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Callous-Unemotional Traits Trajectories Interact with Earlier Conduct Problems and Executive Control to Predict Violence and Substance Use Among High Risk Male Adolescents

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Abstract Callous-unemotional (CU) traits, conduct problems (CP), and deficits in executive control are all linked to the development of more severe antisocial behavior, including violence and substance use. Though previous research has examined the impact of these factors on antisocial outcomes, little work has examined trajectories of CU traits across adolescence and how these trajectories predict greater antisocial behavior in adulthood. Moreover, no study has assessed how severity of early CP and executive control may exacerbate these pathways and increase risk for later violence and substance use. The current study (a) identified trajectories of CU traits among a large, high-risk sample of adolescent males, (b) examined the relationship between CU traits trajectories and future violence and substance use, and (c) examined whether early CP and executive control moderated the effects of a high CU traits trajectory membership and high CP on violence and substance use. Results indicated that: (a) CU traits could be grouped into three stable trajectories across adolescence, (b) the 'high' CU traits trajectory, particularly in the presence of 'elevated' CP, was related to higher violence and substance use, over and above a variety of environmental risk factors, and (c) the effects the 'high' CU traits trajectory on both violence and substance and in the presence of 'elevated' CP was stronger among youth with *high* executive control. These findings highlight the utility of identifying subgroups of youth who differ on trajectories of CU traits for understanding the development and maintenance of severe antisocial behavior.

Keywords Antisocial behavior · Callous-unemotional traits · Conduct problems · Violence · Substance use · Executive control · Trajectories

Antisocial behavior (AB), including early conduct problems (CP) and later violence and substance use, entails great cost to society through its impact on perpetrators, victims, and family members. Recent research has examined the role of callous-unemotional (CU) traits (e.g., lack of empathy and guilt) in the development of AB. In particular, the presence of high CU traits appears to put youth at risk for severe and persistent forms of aggression and violence (Frick et al. 2014). However, despite being conceptualized as 'traits', few studies have examined CU traits longitudinally. Further, no studies have tested whether knowing about *trajectories* of CU traits adds to our understanding of the development of specific types of AB, particularly during the early adulthood period when AB may evolve in its severity (i.e., violence, substance use). Importantly, it is yet to be established the extent to which elevated levels of early CP interact with CU traits trajectories to predict worse AB outcomes. Finally, beyond CU traits, neuropsychological deficits in executive functioning (e.g., low executive control) are strongly related to AB (e.g., Ogilvie et al. 2011). However, no previous studies have examined whether deficits in executive control exacerbate the risk posed by high levels of CU traits and early CP in the prediction of later violence or substance use. The goals of the present study were to identify trajectories of CU traits, examine the prediction of adult AB by CU traits trajectories while controlling for early CP, and explore the impact of

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elevated CP and executive control on the prediction of later violence and substance use by CU traits trajectory membership.

Links Between CU Traits and Antisocial Behavior

Youth with CU traits are characterized by a lack of empathy, lack of remorse and guilt, and reduced affective responsivity to others (Frick et al. 2014). High CU traits have been shown to predict increased risk of AB and violence among youth across different developmental stages and sample types (see Frick et al. 2014 for a review). However, while several studies have linked broader measures of adolescent psychopathic traits (i.e., including impulsive/life-style components) to high risk for substance use (e.g., Andershed et al. 2002), only one study has examined links between CU traits and substance use. Among youth assessed in the 6th grade, CU traits predicted onset and recurrence of substance use by the 9th grade (Wymbs et al. 2012). The lack of attention to potential links between CU traits and substance use is surprising given theoretical links between CU traits/psychopathic traits with substance use (Frick et al. 2014), and the established high comorbidity between substance use and psychopathy (Smith and Newman 1990).

Together, previous studies underscore the importance of CU traits in developmental models of AB. However, previous research is limited by a focus on CU traits assessed at *one time point*, which contradicts widely cited perspectives on individual differences in AB over the life course (Moffitt 1993; Piquero 2008). Indeed, despite well-established individual differences in the onset, chronicity, and *stability* of AB over time, particularly during adolescence, few studies have considered *trajectories* of CU traits. However, this kind of person-centered approach is appealing because it might identify specific discontinuities or groups that emerge based on patterns of data over time, rather than at one time point. Thus, identifying whether youth show stable or high levels of CU traits over time may be a more valid way to predict outcomes compared to simply examining their 'rank' or mean score at any one time point (see Fontaine et al. 2011; Salihovic et al. 2014).

For example, Fontaine and colleagues (2011) examined a large sample of twins from a community sample (N=9578). Joint trajectories of CU traits (high, increasing, decreasing, and low) and CP (high and low) were identified using three time-points from ages 7 to 12. There was asymmetry between CU traits and CP, such that high CU traits trajectory membership was strongly related to having high CP, whereas having high CP was only moderately related to CU traits. Importantly, the small proportion of children with a joint high/increasing CU traits and CP trajectories were at risk of the most negative outcomes at age 12, including emotional problems and hyperactivity (Fontaine et al. 2011). Use of a large, community sample of children followed longitudinally during a critical period of childhood and the group-based approach to examine trajectory membership are strengths of this study. However, more work is needed to examine trajectories of CU traits using multiple time points in high risk youth and across *later adolescence*, when CU traits may become more stable. This is also a period when CU traits trajectories could predict more diverse and severe forms of AB (e.g., substance use and violence). Indeed, adolescence is important because it is a developmental transition characterized by increasing independence and social and physical change, but in the context of immature regulatory functioning (e.g., Arnett 2004). These changes are compounded by greater opportunity to be involved with deviant peers and enact more severe AB. Finally, the transition from adolescence to early adulthood is when AB peaks (e.g., Arnett 2004; Shaw and Gross 2008), making this an important period in which to understand CU trait trajectories, particularly as they may predict escalation into persistent and severe violence or substance use.

