Eur Child Adolesc Psychiatry
DOI 10.1007/s00787-014-0663-3

ORIGINAL CONTRIBUTION

Neighborhood income and the expression of callous–unemotional traits

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Received: 3 July 2014 / Accepted: 11 December 2014

Abstract Callous–unemotional (CU) traits, including an uncaring nature and reduced empathy, represent a strongly heritable pattern of socio-emotional responding linked with elevated risk for severe, persistent delinquent behavior. Although evidence suggests that CU traits vary continuously across the population, research linking CU traits and delinquency is often conducted with incarcerated or clinical samples, obscuring potential heterogeneity in this relationship across the full range of high-CU individuals. Using a nationally representative sample, this study examines the role of neighborhood income in moderating the association between CU traits and delinquency in terms of both level and type of offending. Findings corroborate the link between CU traits and delinquency and suggest that the link between high-CU traits and violent delinquency may be unique to youth living in low-income neighborhoods.

Keywords Delinquency · Callous–unemotional traits · Neighborhoods

Introduction

Callous–unemotional (CU) traits such as shallow affect, reduced empathy, and reduced remorse represent the core affective deficits of psychopathic personality, and are considered among the most significant risk factors for severe, persistent, and treatment-resistant conduct problems and delinquency [1, 2]. Although antisocial behavior typifies many individuals with CU traits, the nature of the relationship between CU traits, psychopathy, and various forms of delinquency remains under debate [3, 4]. CU traits, in particular, are variously described as a risk factor for violent delinquency [5, 6], for instrumental, or goal-directed, delinquency [7], or as not a strong risk factor for any form of delinquency [8, 9]. These inconsistencies may arise because most studies of CU traits are conducted in non-representative, clinical, or incarcerated samples, which may fail to account for heterogeneity in the behavioral expression of CU traits and misrepresent the nature of the relationship between CU traits and delinquency [4].

This study explores heterogeneity in the expression of CU traits and environmental factors that may influence it using a large, nationally representative sample of adolescents. Importantly, this sample enables an examination of the role of neighborhood income across the full range of neighborhood contexts. While prior research examining the developmental environments and behavior of high-CU individuals has largely focused on child (e.g., intelligence) or family level (e.g., parental maltreatment) moderators [10], no previous study has investigated the interaction between neighborhood income and CU traits with regard to delinquency. Recent research has identified a strong link between neighborhood characteristics and delinquency [11–13], reinforcing the importance of the broader developmental context. Some evidence suggests that neighborhood level processes may differentially influence the behavior of individuals with personality-based risk factors [13, 14]. By examining the moderating effect of neighborhood income on the association between CU traits and delinquency, we may, therefore, identify an important source of variation in the behavioral expression of CU traits and, in doing so, illuminate the etiology of adolescent delinquency.

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Published online: 23 December 2014

Callous and unemotional traits

Callous and unemotional traits are a suite of biologically based, heritable, and relatively stable personality traits [1, 15–18]. As such, CU traits are identifiable early in childhood and predict a persistent, distinct profile of reduced emotional reactivity and concomitant patterns of neural dysfunction that include reduced amygdala activity and atypical ventromedial prefrontal cortex response to punishment [19, 20] that persist into adulthood [15, 21, 22]. Consistent with these findings, twin studies have failed to find any strong links between CU traits and environmental factors such as parenting and SES [23], and neurobiological research indicates that youths with CU traits carry patterns of dysfunction distinct from those following abuse and exposure to violence [15, 24].

Moderation in the behavioral expression of CU traits

Although environmental factors may not influence CU traits themselves, an emerging literature suggests that context may influence the behavioral expression of these traits. That is, environmental risk and protection factors may modify the way CU traits manifest themselves in someone's behavior [8, 9, 25]. In adolescence, the primary example of this modification emerges in the variable link between CU traits and delinquent and antisocial behavior.

Dominant models posit that CU traits potentiate delinquency by impairing sensitivity to affective cues that normally inhibit aggression, such as fearful and sad expressions [15, 26]. This pattern of blunted emotional reactivity differs from that of children with environmental risk factors for delinquency such as maltreatment or exposure to trauma, who typically exhibit heightened sensitivity to affective cues and elevated amygdala activity in response to such cues [27, 28]. Individuals with high levels of CU traits also display heightened reward-seeking behavior, which when combined with reduced empathy may lead to aggression and delinquency [1, 2, 15]. However, CU traits are not necessarily expressed through antisocial acts [15]: some research suggests that many individuals with CU traits lead functional, noncriminal lives [8, 9].

One source of this heterogeneity may be environmental risk or protective factors [9, 15]. For example, adults with CU traits but no criminal history tend to come from more advantaged socioeconomic backgrounds and display enhanced executive functioning relative to their incarcerated peers [9]. Conversely, high-CU adults with criminal convictions reported more childhood abuse than those without convictions [25]. These findings suggest that environmental factors may moderate the connection between CU traits and delinquent behavior.

This growing literature has primarily examined family level moderators such as household income and parenting quality rather than broader contextual factors [25, 29, 30]. However, neighborhood context, and in particular neighborhood income, may be equally or more likely to moderate the behavioral expression of CU traits. First, neighborhood income may alter the frequency or severity of delinquent behaviors that high-CU youths commit by altering youths' exposure to crime and delinquency. On average, there are higher rates of delinquency and violent crime in low-income communities [31]. Greater exposure to delinquent models may provide high-CU individuals with more models of and opportunities to engage in delinquent behavior. Howard and colleagues [32] report that exposure to violence fully mediates the link between CU traits and violent delinquency in a detained sample, suggesting that witnessing violence may be a necessary trigger to physical aggression among high-CU individuals. Likewise, Trentacosta and colleagues found that youth impulsivity, a feature of CU traits, predicted antisocial behavior far more strongly in more versus less violent neighborhoods [14]. Second, lower levels of collective efficacy in low-income neighborhoods may also afford high-CU youth more opportunities to offend [11]. That is, in the absence of strong community enforcement of prosocial norms, high-CU individuals may experience fewer and weaker social controls and, thus, more chances to engage in delinquent behavior. In support of this pattern, studies have found that CU traits are more strongly associated with delinquency in neighborhoods with low collective efficacy [13] and more predictive of gang membership in neighborhoods with high residential instability [33].

