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Assessing General Versus Specific Liability for Externalizing Problems in Adolescence: Concurrent and Prospective Prediction of Symptoms of Conduct Disorder, ADHD, and Substance Use

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Prior Dissemination: Data for this manuscript were from the IMAGEN Study and are available from the IMAGEN Consortium by written request (https://imagen-europe.com/). Several prior manuscripts have been published using this sample (https://imagen-europe.com/resources/publications/), but none have addressed research questions involving callousness and disinhibition, apart from Brislin et al. (2019), who developed and validated the IMAGEN-Disinhibition scale used in the current analyses. Portions of the analyses for this manuscript were included in Emily R. Perkins's master's thesis at Florida State University in 2018 and were presented at the 2018 Society for Psychophysiological Research Annual Meeting and the 2019 Society for the Scientific Study of Psychopathy Biennial Meeting.

Ethics Statement: All procedures for the overarching IMAGEN project were approved by the Medical Ethics Commission II of the Heidelberg University Medical Faculty in Mannheim (#2007–024N-MA), according to the standards specified in the Declaration of Helsinki. In addition, approval was granted by local ethics committees at each of the data collection sites (London: Psychiatry, Nursing, and Midwifery Research Ethics Subcommittee, King's College London – Waterloo Campus; Nottingham: Ethics Committee, University of Nottingham Medical School; Dublin: Research Ethics Committee, Trinity College Dublin School of Psychology; Paris: Committee of Protection of Persons Île-de-France VII, Mannheim: Medical Ethics Commission II, Heidelberg University Medical Faculty in Mannheim; Hamburg: Ethics Board, Hamburg Chamber of Physicians; Dresden: Ethics Committee, Technical University Dresden Faculty of Medicine Carl Gustav Carus; Berlin: Ethics Committee, Charité Berlin University of Medicine Faculty of Psychology). All data provided for the present analyses were de-identified and thus exempt from further Institutional Review Board oversight.

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Abstract

This study explored the generality versus specificity of two trait-liability factors for externalizing problems — disinhibition and callousness — in the concurrent and prospective prediction of symptoms of conduct disorder, attention-deficit/hyperactivity disorder (ADHD), and substance use (i.e., alcohol use disorder and history of illicit substance use). Disinhibition involves an impulsive, unrestrained cognitive-behavioral style; callousness entails a dispositional lack of social-emotional sensitivity. Participants were European adolescents from the multi-site IMAGEN project who completed questionnaires and clinical interviews at ages 14 (N=1,504, M_{age}=14.41, 51.13% female) and 16 (N=1,407, M_{age}=16.46, 51.88% female). Disinhibition was related concurrently and prospectively to greater symptoms of conduct disorder, ADHD, and alcohol use disorder;

higher scores on a general externalizing factor; and greater likelihood of having tried an illicit substance. Callousness was selectively related to greater conduct disorder symptoms. These findings indicate that disinhibition confers broad liability for externalizing spectrum disorders, perhaps due to its affiliated deficits in executive function. In contrast, callousness appears to represent more specific liability for antagonistic (aggressive/exploitative) forms of externalizing, as exemplified by antisocial behavior. Results support the utility of developmental-ontogenetic and hierarchical-dimensional models of psychopathology and have important implications for early assessment of risk for externalizing problems.

General Scientific Summary:

This study suggests that assessing dispositional traits of disinhibition and callousness in adolescence can provide important predictive information about later-emerging behavior problems. Further, these trait-risk factors differ in the specificity of their relations with externalizing psychopathology, with disinhibition promoting overall risk and callousness predicting risk for conduct problems in particular.

Keywords

disinhibition; callousness; adolescence; liability; externalizing

Assessment of risk for future psychopathology is crucial to reducing the significant personal and societal costs of mental illness. To gain a clear understanding of risk factors for mental health problems, we must consider the progression of psychopathology in ontogenetic terms — differentiating pre-existing liability factors from fluctuating symptoms of active pathology and persisting consequences of mental illness (Perkins et al., 2020a). From this standpoint, liability factors represent individual-difference characteristics that (1) are evident before symptom onset and (2) reflect genetically influenced processes associated with prospective risk for psychopathology. Liability factors can operate at broader or narrower levels of specificity, with some increasing risk for broad sets of clinical problems and others influencing risk for particular conditions. Distinguishing between broad and specific liability factors facilitates the identification of individuals at high risk for a range of mental illnesses so they can be prioritized for targeted prevention programs. Effective assessment of liability also provides prognostic information about who may benefit from a given form of treatment.