Interaction Between CU Traits and CP in the Prediction of Severe Antisocial Behaviors

The role of earlier CP also needs to be considered in relation to CU traits trajectory group membership and AB outcomes. First, the extent to which high and stable levels of CU traits add to the prediction of AB needs to be established, taking into account the severity of early CP. That is, it is important to establish that any predictive power of CU trajectories is not due to CU trajectories tapping existing, elevated levels of CP. Second, we need to identify whether there are interactive effects between CU traits trajectories and CP, such that knowing about *both* may be helpful in identifying youth most likely to persist in their AB. For example, youth with high CU traits and CP have been shown to exhibit higher impulsivity (Andershed et al. 2002), more instrumental and reactive aggression (e.g., Frick et al. 2003), and increased risk for persistent delinquency into adulthood (Byrd et al. 2012). Further, in the one study that has examined substance use in relation to CU traits, males with both elevated CU traits and CP were at highest risk of substance use by 9th grade, when compared to those with elevated CU traits-only, CP-only, or low CU traits and low CP (Wymbs et al. 2012). Taken together, these findings suggest that identifying high CU traits trajectories may be most powerful when also knowing about levels of CP. To date, however, no previous studies have examined the interactive effect of elevated CP and subsequent CU traits *trajectories* across adolescence in the prediction of substance use or violence.

What is the Role of Executive Control in Predicting AB?

In addition, a large body of research has examined neuropsychological deficits associated with AB. Studies have focused on

executive functioning, an umbrella term referring to a range of cognitive processes, including executive control, working memory, and selective attention (e.g., Chan et al. 2008; Morgan and Lilienfeld 2000). AB among adults and youth has been linked to impairments in many of these processes, including failures to learn from punishment or to alter behavior in the face of changing contingencies. Deficits in executive function are thought to explain why antisocial individuals persist in aggressive or sensation-seeking behavior despite the likelihood of negative consequences (De Brito and Hodgins 2009). In support of this notion, meta-analytic studies examining childhood, adolescent, and adult populations with conduct disorder, oppositional defiant disorder, or antisocial personality disorder, have demonstrated strong links between executive function deficits and AB (e.g., Morgan and Lilienfeld 2000; Ogilvie et al. 2011). However, studies have yet to consider how executive functioning might interact with or exacerbate the effects of CU traits across adolescence in relation to the prediction of later AB, including violence or substance use.

Other Risk Factors for Antisocial Behaviors and CU Traits

Beyond individual-level risk factors, studies have also linked the development of AB to a range of contextual risk factors, including parenting practices and criminality (e.g., Loeber et al. 1998), neighborhood dangerousness (Barnes and Jacobs 2013), and deviant peers (Dishion and Patterson 2006). Further, evidence also suggests an important role of parenting in the development of CU traits (Waller et al. 2013). Thus, any examination of the *unique* main effects of CU traits, as well as interactive effects of CU traits, early CP, and executive control, needs to take into account the influence of these other key sources of risk. However, while studies have highlighted the importance of considering family and contextual risk factors as *predictors* for CU traits and violence/substance use (see Waller et al. 2013), the present study focused on examining the main effects of CU traits trajectories, and thus included family and contextual risk factors as *covariates* (see Waller et al. under review for an examination of these and other factors as *predictors* of CU trait trajectories).

Current Study

The current study sought to improve our knowledge of the development of violence and substance use via three research questions. Given that only two previous studies have examined trajectories of CU traits and both sassessed community samples where levels of CU traits may be relatively low, our first goal was to examine the stability of CU traits in a large sample of high-risk, male youth over a 5 year period, using a group-based trajectory model with five time points, and controlling for baseline levels. Specifically, we examined whether there were qualitatively different groups within our sample, based on their developmental trajectory of CU traits across a key period of adolescence, and the extent to which these trajectories would be marked by change across time. Consistent with previous literature, we hypothesized that a small subset of our high-risk adolescent sample would show a stable trajectory of high levels of CU traits across time. Second, in line with previous literature noting the importance of considering CU traits in the context of CP, we examined the joint predictive effects of earlier CP and CU traits trajectories on later violence and substance use. We hypothesized that elevated CP symptomatology in tandem with a high CU traits trajectory would be associated with the highest levels of AB (Frick et al. 2014). Third, we examined the role of executive control (a subtype of executive function), in relation to links between CU traits trajectories, early CP, and violence/substance use. As no previous studies have examined how or whether executive control moderates the prediction of AB by CU traits and early CP, this third study aim was exploratory. Finally, in order to elucidate *specific* effects of CU traits trajectories, early CP, and executive control on violence or substance use, all models controlled for the well-established effects of putative contextual, parental, and child-level risk factors (Waller et al. 2013).

Methods

Participants

The present study used data from the Pathways to Desistance project, a multisite, longitudinal study of serious juvenile offenders (see Schubert et al. 2004, for complete details of study methodology). Participants in the current study were male youth adjudicated delinquent or found guilty of a serious (overwhelmingly felony level) offense at their current court appearance in Philadelphia, PA (N=605) or Phoenix, AZ (N=565). We restricted analyses to male offenders (N=1,170), as the data set had an insufficient number of females in the sample (n=184) to obtain a stable trajectory model (Nagin 2005). Youth were eligible for study participation if they were between the ages of 14 and 18 and had been charged with a felony or similarly serious non-felony offense (e.g., misdemeanor weapons offense, misdemeanor sexual assault) (see Table 1). Since a large proportion of offenses committed by youth were drug offenses, the proportion of males whose enrollment offense was a drug offense was capped at 15 % at each of the sites. Of eligible youth, 67 % of those who were located and