Conversely, living in high-income neighborhoods may protect high-CU youth against engaging in high levels of delinquency. On average, crime rates are lower in high-income neighborhoods, particularly for violent crime, while employment rates are higher, suggesting that in high-resource neighborhoods high-CU youths are less exposed to models of crime and more exposed to models of legitimate reward-seeking behavior. Higher income neighborhoods also tend to have higher levels of social cohesion, such that people know and protect their neighbors. This cohesion engenders collective efficacy, i.e., community enforcement of prosocial norms [11, 31]. Even for high-CU individuals, this community control may suppress delinquent tendencies by making it easier to pursue reward through legitimate versus illegitimate means. If so, neighborhood income may moderate the impact of CU traits on delinquency such that individuals with high levels of CU traits will be more delinquent than their low-CU peers in low-income but not high-income neighborhoods.

Alternatively, it is possible that neighborhood income influences the type of delinquency that high-CU youths

commit, rather than amount of delinquent behavior. In low-income neighborhoods, greater exposure to violence may facilitate violent delinquency in high-CU youth both because violence is modeled more often and because fewer social controls inhibit the behavior. Rates of non-violent crimes such as theft and property offenses, however, do not vary as widely by neighborhood income [12, 34] suggesting that models of and opportunities to engage in instrumental delinquency are more consistent across neighborhood contexts. Moreover, in higher income communities, high-CU individuals may have greater motivation to commit instrumental crimes like theft because wealthier areas contain more valuable property. Indeed, an experiment in which residents of low-income neighborhoods were randomly assigned to move to higher income neighborhoods found that moving decreased youth's rates of violent crime but increased rates of instrumental crimes like theft [35]. These findings suggest that high-CU youth in low-income neighborhoods may engage in more violent delinquency, relative to both their non-CU peers and high-CU individuals in higher income neighborhoods, but that high-CU individuals in high-income neighborhoods would display elevated levels of instrumental delinquency, such as theft and fraud [36], relative to both non-CU individuals and high-CU individuals in lower income neighborhoods.

The present study

We explore these hypotheses by comparing associations between high-CU traits and delinquency across adolescents living in high-, medium- and low-income neighborhoods. This study is the first to estimate the link between CU traits and adolescent delinquency in a nationally representative sample and thus the first to assess whether studies using non-representative, clinical, or incarcerated samples have accurately represented the nature of the relationship between CU traits and delinquency. It is also the first to examine the moderating effect of neighborhood context on the behavioral expression of CU traits. We define neighborhood context in terms of income because the mechanisms hypothesized to alter the link between CU traits and delinquency—delinquent models, social cohesion, and opportunities and motivation to offend—correlate strongly with neighborhood income. These mechanisms likely operate simultaneously and synergistically, thus examining neighborhood income rather than each constituent part allows for a holistic test of the broader hypothesis that neighborhood context modifies the behavioral expression of CU traits, one that could illuminate the implications of CU traits and the etiology of adolescent delinquency.

Methods

Data and sample

Data are drawn from waves 1 through 4 of the National Longitudinal Study of Adolescent Health (Add Health). In 1,995, the first wave of data was collected ($n = 20{,}745$) from students in 7th to 12th grades; the second wave was collected in 1996 ($n = 14{,}738$, 88.2 % response rate), excluding 12th graders from wave one; the third wave was collected in 2001/2002, re-including the previously excluded 12th graders ($n = 15{,}197$, 77.4 % response rate), when youths were ages 18–28, and the fourth was collected in 2007/2008 ($n = 15{,}701$, 80.3 % response rate) when youths were ages 24–32, again including the previously excluded wave 1 12th graders.

The analytic sample includes all individuals with complete data on the key independent and dependent variables at wave 2 (when youths are between 13 and 18 years old) but not necessarily all covariates ($n = 8{,}695$). To address missing data for covariates only [37], data were multiply imputed using the ICE command in Stata 12.0, which is based on a regression switching protocol using chained equations [38, 39]. Missingness on covariates ranged from 1 to 15 %. Following conventional guidelines [40], 20 imputed datasets were generated, and coefficients and standard errors were combined using the MIM command.

Measures

High callous and unemotional traits

Add Health data collection began prior to the validation of contemporary parent- or child-report CU scales, such as the Antisocial Process Screening Device [41] or Inventory of Callous Unemotional Traits (ICU, 42). However, we were able to exploit items from waves 3 and 4 personality assessments that accurately index the overall construct of CU traits and closely map onto items from the ICU. Items selected were chosen to correspond to identified ICU subscales (callousness, an uncaring nature, and unemotionality). Items indexing "unemotionality" emphasized fearlessness/harm-avoidance following evidence that overall unemotionality is only weakly linked to other CU factors or to external correlates [43], and following preferential inclusion of similar items in adult measures of CU traits and psychopathy [44]. Factor analysis of our scale (Table 3) revealed a clear three-factor structure: callousness, uncaring, and unemotionality/fearlessness. This factor structure is consistent with recent explorations of CU traits, and the emphasis on fearlessness is more consistent with recent conceptualizations of adult psychopathy than overall

Table 1 Sample descriptive statistics

	High CU	Low CU	
Male	79.12	43.47	***
High-income neighborhoods	23.53	25.34	
Moderate-income neighborhoods	52.66	51.45	
Low-income neighborhoods	25.29	23.88	
Ln (family income)	3.50 (0.78)	3.59 (0.83)	
Lives in urban area	53.53	52.22	
White	59.12	57.19	
Black	21.47	20.07	
Hispanic	6.18	7.48	
Asian	2.94	6.08	*
Other race	10.29	9.18	
First language not English	8.53	9.53	
Immigrant family	4.71	6.02	
PPVT	99.49 (15.28)	101.35 (14.17)	*
Std. total delinq.	0.21 (1.37)	−0.02 (0.93)	***
Std. violent delinq.	0.28 (1.47)	−0.05 (0.91)	***
Std. instrumental delinq.	0.09 (1.25)	−0.00 (0.96)	
Depression	1.87 (2.04)	2.60 (2.54)	***
Anxiety	9.00 (2.64)	12.52 (2.84)	***

Data are drawn from the National Longitudinal Study of Adolescent Health

$N = 8{,}695$

Ln represents the natural log, indicating that family income was transformed logarithmically

Standard deviations are presented in parentheses for continuous variables

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

unemotionality [45]. (Table 1; see Table 4 for the created CU checklist and analogous ICU items).