General Liability for Externalizing Problems

Psychological disorders are often grouped according to patterns of comorbidity and shared features, forming transdiagnostic “spectra” (Achenbach & Edelbrock, 1978; Lahey et al., 2017). The externalizing spectrum encompasses disorders characterized by behavioral dysregulation that leads to clinically significant distress and/or impairment in everyday functioning. Disorders within this spectrum include attention-deficit/hyperactivity disorder (ADHD), substance use disorders, conduct disorder, and antisocial personality disorder. These disorders exhibit substantial, systematic comorbidity, arising from shared underlying liability factors (Achenbach & Edelbrock, 1978; Burns et al., 2014; Lahey et al., 2017).

Consistent with the idea of common dysfunction underlying these disorders, twin-modeling research in adolescence and adulthood has demonstrated that a shared genetic factor across externalizing disorders accounts for their systematic comorbidity (Krueger et al., 2002; Young et al., 2000). These studies also showed that disinhibitory personality traits, such as low constraint, operate as indicators of this shared heritability factor. Further, longitudinal research findings suggest that disinhibitory traits prospectively predict externalizing disorders (e.g., Elkins et al., 2006; Krueger, 1999) and subclinical manifestations of externalizing, such as earlier initiation of substance use (McGue et al., 2001). Based on this behavioral-genetic and longitudinal evidence, researchers have posited a dispositional liability — disinhibition — that contributes to all externalizing disorders (Iacono et al., 1999; Perkins et al., 2020a; Yancey et al., 2013; Young et al., 2009). Disinhibition is a dispositional impairment in self-regulation that manifests in poor behavioral control (Patrick et al., 2009, 2013b; Venables et al., 2018a).

Although several processes are evident in relation to externalizing disorders — including trait impulsivity, motor impulsivity, sensation-seeking, impulsigenic traits, and negative affectivity (Beauchaine, 2012; Beauchaine et al., 2010, 2016) — disinhibition is distinguished from these other factors by its specific conceptualization as a deficit in "top-down" (executive) control. Impaired executive function represents a common feature of externalizing disorders that binds them together (Friedman et al., 2020; Young et al., 2009). ADHD, for example, is marked by pervasive inattention (e.g., difficulty sustaining focus) and/or hyperactivity-impulsivity (e.g., blurting out answers; APA, 2013), and cognitive and neuroscience studies have shown that deficits in inhibitory control, error monitoring, and decision making play a critical role in this syndrome (Kasper et al., 2012; Kofler et al., 2019). Impairments in cognitive control and in the tendency to adjust behavior based on consequences are symptomatic of both substance use disorders and conduct disorder, and research indicates a role for executive dysfunction in these conditions as well (Kovács et al., 2017; Luijten et al., 2014; Morgan & Lilienfeld, 2000; Noordermeer et al., 2016). These similar patterns of impairment across externalizing disorders suggest that executive dysfunction may be a common process contributing to their comorbidity. In turn, trait disinhibition is associated with poor performance on cognitive tasks, particularly ones requiring inhibitory control, and with reduced neural reactivity to stimuli signaling the need for response inhibition (Ribes-Guardiola et al., 2020; Venables et al., 2018a; Yancey et al., 2013; Young et al., 2009). Confirmatory factor analysis has demonstrated that personality-based measures of disinhibition cohere with cognitive-performance and brain-response measures of inhibitory control (Venables et al., 2018a). This shared variance has led disinhibition to be conceptualized as a *neurobehavioral* trait dimension — a latent dispositional characteristic that manifests in multiple measurement modalities (e.g., self-report, neural, and behavioral measures; Perkins et al., 2020b). Importantly, the general disinhibition factor from this model relates robustly to externalizing problems (Patrick et al., 2013b; Venables et al., 2018a), suggesting that it is what the personality, cognitive, and brain-response measures have in common that predicts externalizing. Together, these findings indicate that disinhibition reflects proneness to externalizing problems, related to variations in the capacity for inhibitory control and distinct from dispositional factors that confer vulnerability to internalizing problems (Joyner et al., 2021). Although related to

the well-established literature on trait impulsivity in developmental psychopathology (e.g., Beauchaine et al., 2017), disinhibition is distinguished by its links to inhibitory control, rather than reward processing and negative affectivity, and by its specificity to externalizing.