Table 1 Sample characteristics

	N	Minimum	Maximum	M	SD
Baseline variables					
Age	1170	14	18	16.05	1.16
14 (*N*=144) (12.3 %)					
15 (218) (18.6 %)					
16 (346) (29.6 %)					
17 (358) (30.6 %)					
18 (104) (8.9 %)					
Sex (Male)	1170				
Race					
White	225	0	1	0.19	–
Black	493	0	1	0.42	–
Latino	398	0	1	0.34	–
Other	54	0	1	0.05	–
School dropout	1169	0	1	0.16	–
Single parent	1169	0	1	0.45	–
Proportion family arrested	1162	0	1	0.31	0.40
Proportion friends arrested	1168	0	1	0.45	0.38
Neighborhood conditions	1167	1	4	2.35	0.74
# Early onset problems	966	0	5	1.51	1.19
IQ	1158	55	128	84.50	12.84
Anxiety (RCMAS)	1169	1	28	9.79	5.94
Emotion control (Walden)	1169	1	4	2.77	0.66
Executive control (Stroop)	1150	21	79	50.46	7.08
Independent variables					
CP	1170	0	1	0.705	0.456
CU (YPI) Group trajectories	1170				
Low	299	0	1	0.256	0.495
Moderate	673	0	1	0.575	0.500
High	198	0	1	0.169	0.358
CU Traits+CP	1170				
'Low' *CP*					
'Low' CU	120	0	1	0.103	0.315
'Moderate' CU	193	0	1	0.165	0.384
'High' CU	32	0	1	0.027	0.168
'Elevated' *CP*					
'Low' CU	179	0	1	0.153	0.330
'Moderate' CU	480	0	1	0.410	0.471
'High' CU	166	0	1	0.142	0.319
Dependent variables					
Variety of violence					
Baseline	1084	0	8	0.501	1.14
5-year follow-up	995	0	7	0.316	0.863
Variety of substance use					
Baseline	1165	0	9	2.07	1.92
5-year follow-up	995	0	9	0.630	1.02

invited to participate in the research agreed to enroll in the study. Participants completed six annual face-to-face interviews over the course of the study (one baseline and five follow-up). Sample retention for the Pathways Project was high at each follow-up, ranging from 84 to 94 % (*M*=90 %) (see Mulvey et al. 2004 for details).

Measures

Primary Independent Variable

Callous-Unemotional (CU) Traits CU traits were assessed via self-report using the Youth Psychopathic Traits Inventory (YPI; Andershed et al. 2002). The CU traits subscale includes 15 items, rated on a four-point Likert scale (0='does not apply at all' to 4='applies very well'). Examples of CU traits items include: 'I usually feel calm when other people are scared,' and 'I think that crying is a sign of weakness, even if no one sees you'. Items were written so that individuals high in CU traits would read the statements as reflecting positive or admirable qualities. The YPI was administered annually starting with ages 15–19 over a 6-year period (ages 20–24). CU traits scores showed good internal consistency (range, α=0.73–0.79 over the course of the study and the cross-time correlation was high (average interclass r=0.85)).

Dependent Variables

Self-Reported Violent Offending A modified version of the Self-Report of Offending (SRO; Elliott 1990; Huizinga et al. 1991) scale, focused on the items tapping violence, was used at the final assessment point to measure the adolescent's account of his involvement in eight different violent crimes (fights as part of gang activity, assault, carjacking, robbery with weapon, robbery without weapon, shooting someone, shooting at someone, carrying a gun). Youth indicated whether they had done any of these activities over the last 12 months. Each item was coded to reflect whether the respondent reported engaging in each act at least once. Dichotomized items were then summed together. A sum of the number of types of violent offenses committed (a general versatility or variety score) was calculated for each subject at each interview. Variety scales are often compared with frequency scales that index the number of times that a specific act occurred. For the current study, we focused on a variety scale as research indicates that variety scales are more internally consistent and more stable (Bendixen et al. 2003). The intra-class correlation for violence across time was 0.75.

Self-Reported Substance Use We examined self-reported substance use at both the baseline (as a control for autoregressive effects) and final assessment points. Adolescents reported on the frequency of their use of nine substances (marijuana, opiates, cocaine, stimulants, ecstasy, sedatives, hallucinogens, inhalants, amyl nitrate) over the past 12 months. A variety scale (i.e., number of types of substances used in the past year) was calculated and used in the study analyses. Analyses controlled for baseline substance use as a predictor of the 5-year follow-up interview report. The intra-class correlation across time was 0.75.

Moderating Variables (Assessed at Baseline)

Early Conduct Problems (CP) To compute a variable that assessed self-reported symptoms of early CP, we used the SRO measured and general life history interview variables assessed at baseline (Mulvey 2013). In total there were 11 items included in the CP measure: 3 items assessed aggression (e.g., bullying, school fights, and cruelty to animals) and 8 items assessed rule violations (e.g., running away, school problems, fire-setting, fraud). We computed a total score of number of CP items endorsed (i.e., continuous measure). It is noteworthy that all participants at baseline were adjudicated as serious felony level offenders, reducing the potential variability of CP. However, the continuous CP measure was normally distributed (skewness=0.35, kurtosis=−0.61). We also created a binary CP score based on youth endorsing 3 or more items ('elevated' CP; i.e., elevated being a relative term referring to scores being 'high' within our high-risk sample) or fewer than 3 items ('low' CP). We also recomputed the CP measure including 8 items assessing violence (e.g., fight, fights as a part of gang activity, assault, carjack, robbery with weapon, robbery without weapon, shooting at someone, carrying a gun), producing similar results. We report findings based on the binary CP measure *without the violence items* however, to reduce overlap with our outcome assessment of violence versatility. Models examining interactions between CP and CU traits trajectory in the prediction of later violence and substance use also controlled for the main effect of earlier CP on later violence (i.e., the heterotypic continuity/escalation from CP to later violence).

Executive Control Executive control, a subtype of executive function, was assessed through the use of the widely-used Stroop Color-Word Test (Golden 1978), which indexes cognitive flexibility and resistance to interference from outside stimuli. The Stoop Color-Word task is a gold-standard measure of executive control, with many previous studies establishing its psychometric properties and construct validity in both healthy and psychiatric populations (see Cauffman et al. 2009; Golden 1978; Homack and Riccio 2004; Mulvey 2013). This measure assesses the effects of interference on reading ability and comprises three parts: first, participants read a word page (the names of colors printed in black ink), second they read a color page (rows of X's printed in colored ink) and finally the read a word-color page (the words from the first page are printed in the colors from the second page; however, the word meanings and ink colors are mismatched or incongruent). The task included five columns containing 20 items. During the standardized task, subjects look at each sheet and move down columns, reading words or naming ink colors as quickly as possible within a 45-s time limit. The present study used the standard *T*-score for interference based on normed data (see Mulvey 2013; Cauffman et al. 2009). Higher scores reflect better performance and less

interference on reading ability, and higher executive control. T-scores of 40 or less are considered "low" and above 40 are considered in the "normal" range (Golden 1978).