All items were scored on a 5-point rating scale and coded such that 5 indicated higher CU traits. Items were then dichotomized such that responses of 4 or 5 received a 1, and responses below 4 were coded as 0 to isolate extreme expressions of each trait. For example, the response categories for "I sympathize with other's feelings" were: strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree. Of these categories, only disagreement and strong disagreement reflect callousness, and indeed just 3.1 % of respondents chose either of these responses. These items were summed to create a 10-point CU scale, which had a moderate Cronbach's alpha ($\alpha = 0.61$) comparable to other brief assessments of CU [46]. To distinguish individuals high on CU traits, this scale was dichotomized and a dummy variable was created such that individuals scoring 6 or higher received a 1 (high-CU traits), and individuals scoring less than 6 were coded as 0. This cutoff was chosen because, although CU traits can be measured continuously, the association between CU traits and delinquency is likely nonlinear [47], with only high levels of CU traits manifesting in overt delinquent behavior. In our data, we found empirical support for a sharp increase in total lifetime delinquency at a CU score of 6, indicating that this cutoff captures a qualitatively distinct cohort of youths at higher risk for offending (see Fig. 1). In addition, using this cutoff, 3.9 % of the sample was coded as high-CU, a proportion that parallels recent estimates of the prevalence of CU traits in the general population (3.0 %, [48]).

Neighborhood income

As noted above, neighborhood income serves as a strong proxy for the interplay of multiple process variables that may influence the offending of high- and low-CU youth. Thus, we use neighborhood income to characterize neighborhood context. It was measured using the median yearly household income in the youth's census block at wave 2. Neighborhoods in the top 25 % of census block median incomes ($39,721 and above in 1995 dollars, $61,836 in 2014 dollars) were classified as high income; neighborhoods in the bottom quartile ($20,750 and below, $32,300 in 2014 dollars) were classified as low income; the middle 50 % were classified as moderate income.

This information was coded into a series of dummy variables indicating high income and low income, with moderate-income neighborhoods as the omitted category. The categories of the resulting variable correspond as expected to unemployment and crime statistics, with significantly lower unemployment and crime in high- versus low-income neighborhoods (available upon request).

Delinquency: total, violent, and instrumental

We examine adolescent delinquency because adolescence is a time when externalizing behavior and crime peaks. Thus, we generate a measure of total delinquency using all items regarding delinquency from wave 2, when youths were aged 13–18 ($M = 16.2$). These items include instrumental and violent delinquent acts, as well as minor delinquency and status offenses (see "Appendix C" for a full item list). Items were recoded from a 5-point rating scale such that respondents received a 1 if they ever engaged in the activity and a zero otherwise. Then, responses were summed within wave, and were normed by age, yielding a standardized score that reflects level of delinquent behavior relative to peers. Notably, delinquency was measured prior to our measure of CU traits. However, as noted above, CU traits are strongly heritable and relatively stable across time (1, 15–16), reducing the impact of the timing of measurement on individual scores. More specifically, no data support the possibility that engaging in delinquency at wave 2 would increase the likelihood of responding as high CU at wave 3 or 4.

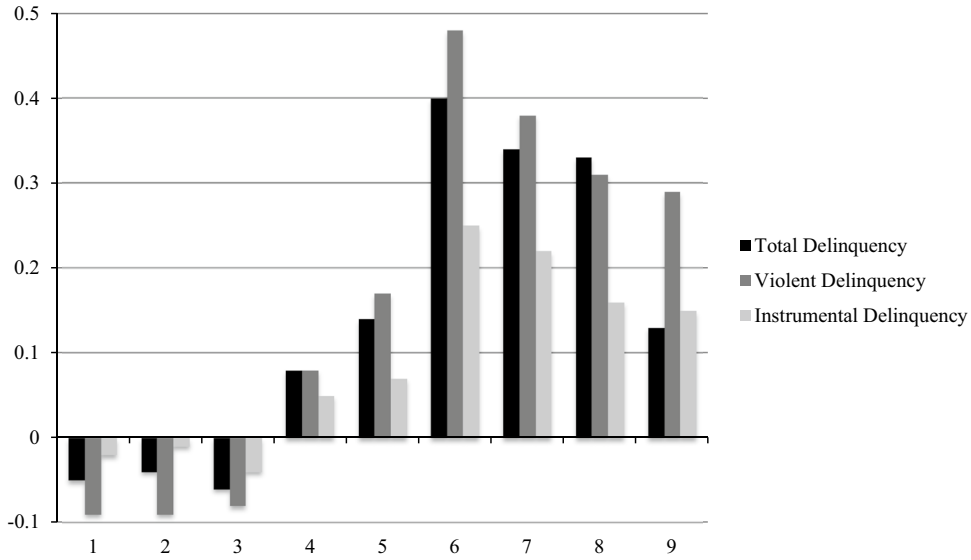

Fig. 1 Mean lifetime delinquency scores by CU indicator scale score

Violent and instrumental delinquency subscales were created using relevant items from the total delinquency scale. As in the full scale, these items were normed within age. The resulting variables are continuous, standardized, average violent and instrumental delinquency measures that reflect elevated levels of delinquency relative to same-age peers. Violent delinquency includes aggressive actions designed to harm or threaten harm to others; instrumental delinquency includes items that reflect proactive, goal-directed delinquency. Full items for each scale are listed in "Appendix C".

Covariates

In all models, we incorporated covariates that correlate with delinquency and/or CU traits. These included gender (wave 4), first language, immigrant status, race, and family income (wave 1), as well as whether youth lived in an urban center (wave 2). We also entered estimated cognitive ability, using scores on the Peabody Picture Vocabulary Test (PPVT-III, wave 3, 49).