Specific Liability for Antisocial Behavior

Although disinhibition provides a compelling explanation for comorbidity among externalizing disorders, other liability factors appear to contribute to particular symptomatic expressions (Krueger et al., 2002, 2007). In particular, trait callousness has been identified as a liability factor for conduct disorder (Frick & White, 2008). Individuals high in callousness demonstrate disruptions in affective response and social affiliation, including emotional insensitivity, deficient empathy for others' welfare, and disdain for close relationships (Frick et al., 2014; Patrick et al., 2009; Viding & McCrory, 2019). Substantial research has shown that the low fear and social disinterest reported by high-callous individuals extend to blunted physiological reactivity to aversive stimuli (Fanti et al., 2017) and deficient recognition of and reactivity to others' distress (Brislin & Patrick, 2019; de Wied et al., 2012; Marsh et al., 2008). One prominent theory (Blair, 1995) posits that this physiological emotion deficit and unresponsiveness to others' distress, coupled with poor socialization, disrupt normal conscience development in high-callous youth. As a result, they exhibit the unempathic social disregard that can lead to violating others' rights and/or important societal norms (Frick & White, 2008; Viding et al., 2012). Consistent with this theory, longitudinal research suggests callousness is strongly related to low empathy and predicts severe antisocial behavior and poor response to conventional psychological treatments (Frick & White, 2008). Drawing on this research, a "limited prosocial emotions" specifier was added to DSM-5 (APA, 2013) to designate youth with conduct disorder who exhibit high callousness. Nonetheless, mechanistic research on callousness as a liability factor for conduct problems is still ongoing.

The association between childhood callousness and conduct problems substantially reflects shared genetic influences (Viding et al., 2007, 2013). Together with longitudinal evidence that callousness prospectively predicts antisocial behavior (Frick & White, 2008), this research implies that callousness is a liability factor for conduct problems (Perkins et al., 2020a). Given its neurophysiological and task-performance correlates, callousness — like disinhibition — has been conceptualized as a neurobehavioral trait (Palumbo et al., 2020). However, research is lacking on the specificity of callousness as a prospective liability for antisocial behavior, as few studies have examined it longitudinally in relation to non-antisocial forms of externalizing. Although some studies have shown that callousness during adolescence prospectively predicts substance use (Baskin-Sommers et al., 2015; Thornton et al., 2019; Wymbs et al., 2012), none of these examined the potential role of disinhibition in these associations.

Given the evidence for disinhibition as a broad liability for externalizing psychopathology, the observed associations between callousness and non-antisocial forms of externalizing, and the moderate correlation between disinhibition and callousness (Baroncelli et al., 2022; Sica et al., 2019), it is important to clarify whether callousness and disinhibition comprise unique liabilities for conduct problems and other forms of externalizing. A recent cross-

sectional study of adolescents reported unique associations for both traits with conduct problems, whereas disinhibition alone was predictive of ADHD symptoms (Sica et al., 2019). However, the developmental course of these patterns is not yet clear, and this prior study did not examine associations with substance use. Thus, longitudinal research including measures of disinhibition and callousness alongside a range of externalizing outcomes is needed to elucidate the nature and specificity of these relations. A greater understanding of disinhibition, callousness, and their relations with clinical symptoms during and across adolescence would provide an important foundation for theories of shared and distinct causal processes contributing to externalizing psychopathology. This work could facilitate the identification of at-risk youths prior to the onset of externalizing problems and the development of tailored treatment plans for distinct trait profiles.

The Current Study

This study addressed the foregoing questions regarding liability for externalizing problems using data from the IMAGEN project, a large, multi-site study of European adolescents (Schumann et al., 2010). The project's longitudinal design allowed for both prospective and cross-sectional analyses of trait-psychopathology relations (i.e., from age 14 to 16, and at ages 14 and 16 separately). Use of a community sample, rather than exclusively clinic-referred youth, was key to the study design, as the goal was to examine individual differences in liability for the occurrence or exacerbation of externalizing problems. By shedding light on patterns of risk in an unselected sample from the population at large, findings can be generalized to inform community screening practices and prevention strategies.

Another important feature of this work is that externalizing psychopathology was operationalized in terms of dimensional symptom-count scores for conditions of interest (i.e., number of symptoms endorsed) rather than binary diagnoses (i.e., present versus absent). This approach allowed for fine-grained analysis of individual-difference effects, unconstrained by arbitrary diagnostic thresholds (Kotov et al., 2017), and served our aim of examining clinical prediction using the full range of individual variability in traits and outcomes. Importantly, the dimensional operationalization of psychopathology also greatly enhances reliability and stability compared to categorical diagnoses (Markon et al., 2011; see Kotov et al., 2017), increases statistical power (Cohen, 1983; MacCallum et al., 2002), and overcomes potential confounds introduced by including functional impairment indicators in categorical diagnostic criteria. Here, we analyzed dimensional conduct disorder, ADHD, and alcohol use disorder symptom scores, as well as estimated scores on a latent factor reflecting the covariance among these externalizing symptoms. Although non-alcohol substance misuse symptoms were not measured, we also examined participants' history of having tried an illicit (non-alcohol) substance — a dichotomous index of early substance initiation, irrespective of its clinical progression (Karoly et al., 2013; Young et al., 2009).