Risk Factor Covariates (Baseline Measures)

Research has also linked child-level, family, and contextual sources of risk to AB. To examine the *unique* effect of CU traits trajectories on AB, we included as many of these factors as possible as covariates. Each of the measures below was evaluated via self-report at baseline.

Individual Characteristics (*i*) *School dropout* was coded as a dichotomous variable (yes/no); (*ii*) *Intelligence* was measured by the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler 1999). The WASI produces an estimate of general intellectual ability based on two subtests, Vocabulary and Matrix Reasoning (see Bowen et al. 2014; Mulvey et al. 2010 for examples of this measure within youth with AB); (*iii*) *Emotion regulation* was measured via self-report using an adapted version of the Children's Emotion Regulation scale (Walden et al. 1995). Of the 33 original items contained in this scale, 12 were included in the version for Pathways to Desistance (e.g., 'I can change my feelings by thinking of something else'). Participants responded on a 4-point Likert-type scale ranging from 'not at all like me' to 'really like me.' Higher scores indicate a better ability to regulate emotion (α=0.81); and, (*iv*) *Anxiety* assessed via the 28-item total score on the Revised Children's Manifest Anxiety scale (RCMAS; Reynolds and Richmond 1985) (α=0.87).

Family/Peer Characteristics (*i*) *Family arrests* were assessed by computing the proportion of family members residing with the participant who had been arrested; (*ii*) *Peer deviance* was assessed by computing the proportion of each participant's four closest friends who had been arrested; and, (*iii*) *Neighborhood conditions* were measured using 21 items adapted from other large-scale studies of neighborhood functioning and impoverishment (Sampson and Raudenbush 1999). Items assessed physical and social disorder in the blocks surrounding their homes (e.g., abandoned buildings, gang activity) and were rated on a four-point scale ranging from 1 (never) to 4 (often). A mean score was computed (α=0.94). (*iv*) *Single-parent household* was measured dichotomously (single parent household/not).

Data Analytic Strategy

Identification of CU Traits Trajectories First, we used group-based trajectory modeling, a type of mixture modeling, to identify subgroups of individuals who followed similar patterns of CU traits over time. Trajectories were created based on chronological age but results are nearly identical using time point in the study. Trajectories, over 5 years, controlling for baseline, overlapped in time with the outcome measures. We used the Latent Gold 4.5 program (Vermunt and Magidson 2008) to estimate the probability that each individual belonged to a given group based on data. We simultaneously derived maximum-likelihood parameter estimates associated with membership in each of the defined trajectories. On the basis of posterior probabilities, individuals were assigned to their most likely group trajectory (Nagin 2005). CU traits were examined across six measurement points including baseline, with a total accelerated longitudinal age range of 14 to 24. Data were tested for different numbers of latent classes, and the fit of different models was compared with the Bayesian information criterion (BIC; Jones et al. 2001). Mixtures of up to six latent classes were considered. The best trajectory solution was determined by three criteria: the lowest BIC value, posterior probabilities, and a model in which each group included at least 5 % of the sample (Nagin 2005). The shape of each trajectory was determined by initially including linear, quadratic, and cubic parameters, and then dropping non-significant trajectories. The shape of each trajectory is identified by the highest order term included in the model. In the first iteration, linear, quadratic, and cubic parameters were included for each of the three trajectories. The cubic parameters were non-significant for each. Thus, in iteration 2 the cubic parameters were dropped from each trajectory. The quadratic parameter was non-significant for the moderate trajectory. Thus, in the final model the quadratic parameter was dropped from the moderate trajectory. For the final model, the moderate trajectory was linear, and the low and high trajectories were quadratic. Multiple imputation (MI) was used to address missing data because other strategies for managing missing data (e.g., listwise or pairwise deletion, mean imputation) may result in biased analyses (Bodner 2008; Graham 2009). In the MI for the current study, we included age at baseline, ethnicity, CP at all follow-up time periods, and measures derived from official records (e.g., total number of court petitions prior to and including baseline and total number of arrests during the 5-year follow-up) to obtain more stable imputed values based on more information. Following recommendations by Bodner (2008), 20 data sets were imputed using STATA 12. This approach, with age-locked trajectories treats this sample as an accelerated longitudinal design with planned missingness and thus leverages 5 years of study data collection to model 8 years of trajectories (Raudenbush and Chan 1992).

Prediction of Violence and Substance Versatility Second, negative binomial regression was used to examine prediction of violent offending and substance use at the final 5-year follow-up assessment. We added child-, family-, and contextual risk factors (assessed at baseline) and CU traits trajectory membership (assessed over the 5 year study period). Traditional linear regression models would have been inappropriate

for analyzing count outcomes because count data do not follow, or approximate, a normal distribution (King 1989). In the current study, an initial conditional Poisson distribution model deviance statistic indicated over-dispersion (when the true variance is bigger than the mean), thus, negative binomial regression analyses were used to examine outcomes of violence and substance use. Variables were entered simultaneously to assess relative associations of the covariates with CU traits trajectory group membership.

Interaction with CP Third, a binary CP variable (i.e., 'elevated' or 'low' CP) was entered into regression models to examine interactive effects with CU traits trajectories. We focused on the interaction between 'high' CU traits trajectory membership and 'elevated' CP. Note that although a 'high' CU traits and 'elevated' CP group was our primary focus, we also examined other possible interactions between 'high', 'low', and 'moderate' CU traits trajectories and 'elevated' versus 'low' CP groups. We provide brief reference to effects for these other interaction terms, but focus on the results for the 'high' CU traits and 'elevated' CP group, who represented youth in whom we were most interested and for whom the most robust effects emerged. Given our relatively large sample size, we were able to model interactions within this 'high' CU traits trajectory group, an option not usually available in smaller datasets where cell sizes would be too small.