Analytic strategy

First, ordinary least squares (OLS) regression models were run to examine the main effects of neighborhood income and high levels of CU traits on total, violent, and instrumental delinquency. Second, interactions between neighborhood income and high levels of CU traits were added to models to explore how neighborhood income may moderate the behavioral expression of CU traits. Because both neighborhood income and CU traits were coded using dummy variables, interactions were not mean centered. Instead, interaction terms represent the difference in average delinquent behavior for high-CU individuals in either high- or low-income neighborhoods relative to non-CU individuals in moderate-income neighborhoods. All analyses included the full set of covariates. Models were weighted using the Add Health wave 4 survey weights to account for the clustered nature of the sample and to produce nationally representative estimates based on sampling design and attrition [50].

Results

CU scale validation and descriptive statistics

First, we sought to validate our CU scale by comparing youth categorized as high- versus low-CU on external correlates associated with established CU measures. We found patterns of bivariate correlations consistent with those observed in previous literature for the relationship between CU traits and gender and internalizing psychopathology. Specifically, we found that CU traits were relatively higher in males than females [51], and that CU traits were negatively associated with validated measures of depression and anxiety, measured with the Center for Epidemiologic Studies scale [CES-D, 52], two psychopathologies that are inversely related to CU traits [53]. Means on depressive symptoms for the high- and low-CU groups were significantly different ($F = 27.59$, $p < 0.001$), with high-CU youth scoring far below low-CU youth (Table 1). This difference remained in an OLS model that controlled for all covariates ($b = -0.85$, $p < 0.001$). Similar results emerged for an anxiety-focused subscale ($b = -3.49$, $p < 0.001$). Importantly, we found no relationship between CU traits and race/ethnicity (with the exception of Asians) or cognitive ability across this nationally representative sample.

Table 2 Linear regression models predicting total, instrumental, and violent delinquency

	Model 1a Total delinq.			Model 1b Instr. delinq.			Model 1c Violent delinq.		
	b	se	*p*	*b*	se	*p*	*b*	se	*p*
High CU	0.22	0.08	0.01	0.12	0.08	0.13	0.24	0.08	0.01
Low-income neighborhoods	0.01	0.04	0.86	−0.02	0.04	0.60	0.05	0.04	0.27
High-income neighborhoods	0.09	0.04	0.02	0.13	0.04	0.00	0.00	0.03	1.00
	Model 2a Total delinq.			Model 2b Instr. delinq.			Model 2c Violent delinq.		
	b	se	*p*	*b*	se	*p*	*b*	se	*p*
High CU	0.10	0.10	0.32	0.08	0.11	0.47	0.03	0.08	0.73
Low-income neighborhoods	0.00	0.04	0.98	−0.02	0.04	0.60	0.02	0.04	0.61
High-income neighborhoods	0.08	0.04	0.04	0.12	0.04	0.00	−0.01	0.03	0.66
CU × low income	0.20	0.21	0.34	−0.01	0.17	0.96	0.57	0.27	0.04
CU × high income	0.30	0.24	0.20	0.20	0.22	0.38	0.32	0.26	0.22

$N = 8{,}695$

Regressions weighted using Add Health design and sampling weights for wave 4

Dependent variables are measured in standard deviation units

Covariates included but not shown include urbanicity, race, gender, immigrant status, family income, first language, and PPVT

Multivariate models

Table 2 displays results from the OLS models predicting each outcome. Note that because delinquency was standardized, each coefficient reflects standard deviation changes in delinquency associated with a one-unit change in each independent variable. Panel 1 displays the main effect of high levels of CU traits on total, violent, and instrumental delinquency, controlling for all covariates. Models 1a and 3a revealed statistically significant associations between high levels of CU traits and total and violent delinquency scales. Estimated coefficients were both roughly 0.25, suggesting that high-CU individuals are a quarter of a standard deviation more delinquent than their low-CU peers across total and violent delinquency ($p < 0.01$). There was no statistically significant relationship between high levels of CU traits and instrumental delinquency. Unexpectedly, youths in high-income neighborhoods were more delinquent than their moderate-income neighborhood peers in models predicting total and instrumental delinquency ($b = 0.10$, $p < 0.05$, and $b = 0.14$, $p < 0.01$, respectively), although not violent delinquency.

Panel 2 displays results from models testing whether associations between high levels of CU traits and delinquency vary by neighborhood income. In Model 1b, no statistically significant interactions emerged between CU traits and neighborhood income in predicting overall delinquency, suggesting that total rates of delinquency do not vary by neighborhood type for high-CU youth. Models 2b and 3b display results separately by type of delinquency. These models suggested that the type of delinquency engaged in by high-CU individuals may vary by neighborhood income. Specifically, in Model 2c, a positive, statistically significant interaction emerged between CU traits and low-income neighborhood such that in low-income neighborhoods the positive relationship between high levels of CU traits and violent delinquency was over half a standard deviation larger than in moderate-income neighborhoods ($b = 0.57$, $p < 0.05$). Plots of conditional means and the results of simple slopes analyses are displayed in Fig. 2. The interaction between high levels of CU traits and low-income neighborhood residence is reflected in the substantially higher levels of violent behavior ($b = 0.47$, $p < 0.05$) among high-CU youth living in low-income neighborhoods. No other interactions attained statistical significance. Additionally, no other contrasts between income groups attained statistical significance (i.e., there were no statistically significant differences in the impact of high levels of CU traits in low versus high-income neighborhoods; tables available upon request).