We tested three *a priori* hypotheses regarding the generality versus specificity of two major trait-liability factors relevant to the externalizing spectrum — disinhibition and callousness

— in predicting the development of symptoms of conduct disorder, ADHD, and substance use in adolescence.

1. Given the conceptualization of disinhibition as broad liability for externalizing problems (Iacono et al., 1999; Krueger et al., 2002, 2007; Sica et al., 2019; Young et al., 2009), we hypothesized that disinhibition would prospectively predict all three externalizing symptom variables (conduct disorder, ADHD, and alcohol use disorder symptoms), over and above concurrent associations. We also hypothesized that disinhibition would predict scores on a latent externalizing factor defined by symptoms of these three diagnostic conditions.

2. In contrast, we expected that, given its theorized specificity to antisocial behavior (Frick & White, 2008; Krueger et al., 2002, 2007; Sica et al., 2019), callousness would selectively predict conduct disorder symptoms when accounting for its covariance with disinhibition.

3. As a complement to the alcohol use disorder symptom analyses, we hypothesized that disinhibition would be associated with increased likelihood of trying an illicit substance. That is, we predicted that disinhibition would be associated not only with variability in alcohol use disorder symptoms, but also with risky substance-related behavior more broadly (Karoly et al., 2013; Young et al., 2009). Given that prior research has not controlled for disinhibition, we had no specific hypothesis regarding unique associations for callousness with illicit substance use.

Method

Participants

Participants in the Time 1 (T1) assessment of the IMAGEN project were adolescents (N=2,260) recruited from local high schools in eight European cities: London and Nottingham, England; Dublin, Ireland; Paris, France; and Mannheim, Hamburg, Dresden, and Berlin, Germany. Demographic details of the T1 sample are described in Schumann et al. (2010); mean age at T1 was 14.45 years (SD=.34), 52% were female, and 95% reported White-European ethnicity. The Time 2 (T2) assessment, two years later (mean age=16.52, SD=0.63), included 1,654 (74.33%) of the T1 participants.

Inclusion criteria and missing data.—Participants were included in analyses if they met both of the following criteria for a given time point: (1) provided responses to at least 75% of questionnaire items included in both the callousness and disinhibition scales (14% of exclusions from the complete IMAGEN sample at T1), thereby ensuring adequate content coverage from the different questionnaires, and (2) were not missing age, sex, or assessment site data (86% of exclusions), as these were considered crucial covariates. These inclusion criteria resulted in base samples of N=1,504 at T1 (age 14; M_{age}=14.41, SD=.43, 51.13% female) and 1,407 at T2 (age 16; M_{age}=16.46, SD=.51, 51.88% female). Relative to those included, IMAGEN participants excluded from the T1 base sample were somewhat higher in disinhibition, $t(2190)=3.79$, $p<.001$ (M_{diff}=.05), but did not differ in callousness ($t(2153)=1.23$, $p=.22$) or sex ($X^2(1)=.04$, $p=.084$). The attrition sample did not

differ from longitudinal participants in T1 age, $t(1502)=1.25$, $p=.21$, or T1 callousness, $t(1502)=.67$, $p=.50$, but contained a somewhat higher proportion of males, $X^2(1)=4.95$, $p=.03$, and was higher in T1 disinhibition, $t(1502)=4.02$, $p<.001$ ($M_{diff}=.13$), suggesting that males and more disinhibited individuals had higher drop-out rates. Participants from among these base samples were excluded from a given model if they did not provide data for that outcome measure at that time point (mean exclusion rate=.76%, range=0 to 3.19%). (See Supplemental Figure A for detailed information regarding exclusions.)

This listwise exclusion approach was used in part because there is no consensus regarding the optimal handling of missing data in negative binomial regression (see description below; Lukusa et al., 2017). Importantly, the vast majority of excluded participants (>90%) were missing data for age. Approaches such as multiple imputation rely on other variables known to correlate strongly with the missing variables; however, in this case, no other variable met this criterion (all rs<.10), making it likely that imputed age data would be imprecise and biased (Lee & Simpson, 2014). Therefore, we chose not to use multiple imputation for our analyses, even though it would have increased our sample size. Nonetheless, exploratory analyses using this approach revealed very similar patterns of results, suggesting the choice of listwise deletion did not introduce excessive bias.

Assessment Procedure

The T1 assessment was completed at the IMAGEN Consortium research laboratories with adolescents and their parents. Adolescents completed questionnaires, clinical interviews, neuroimaging, and blood sampling; parents completed questionnaires and clinical interviews about their children. All procedures were conducted in participants' native language (English, French, or German). At T2, families participated in a reduced remote protocol including online questionnaires and a phone-based clinical interview.