Moderation by Executive Control Finally, we examined whether the effects of CU traits trajectories and CP symptoms on later violence and substance use were further moderated by executive control, as indexed by the Stroop Color-Word interference score. An interaction term between 'high' CU traits trajectory and 'elevated' CP group membership and executive control score was added to models. Using the PROCESS tool (Hayes 2012), we also ran an interactional model that examined at which *specific* Stoop T-scores the interaction between 'high' CU and 'elevated' CP (CU+CP+) was significant (e.g., PROCESS provides information about the interaction and the simple effects at levels of the moderator where the interaction is significant).

Results

Trajectories of CU Traits

First, we found that a three-group solution for CU traits trajectories fit the data best (Fig. 1). The estimate for entropy was 0.897, indicating appropriate distinction of the three trajectories. Overall, the data revealed a uniform pattern of low-to-high CU traits over time. Group 1 (26.5 %) had low CU traits at baseline that remained low and stable in the follow-up periods ('low'). Group 2 (57.4 %) had a moderate level of CU traits across the study period ('moderate'). Group 3 (16.1 %) had high CU traits at baseline that remained stable and high in the follow-up periods ('high'). Posterior probabilities indicated that, on average, individuals were well matched to the groups to which they were assigned (average posterior probabilities were as follows: 'low' group=69 %, moderate group=73 %, high group=82 %). Next, we used multinomial regression to examine whether differences among trajectory groups existed in AB and other relevant variables. Not surprisingly, the 'high' CU group committed the highest average number of violent crime types at 5 year follow-up (0.66) compared to the 'low' (0.16) and 'moderate' (0.29) groups. Participants in the 'high' CU group also used more types of substances at follow-up (0.97) compared to the 'low' (0.46) and the 'moderate' CU (0.60) trajectory groups. Also, as expected, a large proportion of the 'high' CU traits trajectory group (83.8 %) was classified as being in the 'elevated' early CP group compared youth in the 'low' (59.9 %) or 'moderate' (71.3 %) groups. Indeed, youth in the 'low' and 'moderate' CU groups were 54.3 and 23.7 % less likely to be in the 'elevated' CP group respectively compared to the 'high' CU traits group. By contrast, only 19.3 % of youth who we classified as being in the 'elevated' CP group were in the 'high' CU trajectory group.

Main Effect of CU Traits Trajectories in the Prediction of Violence and Substance Use

We examined whether CU traits trajectories predicted violence, controlling for individual-, family-, peer-, and neighborhood-level risk factors[1] and baseline CP. First, we found that individuals in the 'low' and 'moderate' CU traits trajectory groups were 68.8 and 45.5 % less likely, respectively, to exhibit violence versatility at follow-up compared to those in the 'high' CU traits trajectory group (Table 2, Model 1). Significant associations were also found between CU traits trajectories and substance use at the 5-year follow-up assessment, controlling for covariates as before (Table 3, Model 1). Youth in the 'low' and 'moderate' CU traits trajectory groups were 42.6 and 30.7 % less likely, respectively, to

[1] The inclusion of these covariates is important given the number of individual, peer, and family factors linked to violence and substance use. Our analyses demonstrate that CU traits trajectories predicted violence and substance use above and beyond these other factors. However, the 'high' CU-violence ($p<0.001$) and 'high' CU–substance use ($p=0.001$) relationships were significant even when not including these covariates. A model not including covariates indicated that the 'high' CU group was 2.83 times more likely to engage in violent versatility at the 5 year follow-up and 1.44 times more likely to engage in versatile use of substances at the 5 year follow-up point.

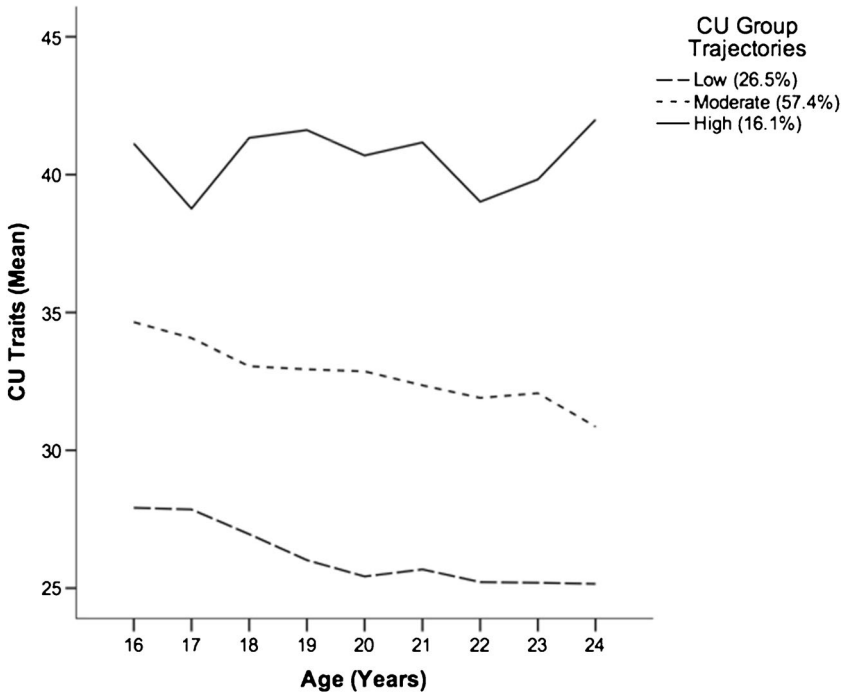

Fig. 1 Trajectories of CU traits

use a greater variety of substance types at follow-up compared to participants in the 'high' CU traits group.