Supplementary analyses

We conducted a series of sensitivity analyses to assess several of the assumptions of our primary models (see "Appendix D"). First, we reduced the sample to an urban subsample ($N = 4{,}545$). Neighborhood context was expected to be more salient in urban areas where census blocks are geographically smaller, and where neighborhoods are more self-contained than in suburban or rural

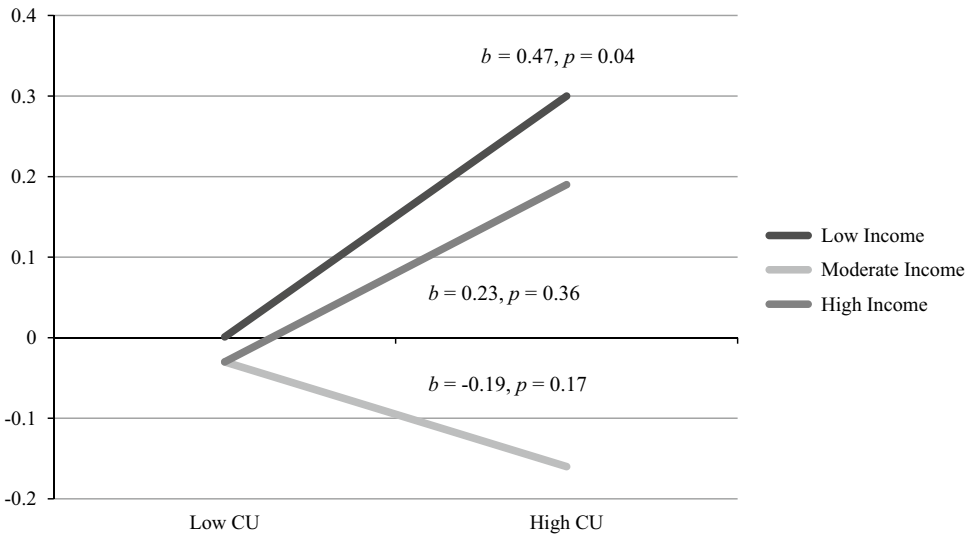

Fig. 2 Mean levels of violent delinquency by CU traits and neighborhood income

areas. Indeed, much existing neighborhood research examines urban neighborhoods for this reason [54, 55]. Thus, we expected the impact of CU traits to be constant across the urban subsample and the full sample, but that neighborhood influences may become stronger. Table 5 presents the results of this analysis. As expected, the main effect of high levels of CU traits was replicated in the model predicting overall delinquency and the interaction term between high levels of CU traits and low-income neighborhood residence increased in magnitude in the model predicting violent delinquency. In addition, the interactions between high levels of CU traits and high-income neighborhood residence in models predicting total and instrumental delinquency were large and statistically significant at the 0.10 level. The results suggest that high-CU individuals in high-income urban neighborhoods may engage in more instrumental delinquency than their high-CU peers in moderate-income urban neighborhoods, though this finding should be interpreted with caution given its trend-level significance.

Second, we replicated our primary analysis using neighborhood and delinquency data drawn from wave 3 of Add Health ($N = 11{,}677$). At wave 3, youths were aged 18–28, thus most were no longer adolescents. High levels of delinquency are less normative in early adulthood, thus even if the level of delinquency engaged in by high-CU youth stayed constant, the reduction in delinquency for low-CU youth should increase the association between high levels of CU traits and delinquency. Indeed, at wave 3, main effects between high levels of CU traits and delinquency were positive and statistically significant across all delinquency types (Table 6, panel 1). However, in the models including interactions between CU traits and neighborhood income (Table 6, panel 2), main effects of CU traits remain, but no interaction terms reached statistical significance. It is important to note that by wave 3 youths were more likely to have selected their neighborhood, making differential associations between high levels of CU traits and delinquency in different neighborhood types difficult to interpret. Indeed, if all youths choose neighborhoods based on preferences for delinquent behavior differential associations between high levels of CU traits and neighborhood income would not be observed.

Finally, we replicated our main models controlling for self-reported delinquency at wave 1. By accounting for previous levels of the dependent variable, we accounted for the possibility of prior delinquency influencing self-report of CU traits or neighborhood residence. This likely overcontrols for the influence of CU traits, as CU traits are theoretically constant personality factors that have impacted wave 1 delinquency as well. As expected, in these models (Table 7) the main effect of CU traits on delinquency was substantially reduced across all delinquency types. However, the interaction between high levels of CU traits and low-income neighborhood residence in models predicting violent delinquency retained size and significance, suggesting that high-CU youths in low-income neighborhoods increase their violent delinquency relative to their high-CU peers in other neighborhoods during adolescence.

Discussion

This study investigated whether neighborhood-level income is associated with alterations in the behavioral expression of CU traits. First, we linked high-CU traits with significantly higher levels of total and violent delinquency. This finding corroborates in a large, nationally representative sample the links between CU traits and delinquency that have been consistently detected using non-representative samples. Second, we did not observe a protective effect

of living in high-income neighborhoods for high-CU individuals. Rather, high-income high-CU individuals were equally likely to engage in delinquency as their moderate income, high-CU peers. Moreover, we found that neighborhood context alters the type, rather than the extent, of delinquency in which high-CU individuals engage. Specifically, CU traits were more strongly predictive of violent delinquency in low-income neighborhoods. Additionally, supplementary analyses revealed that in urban neighborhoods, CU traits may be more strongly predictive of instrumental delinquency in high-income neighborhoods, though this finding should be interpreted with caution ($p < 0.10$).

The differential relationship between CU traits and delinquency by level of neighborhood income may arise from income-associated, neighborhood-level variation in antisocial modeling and opportunities to offend. First, behavioral models may influence the type of delinquency in which high-CU individuals engage. Reduced empathy and remorse may result in goal-directed delinquency across high-CU individuals [36, 56]; however, neighborhoods with different patterns of crime may model different strategies for attaining rewards. Low-income neighborhoods have far higher rates of violent crime [12, 34]. Thus, in low-income neighborhoods, where violence is modeled as a potentially successful strategy, high-CU individuals may accordingly display higher levels of violent delinquency. Indeed, previous research has demonstrated that the relationship between CU traits and violent offending is fully mediated by exposure to violence [32], suggesting that even for high-CU individuals, external examples of delinquency precipitate engagement in delinquent acts.

Second, opportunities to offend may vary by neighborhood income. Neighborhood income is positively related to social cohesion, which is associated with lower levels of delinquency through monitoring and prosocial norms [31]. In low-income neighborhoods, low levels of social control may provide opportunities to offend that high-CU individuals exploit. Indeed, our findings are in line with previous work suggesting that CU-related personality traits including impulsivity and callousness are more strongly associated with delinquent behavior and delinquent peer group association in neighborhoods with low social cohesion [1, 14, 33, 57]. The stronger relationship between CU traits and violence in low-income neighborhoods suggests that informal neighborhood controls may play an important role in preventing violent delinquency among high-CU individuals.