Ethical considerations.—Adolescent assent and parental informed consent were obtained in writing via mail at T1 and T2. All study procedures were approved by each university's ethics committee, following the Declaration of Helsinki. The IMAGEN Consortium granted approval for this study's secondary analyses of de-identified data.

Questionnaires

Trait predictors.—The IMAGEN-Disinhibition and Callousness scales were used to measure the traits of interest. Each was created through a well-established approach to scale development (e.g., Drislane et al., 2015, 2018; Hall et al., 2014), employing items from personality and behavior questionnaires administered to IMAGEN participants. The development, validation, and content of the IMAGEN-Disinhibition scale are detailed in Brislin et al. (2019); it consists of 22 items reflecting impulsivity, low constraint, and sensation-seeking. In the samples analyzed for that article, IMAGEN-Disinhibition demonstrated acceptable to good internal consistency (αs=.74 to .81), good temporal stability from T1 to T2 (r=.61), and good convergent and discriminant validity with questionnaire measures, clinical interviews, and psychophysiological responses.[1]

The IMAGEN-Callousness scale was developed for this study using similar techniques (see Method A and B and Table A of the Supplemental Material). It consists of 17 items reflecting lack of prosocial orientation, selfishness, antagonism, and manipulativeness. IMAGEN-Callousness demonstrates acceptable internal consistency reliability (αs=.76 at T1 and .77 at T2) and good temporal stability from T1 to T2 (r=.60). In a separate undergraduate sample (N=109), IMAGEN-Callousness was highly correlated (r=.73) with a well-validated measure of the same construct, the Callous-Aggression factor scale of the Externalizing Spectrum Inventory (Patrick et al., 2013a), which in turn is associated with various brain and behavioral indices of callousness (Brislin et al., 2018; Brislin & Patrick, 2019). Further, within a subsample of IMAGEN participants at T2 (N=999), IMAGEN-Callousness was negatively correlated (r=−.53, p<.001) with the Interpersonal Reactivity Index facet of Empathic Concern (Davis, 1980). In contrast, IMAGEN-Disinhibition was only weakly related to Empathic Concern (r=−.11, p<.001). In a linear regression model, when both traits were entered as predictors of Empathic Concern, only IMAGEN-Callousness maintained negative prediction, whereas IMAGEN-Disinhibition evidenced a small *positive* association (βs=−.59 and .14, respectively; ps<.001). In other words, IMAGEN-Callousness was selectively associated with a theoretically similar construct: empathic concern (see Waller et al., 2020). These findings provide initial support for the reliability and validity of the IMAGEN-Callousness scale. A more detailed characterization of the IMAGEN sample's levels of these traits is provided in Supplemental Method C and Supplemental Figures B and C.

Substance use.—The Alcohol Use Disorders Identification Test (AUDIT; Saunders et al., 1993) was used to assess alcohol use disorder symptoms. The AUDIT is a 10-item self-report scale that assesses frequency and severity of alcohol use across three subscales — frequency, alcohol dependence symptoms, and harmful alcohol use — as well as a total score. The total score was used in the present analyses; internal consistency was acceptable, αs=.75 to .76, depending on the time point. Further characterization of the IMAGEN sample's levels of alcohol use is provided in Supplemental Method C. Illicit substance use was assessed using items from the European School Survey Project on Alcohol and Drugs (ESPAD, Hibell et al., 1997). Lifetime use of illicit substances was coded as a single dichotomous (yes/no) summary variable reflecting use of any non-prescribed psychoactive substance apart from alcohol.

Clinical Interview

The Development and Well-Being Assessment (DAWBA; Goodman et al., 2000) was administered to participants by a trained clinician in person at T1 and via telephone at T2. The DAWBA is a semi-structured interview that assesses internalizing and externalizing psychopathology in a manner similar to DSM-IV-TR (APA, 2000).[2] Item-level responses

[1]At the suggestion of an anonymous reviewer, we conducted exploratory factor analyses of the IMAGEN-Disinhibition item set at each assessment point to evaluate its unidimensionality. One-factor solutions emerged at both T1 and T2, despite the scale's inclusion of items from multiple questionnaires: The magnitude of the first eigenvalue was 4.42 at T1 and 4.62 at T2, and it accounted for more than 20% of variance in total scores at each assessment point; subsequent eigenvalues fell below 1.70 at both T1 and T2, with each accounting for less than 7.75% of score variance.

[2]No major changes were made to the main diagnostic criteria for either ADHD or conduct disorder from DSM-IV-TR to the current DSM-5.

were aggregated to compute separate dimensional symptom count scores for conduct disorder and ADHD.[3] As some items included more than two response options, this variability was represented in symptom counts by assigning integer values for each response option (e.g., “no” = 0, “a little” = 1, “a lot” = 2; for a different item, “no” = 0, “yes” = 2).