Interaction Between CU Traits Trajectories and Early CP in the Prediction of Violence and Substance Use

For the prediction of violence, the interaction between CU traits trajectories and CP symptoms indicated significant differences between the 'high' CU traits group and all subgroups with the exception of the 'high' CU traits and 'low' CP group (Table 2, Model 2).[2] Specifically, compared to the CU+CP+ group, the 'low' CU traits trajectory group who were classified as having 'low' CP was 82.8 % less likely to show violence versatility at the 5-year follow-up assessment. Results were similar when the CU+CP+ group was compared to other groups: 'moderate' CU traits group with 'low' CP (75.7 % less likely), 'low' CU and 'elevated' CP group (62.0 % less likely), and the 'moderate' CU and 'elevated' CP group (32.5 % less likely). These comparisons indicate that CU traits trajectory group membership over time was a better predictor of later outcomes than early levels of CP only. Further, the comparison between CU+CP+ and the group with 'high' CU traits but 'low' CP was not significant, highlighting the robust and unique effect of high CU traits trajectories on future violent offending, regardless of earlier CP.

For the prediction of substance use, analyses comparing specific subgroups to the CU+CP+ group indicated that youth in the 'low' and 'moderate' CU traits trajectory groups with 'low' CP were 60.4 and 44.4 % less likely to exhibit substance versatility at follow-up, respectively (Table 3, Model 2). All other group comparisons (i.e., 'high' CU traits with 'low' CP; 'low' CU traits and 'elevated' CP; 'moderate' CU traits and 'elevated' CP) with the CU+CP+ group did not reach significance. These non-significant comparisons suggest the importance of considering either 'high' CU traits trajectory membership or earlier elevated CP symptoms in relation specifically to the prediction of substance use versatility. As before, the results were robust to the effects of various putative family, child and contextual sources of risk, as well as earlier baselines assessments of substance versatility.

Further Moderation by Executive Control

The results of the moderation analyses are presented in Column 3 of Tables 2 and 3 (Model 3). The main effect of executive control at baseline was not significant in predicting later violence or substance use. However, we found a significant interaction between executive control and all subgroups when compared to the CU+CP+ group in the violent offending model. Probing of these significant interactions suggested that youth in the CU+CP+ group with *high* executive control (i.e., high Stroop difference T-scores) showed higher violence

[2] We re-ran the analyses using the continuous CP measure and results were consistent with the binary CP measure. Specifically, individuals with higher levels of CP were more likely to display violence versatility (B=0.21, $p<0.01$) and substance use (B=13, $p<0.01$) at the 5-year follow-up assessment. Moreover, adolescents with 'high' CU traits trajectories and elevated levels of earlier CP were more likely to exhibit violence and substance use at follow-up.

Table 2 Odds ratio for the impact of CU trajectories, CU+CP, and executive control on violence versatility

	Model 1: CU trajectories	Model 2: CU+CP+	Model 3: CU+CP+ × Executive control
CP (Baseline)	2.64***	2.64***	2.63**
'Low' CU	0.312***	–	–
'Moderate' CU	0.545***	–	–
'Low' CU/'Low' CP	–	0.172***	0.956***
'Moderate' CU/'Low' CP	–	0.243***	0.974***
'High' CU/'Low' CP	–	0.919	0.984**
'Low' CU+'Elevated' CP	–	0.380***	0.970***
'Moderate' CU+'Elevated' CP	–	0.675*	0.990**

The reference group in Model 1 'High' CU trajectory group. The reference group for Models 2–3 is 'High' CU+'Elevated' CP. *$p<0.05$ **$p<0.01$ ***$p<0.001$

versatility scores (Fig. 2). Specifically, CU+CP+ youth with Stroop T-scores above the 85th percentile ($n=29$) were more likely to exhibit violence versatility at follow-up than other groups. For substance use, youth in the 'low' and 'moderate' CU traits trajectory groups with 'low' CP were significantly less likely to exhibit substance versatility at follow-up compared to the participants in the CU+CP+ and high executive control group. All other group comparisons with the CU+CP+ group did not reach significance. The significant comparisons indicate that respondents in the CU+CP+ group with Stroop T-scores above the 61st percentile ($n=75$) were more likely to use a variety of substances at follow-up compared to the 'low' and 'moderate' CU traits groups with 'low' CP (Fig. 3).

Discussion

In the current study we examined the impact of CU traits trajectories, self-reported CP symptoms, and executive control on AB among a large high-risk sample of adolescent males. We explored several questions relating to identifying trajectories of CU traits and their association with later AB, the interactions between CU traits trajectories and earlier CP symptoms on later AB, and the moderating role of executive control in these pathways. This is the third study to have examined *trajectories* of CU traits among youth, and the first to do so among a large group of males at high risk of engaging in high levels of future violence and substance use. Our findings extend understanding of the development of CU traits and severe AB in three ways.

Identification and Predictive Validity of CU Traits Trajectories in Adolescence

First, our findings yielded three meaningful trajectories of CU traits across adolescence that appeared stable over the assessment period. Our results fit with the broader literature, highlighting the need for studies to consider individual differences in the level of adolescent personality and antisocial features *over time* (e.g., Moffitt 1993; Piquero 2008; Waller et al. under review). In particular, a small subset of youth (16.1 %) was classified as showing high and stable levels of CU traits across the study period. This 'high' CU traits trajectory membership was related to violence and substance use, even after controlling for a variety of individual-, family-, and peer-level

Table 3 Odds ratio for the impact of CU trajectories, CU+CP, and executive control on substance use versatility

	Model 1: CU trajectories	Model 2: CU+CP+	Model 3: CU+CP+ × Executive control
CP (Baseline)	1.45**	1.43**	1.47**
'Low' CU	0.574***	–	–
'Moderate' CU	0.693**	–	–
'Low' CU/'Low' CP	–	0.396***	0.983**
'Moderate' CU/'Low' CP	–	0.556**	0.988*
'High' CU/'Low' CP	–	1.63*	1.01
'Low' CU+'Elevated' CP	–	0.805	0.996
'Moderate' CU+'Elevated' CP	–	0.851	0.996

The reference group in Model 1 'High' CU trajectory group. The reference group for Models 2–3 is 'High' CU+'Elevated' CP. *$p<0.05$ **$p<0.01$ ***$p<0.001$