Conversely, instrumental offending may be more difficult to monitor and, thus, control through social cohesion. If so, in high-income neighborhoods, greater social cohesion could not successfully inhibit delinquent acts, such as theft or burglary committed by high-CU youth. Moreover, high-CU youth in high-income urban neighborhoods may be more motivated to offend in this way because of their proximity to desirable goods [58]. Although the relationship between CU traits and instrumental delinquency in high-income neighborhoods was larger than in moderate-income neighborhoods only at the trend level in the urban subsample ($p < 0.10$), the pattern suggests that greater opportunities to commit property offenses may be related to higher levels of instrumental delinquency. Thus, this finding, though tentative, warrants further investigation.

It is important to note that our results cannot be explained through differences in cognitive skills. Research has suggested that enhanced cognitive functioning may keep high-CU individuals from criminal careers [8, 9]. However, all models were controlled for scores on the PPVT, a receptive language assessment. Moreover, mean PPVT scores did not differ for high- and low-CU individuals within each neighborhood category.

Limitations

This study used a novel measure of CU traits designed using items analogous to those in a commonly used CU scale. This scale is not clinically validated; however, it performed well on multiple validity checks, including replication of population level high-CU rates and expected associations with delinquency, gender, depression, and anxiety, as well as expected absences of association with race and cognitive ability. The scale also had an internal consistency level comparable to validated CU scales [46].

Our reliance on self-report measures of CU traits may influence associations between CU traits and outcomes. Because youth reported on CU traits and all outcomes, shared method variance could have inflated main associations between CU and delinquency. Although self-reported delinquency is likely a more accurate measure of delinquent activity for high-CU individuals than arrest records, which depend on being caught, recall of delinquent activity may not be accurate. Parent- or teacher-reported delinquency might strengthen the accuracy of the measure.

Next, we use neighborhood income as a proxy for neighborhood level processes, including the modeling of criminal behavior, opportunities for criminal behavior, and social cohesion. We do so because these processes likely work in tandem to influence the expression of CU traits. If this is the case, measuring any one process understates the potential role of neighborhood context in influencing the behavioral expression of CU traits. Though we use a large dataset, the small number of high-CU individuals renders a precise analysis of the interplay of neighborhood processes in producing delinquent behavior among high-CU youth impossible in the current data. However, testing these pathways is an important future direction, and crucial for clinical applications. In addition, neighborhood income is

the most policy relevant neighborhood characteristic. For example, the Housing and Urban Development (HUD)-funded Moving to Opportunity experiment [35] randomly assigned public housing tenants to move from high- to low-poverty neighborhoods. Our results could suggest a source of heterogeneity in the efficacy of such policies and programs.

Finally, if parents select the neighborhoods they live in based on their own CU traits and tendency toward delinquency, there may be an unmeasured heritability effect that may explain the relationship between CU traits and delinquency across different neighborhoods. However, CU traits were not significantly associated with neighborhood type using either the dichotomous or continuous CU measure. These null findings suggest that parents did not select neighborhoods based on CU traits, and that an unmeasured genetic factor is unlikely to be driving the present findings. Nonetheless, because youths were not randomly assigned to neighborhoods, the average association between neighborhood income and delinquency could have been driven by factors that covary with neighborhood residence and delinquency. We attempted to minimize this omitted variable bias by controlling for indicators of socioeconomic status and cognitive ability, and entering a lagged-dependent variable in sensitivity analyses; however, unmeasured factors could still bias this link.

Conclusions

This study found associations between neighborhood income and the behavioral expression of CU traits over and above personal characteristics, using a large, nationally representative sample. Analyses revealed heterogeneity in the behavioral expression of CU traits, particularly with regard to the type of delinquent behavior. The study also demonstrates the importance of studying CU traits using community samples and seeking to clarify links between CU traits and behaviors that may not be violent but may be equally costly to individuals and society.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix A

See Table 3.

Table 3 Factor analysis for dichotomous and continuous versions of the psychopathy scale

Variable	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
Dichotomized items						
Not sympathetic	0.4206	0.4206	−0.1102		×	
Not worried about others	0.5139	0.4596	−0.1061		×	
Feel other's emotions	0.4732	0.4230	−0.1455		×	
Not into others	0.4566	0.4826	−0.1396		×	
Keeps cool	0.4016	−0.5759	−0.0381	×		
Relaxed	0.5150	−0.5054	−0.0172	×		
Not easily bothered	0.5361	−0.5006	−0.0517	×		
Not worried	0.4713	−0.2278	0.0057	×		
Tries thrills	0.1826	0.1201	0.7506			×
Takes risks	0.1932	0.1017	0.7528			×
Continuous items						
Not sympathetic	0.6739	−0.1911	−0.0716	×		
Not worried about others	0.7126	−0.2016	−0.0325	×		
Feel other's emotions	0.6817	−0.1805	−0.1173	×		
Not into others	0.6597	−0.3172	−0.0741	×		
Keeps cool	0.0165	0.7169	−0.0748		×	
Relaxed	0.2312	0.7028	−0.0772		×	
Not easily bothered	0.2607	0.6961	−0.0995		×	
Not worried	0.3898	0.5389	−0.0958		×	
Tries thrills	0.1591	0.0738	0.8007			×
Takes risks	0.2003	0.1352	0.7752			×

Appendix B

See Table 4.

Table 4 Callous–unemotional traits scale items and inventory of callous–unemotional trait analogs

Add health scale	ICU items
I sympathize with others' feelings (R)	I am concerned about the feelings of others (R) I try not to hurt others' feelings (R)
I worry about things (R)	I do not care about doing things well I do not care about being on time I care about how well I do at school or work (R) I do not like to put the time into doing things well
I am not interested in other people's problems	I do not care who I hurt to get what I want I apologize ("say I am sorry") to persons I hurt (R)
I am relaxed most of the time	I work hard on everything I do (R)
I am not easily bothered by things	I do not care if I get into trouble I feel bad or guilty when I do something wrong (R) I do not feel remorseful when I do something wrong
I feel others' emotions (R)	I seem very cold and uncaring to others The feelings of others are unimportant to me
I am not really interested in others	I do things to make others feel good (R)
I keep my cool	I express my feelings openly (R) I do not show my emotions to others I do not let my feelings control me It is easy for others to tell how I am feeling (R) I am very expressive and emotional (R) I hide my feelings from others
Do you agree or disagree that you like to take risks	(No equivalent item)
I often try new things just for fun or thrills, even if most people think they are a waste of time	(No equivalent item)
(No equivalent item)	What I think is "right" and "wrong" is different from what other people think I easily admit to being wrong (R) I always try my best (R)

Appendix C

See Table 5.