Conduct disorder symptoms that were worded similarly to items in the trait disinhibition and callousness scales (e.g., items pertaining to history of legal trouble, bullying, etc.) were not included in the symptom count variable employed in our analyses, in order to avoid criterion contamination; however, results were highly similar regardless of their inclusion. All items included in symptom counts are listed in Supplemental Table B. More information about the sample’s levels of conduct disorder and ADHD symptoms is provided in Supplemental Method C.

Analytic Strategy

Scores on the disinhibition and callousness measures were inspected for outliers using a criterion of median ± 2 interquartile ranges, Winsorized to the criterion value, and then *z*-scored to facilitate ease of interpretation.

The clinical symptom variables (conduct disorder, ADHD, and alcohol use disorder) exhibited positively skewed distributions given their modest rates of occurrence in this community adolescent sample; a large proportion of individuals reported 0 symptoms at each time point (see Supplemental Table C). Given these distributional characteristics and the count nature of the symptom data, key assumptions of traditional ordinary least squares (OLS) regression were violated. Consequently, negative binomial regression models were used to evaluate predictive relations of disinhibition and callousness with these criterion variables.[4] Negative binomial models produce an incidence rate ratio (IRR) for each predictor, which is interpreted as reflecting the percent increase in the outcome variable for a one-unit increase in the predictor over the predictor’s mean. For example, an IRR of 1.20 would suggest a 20% increase in the outcome variable, whereas an IRR of .70 would signify a 30% decrease. Logistic regression was used to examine relations of the two traits with lifetime history of illicit substance use due to its dichotomous coding. The resulting odds ratios are interpreted as the increase in likelihood of having used an illicit substance per one-unit increase in the predictor.

Confirmatory factor analysis, implemented via the lavaan package (version 0.6–7; Rosseel, 2012) of the R statistical environment (version 4.0.4; R Core Team, 2021), was used to fit a bifactor model of externalizing psychopathology. Following prior work in both youth and adults (Krueger et al., 2002; Martel et al., 2010; Tackett et al., 2013), all symptoms of conduct disorder, ADHD, and alcohol use disorder were allowed to load onto both their syndrome-specific factor and a general factor. Estimated scores for the general externalizing factor of this model were used as an additional outcome measure in OLS regression analyses to directly test hypotheses regarding shared liability for externalizing.

[3]Given evidence for distinct subdimensions underlying conduct disorder (Burt, 2012), supplemental analyses examined rule-breaking and aggressive symptoms as separate outcomes; see Supplemental Results and Supplemental Figures D and E.

[4]For purposes of comparison with prior published work, we also performed analyses of the current data using OLS regression, obtaining similar results; these are available from the first author upon request.

Concurrent analyses utilized data at T1 and T2 separately, with callousness and disinhibition predicting the criterion variable (i.e., conduct disorder, ADHD, alcohol use disorder symptoms; history of illicit substance use; predicted externalizing factor scores) at each time point. Prospective analyses examined traits at T1 as predictors of outcomes at T2, over and above T1 values. One set of prospective analyses simply included the T1 value as a covariate. A complementary set of analyses instead included the raw residual T1 value after regressing out variance in common with either trait at T1, to allow all covariance between the T1 trait and T2 outcome to be reflected in the trait coefficient.[5] All regression analyses were conducted in R using the MASS package (version 7.3–53; Venables & Ripley, 2002) and controlled for age, sex, and assessment site, although results were highly similar when these covariates were not included. Wald tests were used to compare the magnitude of coefficients for disinhibition and callousness within a given model. The *p*-values from all regression models were adjusted using Holm's (1979) step-down procedure within a given syndrome; these adjusted values are denoted by p_H.

Results

Descriptive statistics and zero-order correlations for all study variables are provided in Supplemental Table C. Regression results for all outcome variables are depicted in Figures 1, 2, 3, 4, and 5. Results from supplemental analyses of separate rule-breaking and aggressive symptom subdimensions of conduct disorder are presented in the Results section of the Supplement and in Supplemental Figures D and E.

Disinhibition and callousness were moderately intercorrelated at each time point (both Pearson's *r*s=.45, *p*s<.001), and both exhibited moderately high (*r*~.6) stability from T1 to T2, as noted in the Method. Symptom counts for conduct disorder and ADHD were weakly to moderately intercorrelated (Spearman's ρs=.27 at T1 and .31 at T2, *p*s<.001), with moderate longitudinal stability (ρs=.41 and .42, respectively, *p*s<.001). The alcohol use disorder symptom and illicit substance use variables were weakly to moderately intercorrelated (point-biserial correlations [r_{pb}s]=.34 and .46 at T1 and T2, respectively, *p*s<.001) and showed low-to-moderate stability over time (ρ=.43 for alcohol use disorder symptoms; φ=.31 for illicit substance use; *p*s<.001), consistent with expected developmental change in substance use across adolescence. Both substance use variables were weakly to moderately associated with concurrent conduct disorder symptoms (ρs and φs=.24 to .34) and weakly with ADHD symptoms (ρs and φs=.06 to .16). The general externalizing factor was moderately stable over time (*r*=.45, *p*<.001).