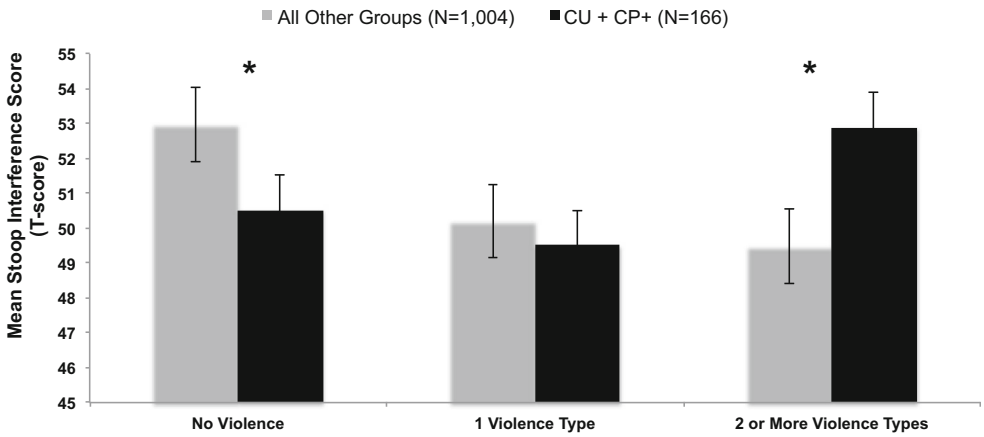

Fig. 2 Interaction among CU traits, CP, and executive control on violence. Note: CU+CP+= 'High' CU+'Elevated' CP group. *Asterisks* indicate significant effects at $p<0.05$

risk factors, as well as baseline levels of CP and earlier substance use. These results are in line with previous studies suggesting that the presence of CU traits is related to more severe AB and substance use among youth, but also extends this prior literature to assess developmental trajectories using a stringent control for confounding variables (e.g., Frick et al. 2014; Wymbs et al. 2012). In particular, CU traits are theorized to increase risk for violent and substance use behaviors because youth may be less responsive to the emotional distress of victims (Marsh and Blair 2008) and are highly focused on reward, with little care for consequences (Blair 2013). Our findings are also in line with the adult literature, where studies have demonstrated high overlap between psychopathy and substance use (Taylor and Lang 2006).

Risk Associated with CU Traits and Elevated Levels of Earlier Self-Reported CP Symptoms

Second, our results highlight the risk associated with youth having high and stable levels of CU traits and existing, elevated levels of self-reported CP symptoms. As predicted, the 'high' CU trajectory group had significantly higher levels of self-reported CP symptoms at baseline when compared to youth with either 'moderate' or 'low' CU traits trajectories. However, there was evidence of *asymmetry* in the relationship between CU traits and CP. Specifically, youth with high CU traits were highly likely to be classified as having 'elevated' CP (83.8 %) but youth with 'elevated' CP were only moderately likely to be classified as being in our 'high' CU traits trajectory group (19.3 %), indicating that those with CU traits are very likely to have 'elevated' levels of CP but most individuals with 'elevated' CP are not high on CU traits. Our findings fit with a previous trajectory analysis among a population sample of children, where a similar asymmetrical relationship emerged (Fontaine et al. 2011), indicating that CU traits may primarily be considered as a particularly severe subgroup within adolescents exhibiting CP. Further, these findings are in line with the adult literature, where antisocial personality disorder does not always overlap with psychopathy, whereas most individuals with psychopathy meet criteria for antisocial personality disorder (e.g., Forsman et al. 2010). Unlike Fontaine and colleagues, however, we did not identify subgroups with 'changing' CU traits – including increasing or decreasing CU traits. Instead, we found relatively high within- and between-person stability in CU traits across time. One explanation for this difference may arise from sample type. We focused on a high-risk, older sample of youth who had already had contact with the law and among whom trajectories of CU traits may have been more stable. In

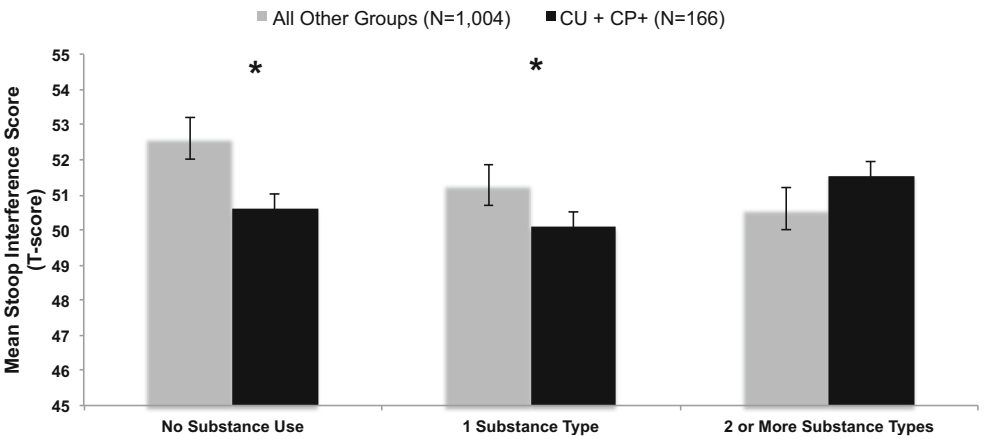

Fig. 3 Interaction among CU traits, CP, and executive control on substance use. Note: CU+ CP+= 'High' CU+'Elevated' CP group. *Asterisks* indicate significant effects at $p<0.05$

contrast, Fontaine and colleagues examined CU traits trajectories among a population-based sample of twins who were assessed at much younger ages (7–12 years old), when CU features may be expected to be less stable. Thus, sample type and developmental stage may affect relative 'stability' of CU traits (also see Waller et al. 2013).