Table 5 Delinquency items

Total delinquency items
In the past 12 months, how often did you paint graffiti or signs on someone else's property or in a public place?
···deliberately damage property that did not belong to you?
···lie to your parents or guardians about where you had been or whom you were with?
···take something from a store without paying for it?
···run away from home?
···drive a car without its owner's permission?
···stead something worth more than $50?
···go into a house or building to steal something?
···use or threaten to use a weapon to get something from someone?
···sell marijuana or other drugs?
···steal something worse less than $50?
···act loud, rowdy, or unruly in a public place?
···take part in a fight where a group of your friends was against another group?
During the past 12 months, how often did each of the following things happen?
···you pulled a knife or gun on someone.
···you shot or stabbed someone.
In the past 12 months, how often did you… get into a serious physical fight?
···use a weapon in a fight?
In the past 12 months how often did you hurt someone badly enough to need bandages or care from a doctor or nurse?
Violent delinquency items
In the past 12 months, how often did you… use or threaten to use a weapon to get something from someone?
···take part in a fight where a group of your friends was against another group?
···get into a serious physical fight?
···use a weapon in a fight?
···hurt someone badly enough to need bandages or care from a doctor or nurse?
During the past 12 months, how often did each of the following things happen?
···you pulled a knife or gun on someone
···you shot or stabbed someone
Instrumental delinquency items
In the past 12 months, how often did you… steal something worth more than $50?
···lie to your parents or guardians about where you had been or whom you were with?
···take something from a store without paying for it?
···go into a house or building to steal something?
···use or threaten to use a weapon to get something from someone?
···sell marijuana or other drugs?
···steal something worth less than $50

Appendix D: Supplementary analyses

See Tables 6, 7 and 8.

Table 6 Linear regression models predicting total, instrumental, and violent delinquency in an urban subsample

	Total delinquency			Instrumental delinquency			Violent delinquency		
	b	se	*p*	*b*	se	*p*	*b*	se	*p*
High CU	0.25	0.12	0.03	0.12	0.11	0.29	0.23	0.13	0.07
Low-income neighborhoods	0.09	0.05	0.11	0.01	0.06	0.84	0.12	0.05	0.03
High-income neighborhoods	0.05	0.06	0.39	0.11	0.06	0.10	−0.02	0.05	0.65
Black	0.00	0.07	0.94	−0.07	0.06	0.30	0.15	0.06	0.02
Hispanic	0.24	0.10	0.03	0.17	0.10	0.10	0.22	0.10	0.03
Asian	0.06	0.09	0.48	0.15	0.10	0.16	−0.05	0.09	0.57
Other	0.21	0.08	0.01	0.19	0.08	0.01	0.17	0.06	0.01
Immigrant family	−0.23	0.08	0.01	−0.16	0.07	0.03	−0.15	0.08	0.08
Family income	−0.01	0.03	0.63	0.00	0.03	0.98	−0.05	0.03	0.09
First language	−0.13	0.08	0.12	−0.09	0.09	0.31	−0.10	0.07	0.14
PPVT	0.00	0.00	0.12	0.00	0.00	0.01	0.00	0.00	0.09
Male	0.17	0.04	0.00	0.02	0.04	0.61	0.29	0.04	0.00
Constant	−0.31	0.18	0.09	−0.47	0.18	0.01	0.21	0.17	0.24
High CU	0.02	0.11	0.85	−0.04	0.12	0.72	−0.08	0.08	0.29
Low-income neighborhoods	0.07	0.05	0.23	0.00	0.06	0.94	0.08	0.05	0.13
High-income neighborhoods	0.03	0.06	0.63	0.09	0.07	0.20	−0.04	0.04	0.37
CU × low income	0.48	0.33	0.15	0.18	0.23	0.44	0.97	0.45	0.04
CU × high income	0.49	0.29	0.09	0.46	0.28	0.10	0.40	0.30	0.19
Black	0.00	0.07	0.96	−0.07	0.06	0.31	0.15	0.06	0.03
Hispanic	0.24	0.10	0.02	0.16	0.10	0.10	0.22	0.10	0.02
Asian	0.06	0.09	0.49	0.15	0.10	0.15	−0.05	0.09	0.56
Other	0.21	0.08	0.01	0.19	0.08	0.01	0.17	0.06	0.01
Immigrant family	−0.22	0.08	0.01	−0.16	0.07	0.03	−0.14	0.08	0.08
Family income	−0.01	0.03	0.65	0.00	0.03	0.98	−0.04	0.03	0.10
First language	−0.13	0.08	0.12	−0.10	0.09	0.31	−0.10	0.07	0.13
PPVT	0.00	0.00	0.12	0.00	0.00	0.01	0.00	0.00	0.08
Male	0.16	0.04	0.00	0.02	0.04	0.62	0.29	0.04	0.00
Constant	−0.30	0.18	0.09	−0.47	0.18	0.01	0.22	0.17	0.21

$N = 4{,}545$

Regressions weighted using Add Health design and sampling weights for wave 4

Dependent variables are measured in standard deviation units

Table 7 Linear regression models predicting total, instrumental, and violent delinquency using wave three data

