance use for individuals who experience its criminogenic effects (e.g., feeling of hopelessness, exposure to substance use and violence), regardless of one's individual characteristics (i.e., impulse control). Alternatively, neighborhood characteristics in the form of low disorder may fail to protect youth from substance use who are low in impulse control. In other words, the current findings suggest that the risk for substance use related to low impulse control may only be apparent in less harmful social contexts (e.g., neighborhoods that lack disorder; Raine 2002). Taken together, these findings suggest that research should study other moderating factors (e.g., peers, family, and school) that may act as protective factors for adolescents with individual predispositions to substance use, such as impulse control. Additionally, these findings suggest the need for research to identify the mechanisms through which neighborhoods characterized by high rates of social disorder promote substance use. Potential mechanisms include increased opportunity for substance use due to a lack of informal social control, increased presence of models for substance use, and culture norms supportive of substance use (Allison et al. 1999). Consistent with these possible mechanisms, our measure of neighborhood disorder

included items indicating whether substances (e.g., as evidenced by needles or syringes) or individuals using substances (e.g., people smoking crack, people using needles or syringes to take drugs) were present in the adolescent's neighborhood.

These results need to be interpreted in the context of several important limitations of the study. Most importantly, the data are cross-sectional, and longitudinal studies in which outcomes are measured later in time from the predictors and moderators allow for stronger inferences to be made about moderation. Additionally, although the sample was large and was both geographically and ethnically diverse, it only included justice-involved boys and, as a result, the findings may not generalize to community samples and samples of girls. Similarly, the generalizability of the current findings to non-justice involved youth who engage in externalizing behaviors also requires further testing. Further, all measures were based on the adolescent's self-report (e.g., delinquency and neighborhood disorder), which makes it possible that some of the associations may have been inflated due to shared method variance. Thus, the results need to be replicated using other methods of assessment, such as using census track data to assess impoverished neighborhoods or drug testing to assess substance use. In addition, impulsivity is a multidimensional construct (Whiteside and Lynam 2001), which the measure used in the current study does not capture. The inclusion of a measure that captures the multidimensionality of impulsivity may uncover unique associations among the different facets of impulsivity and membership groups that differ in their level of delinquency and substance use. Also, the strength of the effects for the significant main effects and interactions were quite small, somewhat attenuating their importance for both policy and research. Finally, in the introduction, we provided theoretical and empirical reasons for testing whether the moderating role of neighborhood disorder may differ across distinct patterns of delinquency and substance use. However, the classes that emerged could easily be conceptualized as differing along a continuum of severity, rather than as classes with distinct etiologies.

Within the context of these limitations, our results contribute to a growing body of research highlighting the need to study the potential moderating effects of contextual risk factors when studying the associations of individual characteristics with adolescent externalizing behaviors (Elliott et al. 2015). Specifically, this study did so by considering distinct types of externalizing behaviors (i.e., delinquency and substance use) separately and identifying heterogeneity in patterns externalizing behaviors. This is important given the potential for unique causal pathways to different types and patterns of externalizing behaviors (Moffitt 2006). In the current sample CU traits, low impulse control, and neighborhood characteristics all contribute independently to distinguishing among patterns of delinquent behavior. This is not only important for the development of theoretical models but it also

supports the use of multi-component treatments for delinquency that consider both the predispositions in the child and the influence of his or her context (Burns et al. 2003; Henggeler et al. 1998). Our results also suggest that CU traits and neighborhood contribute uniquely when distinguishing among patterns of adolescent substance use in a juvenile justice-involved sample. However, it does appear that the effects of impulse control on substance use are stronger in neighborhoods characterized by low levels of physical and social disorder. Thus, interventions targeting improvements in the living conditions within communities may have positive effects on substance use for youth with normative levels of impulse control (Truong and Ma 2006); however, such approaches may not return similar effects for certain vulnerable youth. Thus, research should continue to focus on identifying those mechanisms (e.g., family, peers, and school) that may be most influential in preventing externalizing behaviors, particularly for youth with certain dispositional tendencies that elevate their risk for substance use (e.g., impulsiveness, CU traits).

Conflict of Interest The authors declare that they have no conflict of interest.

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