Conduct Disorder Symptoms

Age 14 (T1).—At the zero-order level, both disinhibition and callousness were significantly related to conduct disorder symptoms at T1, ρs=.44 and .30, respectively

[5]The rationale for this approach is that a portion of the covariance between T1 and T2 symptoms is expected to reflect trait-based liability. Consequently, in a regression model that includes T1 symptoms and T1 traits as predictors of T2 symptoms, the T1 trait variance that overlaps with T1 symptoms is not reflected in the trait's regression coefficient. Statistically removing trait-related variance from the T1 symptom count may therefore yield a more accurate estimate of how the T1 trait relates to T2 symptoms. Results from analyses using this alternative theory-based approach are reported for purposes of comparison with findings from more conventional, conservative analyses.

(ps<.001). In the negative binomial regression model, the two traits were independently related to conduct disorder symptoms, over and above the effects of age, sex, and assessment site. The incidence rate ratios (IRRs) with 95% confidence intervals (CIs) for disinhibition and callousness were 1.61 [1.51, 1.72] and 1.26 [1.18, 1.34], respectively (p_Hs<.001). A follow-up Wald test revealed that the IRR for disinhibition was larger than that for callousness, Z_{diff}=4.52, p<.001. The adjusted pseudo-R^2 for this model was .24.

Age 16 (T2).—Disinhibition and callousness were moderately correlated with conduct disorder symptoms at T2, ρs=.50 and .31, respectively (ps<.001). In the negative binomial model, estimates were comparable to those at T1, with IRRs and 95% CIs of 1.77 [1.66, 1.89] and 1.17 [1.10, 1.25] for disinhibition and callousness, respectively (p_Hs<.001), and a larger coefficient for disinhibition (Z_{diff}=7.26, p<.001). The adjusted pseudo-R^2 was .27.

Prospective prediction (T1 to T2).—T1 disinhibition and callousness were each associated with T2 conduct disorder symptoms at the zero-order level, ρs=.35 and .24, respectively (ps<.001). In the prospective negative binomial model that included T1 conduct disorder symptoms as a covariate, IRRs for T1 disinhibition and callousness were 1.27 [1.18, 1.36] (p_H<.001) and 1.08 [1.01, 1.16] (p_H=.02), respectively, with an adjusted pseudo-R^2 of .19. When the residualized T1 conduct disorder variable (see above) was used instead, prospective IRRs were 1.43 [1.35, 1.53] and 1.14 [1.07, 1.22], respectively (both p_Hs<.001), with an adjusted pseudo-R^2 of .20. In both cases, disinhibition was a significantly stronger predictor than callousness (Z_{diff}s=2.76 and 4.02, ps<.01 and .001 for the respective prospective models).

ADHD Symptoms

Age 14 (T1).—At the zero-order level, both disinhibition and callousness were associated with ADHD symptoms at T1, with a larger effect for disinhibition (ρ=.38, versus .15 for callousness; both ps<.001; Steiger's Z=8.96, p<.001). In the negative binomial regression model, only disinhibition was independently related to T1 ADHD symptoms, over and above the effects of age, sex, and assessment site; any zero-order effect of callousness was attributable to its overlap with other predictors. The IRRs with 95% CIs for disinhibition and callousness were 1.78 [1.63, 1.95] (p_H<.001) and .98 [.90, 1.07] (p_H=.69), respectively, with disinhibition showing a much stronger effect (Z_{diff}=7.86, p<.001). The adjusted pseudo-R^2 for this model was .15.

Age 16 (T2).—Disinhibition and callousness were moderately correlated with ADHD symptoms at T2, ρs=.42 and .22, respectively (ps<.001). In the negative binomial model, estimates were comparable to those at T1, with a large IRR of 2.08 [1.88, 2.31] for disinhibition (p_H<.001) and a nonsignificant effect for callousness (IRR = 1.05 [.95, 1.17], p_H=.62; Z_{diff}=7.65, p<.001). The adjusted pseudo-R^2 was .21.