	Total delinquency			Instrumental delinquency			Violent delinquency		
	b	se	*p*	*b*	se	*p*	*b*	se	*p*
High CU	0.44	0.14	0.00	0.35	0.15	0.02	0.41	0.12	0.00
Low-income neighborhoods	0.03	0.04	0.43	0.04	0.04	0.39	−0.01	0.03	0.65
High-income neighborhoods	0.01	0.04	0.80	0.02	0.04	0.58	−0.03	0.03	0.28
Urban dweller	0.03	0.03	0.34	0.04	0.03	0.20	−0.01	0.03	0.73
Black	0.12	0.05	0.02	0.09	0.05	0.09	0.15	0.05	0.01
Hispanic	0.02	0.05	0.68	0.01	0.06	0.84	0.04	0.05	0.38
Asian	0.01	0.07	0.84	0.03	0.09	0.74	−0.02	0.05	0.68
Other	0.10	0.06	0.08	0.08	0.05	0.13	0.11	0.06	0.07
Immigrant family	−0.06	0.07	0.42	0.00	0.07	0.96	−0.16	0.05	0.00
Family income	0.02	0.02	0.32	0.02	0.02	0.29	0.00	0.02	0.83
First language	−0.09	0.07	0.16	−0.10	0.07	0.14	−0.03	0.06	0.66
PPVT	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.02
Male	0.44	0.03	0.00	0.31	0.03	0.00	0.38	0.03	0.00
Constant	−0.55	0.13	0.00	−0.60	0.14	0.00	0.02	0.09	0.81
High CU	0.48	0.20	0.02	0.35	0.19	0.06	0.52	0.18	0.00
Low-income neighborhoods	0.03	0.03	0.33	0.03	0.03	0.36	0.00	0.03	0.92
High-income neighborhoods	0.02	0.03	0.62	0.03	0.04	0.48	−0.02	0.03	0.44
CU × low income	−0.01	0.39	0.98	0.12	0.43	0.79	−0.25	0.29	0.38
CU × high income	−0.26	0.24	0.29	−0.20	0.23	0.39	−0.25	0.28	0.39
Urban dweller	0.03	0.03	0.35	0.04	0.03	0.20	−0.01	0.03	0.71
Black	0.12	0.05	0.02	0.09	0.05	0.08	0.15	0.05	0.01
Hispanic	0.02	0.05	0.69	0.01	0.06	0.85	0.04	0.05	0.40
Asian	0.01	0.07	0.85	0.03	0.09	0.75	−0.02	0.05	0.68
Other	0.10	0.06	0.08	0.08	0.05	0.13	0.11	0.06	0.07
Immigrant family	−0.06	0.07	0.41	0.00	0.07	0.97	−0.16	0.05	0.00
Family income	0.02	0.02	0.31	0.02	0.02	0.28	0.00	0.02	0.82
First language	−0.09	0.07	0.18	−0.10	0.07	0.15	−0.03	0.06	0.66
PPVT	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.02
Male	0.44	0.03	0.00	0.31	0.03	0.00	0.38	0.03	0.00
Constant	−0.55	0.13	0.00	−0.60	0.14	0.00	0.02	0.09	0.80

$N = 11{,}677$

Regressions weighted using Add Health design and sampling weights for wave 4

Dependent variables are measured in standard deviation units

Table 8 Linear regression models predicting total, instrumental, and violent delinquency controlling for earlier delinquency

	Total delinquency			Instrumental delinquency			Violent delinquency		
	b	se	*p*	*b*	se	*p*	*b*	se	*p*
High CU	0.04	0.06	0.53	−0.04	0.06	0.53	0.11	0.08	0.15
Low-income neighborhoods	−0.01	0.03	0.84	−0.04	0.04	0.36	0.04	0.03	0.26
High-income neighborhoods	0.07	0.03	0.04	0.11	0.04	0.01	−0.02	0.03	0.55
Delinquency W1	0.57	0.03	0.00	0.49	0.03	0.00	0.41	0.03	0.00
Urban dweller	−0.01	0.03	0.78	0.01	0.03	0.74	−0.02	0.03	0.37
Black	−0.02	0.04	0.61	−0.06	0.04	0.13	0.08	0.05	0.10
Hispanic	0.12	0.07	0.09	0.07	0.07	0.35	0.11	0.07	0.10
Asian	0.01	0.06	0.88	0.08	0.07	0.22	−0.06	0.07	0.42
Other	0.07	0.06	0.21	0.05	0.06	0.38	0.11	0.07	0.12
Immigrant family	−0.09	0.06	0.17	−0.04	0.07	0.53	−0.06	0.06	0.33
Family income	−0.01	0.02	0.65	0.01	0.02	0.65	−0.05	0.02	0.02
First language	−0.05	0.06	0.39	−0.01	0.06	0.86	−0.07	0.06	0.27
PPVT	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Male	0.02	0.02	0.45	−0.10	0.02	0.00	0.18	0.03	0.00
Constant	−0.20	0.12	0.09	−0.40	0.12	0.00	0.38	0.11	0.00
High CU	−0.06	0.07	0.42	−0.06	0.08	0.45	−0.09	0.07	0.19
Low-income neighborhoods	−0.02	0.03	0.59	−0.04	0.04	0.35	0.01	0.03	0.75
High-income neighborhoods	0.06	0.03	0.07	0.11	0.04	0.01	−0.03	0.03	0.30
CU × low income	0.22	0.17	0.20	0.01	0.13	0.94	0.59	0.25	0.02
CU × high income	0.19	0.19	0.34	0.10	0.17	0.57	0.24	0.26	0.36
Delinquency W1	0.57	0.03	0.00	0.49	0.03	0.00	0.41	0.03	0.00
Urban dweller	−0.01	0.03	0.77	0.01	0.03	0.74	−0.02	0.03	0.38
Black	−0.02	0.04	0.63	−0.06	0.04	0.13	0.08	0.05	0.08
Hispanic	0.12	0.07	0.08	0.07	0.07	0.35	0.12	0.07	0.09
Asian	0.01	0.06	0.88	0.08	0.07	0.22	−0.06	0.07	0.41
Other	0.08	0.06	0.19	0.05	0.06	0.38	0.12	0.07	0.10
Immigrant family	−0.09	0.06	0.17	−0.04	0.07	0.54	−0.06	0.06	0.36
Family income	−0.01	0.02	0.67	0.01	0.02	0.65	−0.05	0.02	0.02
First language	−0.05	0.06	0.38	−0.01	0.06	0.85	−0.07	0.06	0.26
PPVT	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Male	0.02	0.02	0.46	−0.10	0.02	0.00	0.18	0.03	0.00
Constant	−0.20	0.12	0.09	−0.40	0.12	0.00	0.38	0.11	0.00

$N = 8{,}695$

Regressions weighted using Add Health design and sampling weights for wave 4

Dependent variables are measured in standard deviation units

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