Moreover, we found that youth with a joint 'high' CU traits trajectory and elevated levels of self-reported CP (CU+CP+) showed the highest likelihood of later violence, but they did not differ significantly from youth with 'high' CU traits and 'low' levels of CP. Thus, although CU+CP+ youth showed the most violence later, the effect appeared to be driven by CU traits trajectories rather than CP levels. Thus, findings suggest that within adjudicated youth, high and chronic levels of CU traits may be more important in predicting outcomes over and above existing AB (also see Frick et al. 2014). For substance use however, there was a subtly different pattern of findings. As with violence, CU+CP+ youth were most likely to show more substance use, but only when compared to groups with 'low' or 'moderate' CU traits and *low* levels of CP. Specifically, a 'high' CU traits trajectory (regardless of the level of CP) *or* a classification of elevated CP (even for 'low' or 'moderate' CU traits) were both related to later substance use. In this regard, findings suggest that while CU traits may exacerbate risk, elevated levels of CP even in the absence of CU traits, increase the likelihood of later substance use. Though speculative, it is possible that the mechanisms leading to engagement in substance use differ between these groups – for example, elevated CP levels in the absence of CU traits have been linked to emotional dysregulation and impulsivity, whereas elevated CP and CU traits appear to be related to lower emotional responsivity and punishment insensitivity (Frick and Morris 2004). Further, work among adults has demonstrated that psychopathic traits, AB, and substance use disorders may overlap at a latent level because of a shared heritable risk for AB (Blonigen et al. 2005). Thus, CU traits may act a *specific* risk factor for violence but a more *general* correlate of AB, producing overlap with CP and substance use. However, future studies are needed to test this question among samples of children and adolescents.

Moderation by Executive Control

Finally, a novel aspect of this study is that we examined moderating effects of executive control on links between CU traits, CP, and later violence and substance use. A large body of literature suggests that deficits in executive control are related to higher aggression and sensation-seeking behavior (De Brito and Hodgins 2009). However, the present study found that the effects of CU+CP+ on both violence and substance versatility were stronger among youth with *high* executive control. In other words, for youth with high, stable CU traits and elevated levels of early CP, higher executive control (i.e., cognitive flexibility and resistance to interference from stimuli) increased the likelihood that youth would exhibit violence and substance versatility. This finding is surprising given the separate literatures linking each of these three variables (high CU traits, elevated self-reported CP symptoms, *and low* executive control) to worse AB. However, in our sample, this small group of youth (n=29) may represent an important at-risk subtype who account for the very worst AB outcomes. It is noteworthy that in a previous cross-sectional study that examined detained males adolescents, Muñoz and colleagues found that males with high CU traits and high verbal ability scores reported greater violence compared to males with low CU traits and low verbal ability (Munoz et al. 2008). Further, in a large population sample of males followed from ages 12 to 24, Barker and colleagues (2011) found that *higher* neurocognitive ability was related to chronic theft over time. Finally, Waschbusch and Willoughby (2008) also reported that CU traits and CP were the strongest predictors of aggression in children with low ADHD symptoms (a disorder associated with deficits in executive control). Taken together, these previous studies, along with the present findings, suggest that *higher* executive control may enable CU+CP+ youth to successfully engage in violence or substance versatility. In particular higher executive control may support the planning and implementation of more effective strategies to obtain their desired goals, either through violence or other methods, with less chance of spending time incarcerated.

Strengths and Limitations

There were a number of strengths to the current study, including assessment of a large, high-risk sample of male youth, followed for 5 years, novel examination of interactive effects of CU traits trajectories, self-reported CP, and executive control, and stringent control in models for the potential effects of relevant covariates. However, our findings should be considered alongside a number of limitations. First, with the exception of the measure of executive control, we relied on self-report for all measures. Though youth may be the best reporters of some of these behaviors (i.e., substance use, violence) and use of autoregressive effects can somewhat mitigate shared-method bias, our approach may have overestimated effects through shared method biases. Future studies examining prospective links between CU traits trajectories and CP and violence or substance use should include objective reports or official records to avoid potential limitations associated with single reporter data collection. Second, because some items assessing self-reported CP symptoms were only available at baseline assessments, we were unable to examine interactive effects of CP at later assessment waves with CU traits trajectories. Joint trajectory analysis of CP and CU traits in this sample would be very interesting but with our current measure of CP, it was not possible. Third, because of

power issues, we were unable to include females from the Pathways study, as we would not have been able to estimate trajectory group memberships. Previous studies have estimated trajectories of CU traits among females (Fontaine et al. 2011), but future studies are needed to examine trajectories of CU traits among high-risk adolescent samples including both males and females. Fourth, the proportion of the sample enrolled specifically with a drug offense was capped at 15 %, which may have meant that there was reduced variability in assessment of substance use at the final assessment point. Thus, our findings may not generalize to other adjudicated samples of youth among whom rates of substance use may be higher due to greater rates of drug related offenses. However, drug offenses are not necessarily indicative of use, meaning that many 'non-substance' offenders may have had high levels of substance use, although this overlap is difficult to evaluate within the Pathways dataset. Moreover, we caution use of the terms 'elevated' and 'low' that simply refer to *relative* levels of CP in our high-risk sample, and would likely not apply in more normative samples, highlighting the need for replication of our finding in different sample types. Finally, although the current study was novel in examining the moderating effect of executive control on links between CU traits, CP, and AB, we focused on an interference paradigm with the Stroop Color-Word task, which only indexes one type of executive control. Future studies are needed that incorporate a wider battery of neuropsychological assessments.

Conclusions

The current study adds to the evidence base supporting CU traits as a useful subtyping approach within youth AB (cf., DSM-5; Frick et al. 2014). In particular, youth with high and stable CU traits were more likely to engage in violence and substance use 5 years later, over and above both elevated levels of existing self-reported CP, earlier substance use, and a range of other relevant covariates. Thus, assessing CU traits among high-risk adolescents may be particularly useful for targeting early or tailored intervention and treatment components. Beyond links between CU traits and violence and substance versatility, we found an interesting interaction with early CP and executive control. Specifically, youth with 'high' CU, 'elevated' CP, and *high* executive control were at greater risk of engaging in AB, which may fit with previous conceptualizations of psychopathy whereby cognitive abilities goes some way toward masking some of the negative behavioral and interpersonal features linked to psychopathy (e.g., Cleckley 1976). Taken together, the findings of this study highlight the utility of identifying subgroups of youth who differ in the *trajectories* of their CU personality features, which appears to have meaningful predictive validity in relation to costly and harmful AB.

Conflict of Interest None declared

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