Prospective prediction (T1 to T2).—T1 disinhibition and callousness were each associated with T2 ADHD symptoms at the zero-order level, ρs=.28 and .12, respectively (ps<.001). In the prospective negative binomial model that included T1 ADHD symptoms as a covariate, IRRs for T1 disinhibition and callousness were 1.34 [1.21, 1.48] (p_H<.001)

and .93 [.84, 1.03] (p_H=.60), respectively, with an adjusted pseudo-R^2 of .20. When the residualized T1 ADHD variable was used instead, the prospective IRR for disinhibition was 1.66 [1.51, 1.82] (p_H<.001), and for callousness, IRR = .93 [.85, 1.03] (p_H=.60), with an adjusted pseudo-R^2 of .22. In both cases, disinhibition was the stronger predictor, Z_{diff}s=4.30 and 6.92, respectively, ps<.001.

Substance Use

Age 14 (T1).—At the zero-order level, both disinhibition and callousness were associated with T1 alcohol use disorder symptoms, with a larger effect for disinhibition (ρ=.37, versus .21 for callousness; both ps<.001; Steiger's Z=6.26, p<.001). A similar pattern of results was observed for the dichotomous outcome of having used an illicit drug (r_{pb}=.22 and .13 for disinhibition and callousness, respectively, ps<.001; Steiger's Z=3.39, p<.001). In the negative binomial regression model, both traits retained independent prediction of AUD symptoms (disinhibition IRR=1.75 [1.61, 1.91], p_H<.001; callousness IRR=1.17 [1.07, 1.27], p_H=.002), although the coefficient for disinhibition was much larger (Z_{diff}=5.49, p<.001). The adjusted pseudo-R^2 for this model was .22. For illicit drug use, the odds ratios with 95% CIs for disinhibition and callousness were 2.12 [1.73, 2.61] (p_H<.001) and 1.13 [.92, 1.37] (p_H=.96), respectively.

Age 16 (T2).—Disinhibition and callousness were correlated with AUD symptoms at T2, ρs=.41 and .16, respectively, and with having used an illicit drug (r_{pb}s=.33 and .16, respectively; all ps<.001). In the negative binomial model, only disinhibition independently predicted AUD symptoms, with a medium-sized IRR of 1.56 [1.47, 1.65] for disinhibition (p_H<.001) and a nonsignificant effect for callousness (IRR=.98 [.93, 1.04], p_H>.99; Z_{diff}=9.26, p<.001). The adjusted pseudo-R^2 for this model was .18. For illicit drug use, the odds ratios with 95% CIs for disinhibition and callousness were 2.39 [2.05, 2.81] (p_H<.001) and 1.00 [.86, 1.16] (p_H=.96), respectively.

Prospective prediction (T1 to T2).—T1 disinhibition and callousness were each associated with T2 AUD symptoms at the zero-order level, ρs=.30 and .13, respectively, and with having used an illicit drug by T2, r_{pb}s=.25 and .15 (all ps<.001). In the prospective negative binomial model that included T1 AUD symptoms as a covariate, IRRs with 95% CIs for T1 disinhibition and callousness were 1.23 [1.16, 1.31] (p_H<.001) and .99 [.94, 1.05] (p_H>.99), respectively, with an adjusted pseudo-R^2 of .12. When the residualized T1 AUD symptoms were used instead, the prospective IRR for disinhibition was 1.34 [1.26, 1.41] (p_H<.001); for callousness, IRR=1.01 [.96, 1.07] (p_H>.99). The adjusted pseudo-R^2 was .15. In both prospective models, disinhibition was a significantly stronger predictor than callousness, Z_{diff}s=4.39 and 5.65, ps<.001. For illicit drug use, the odds ratios with 95% CIs for disinhibition were 1.67 [1.44, 1.94] for the traditional prospective model and 1.85 [1.60, 2.16] for the residualized prospective model (p_Hs<.001); for callousness, the corresponding values were 1.05 [.91, 1.22] and 1.08 [.93, 1.24] (both p_Hs=.96).

Predicted Externalizing Scores

The bifactor model of conduct disorder, ADHD, and alcohol use disorder symptoms provided acceptable-to-good fit at both time points according to criteria recommended by

Hu and Bentler (1999) and Schreiber et al. (2006). The Comparative Fit Index (CFI) was .88 at T1 and .89 at T2, and the Tucker-Lewis Index (TLI) was .86 and .87, respectively; the Root Mean Square Error of Approximation (RMSEA) was .050 with a 90% CI of [.047, .053] at T1 and .048 [.045, .051] at T2; and the Standardized Root Mean Square Residual (SRMR) was .047 at T1 and .050 at T2. Estimated scores on the latent general externalizing factor were extracted for each participant for further analysis and log-transformed to account for non-normality of the residuals.

Age 14 (T1).—At the zero-order level, both disinhibition and callousness were associated with externalizing, although the effect for disinhibition was much larger: *r*s=.46 and .25, respectively, *p*s<.001, Steiger's Z=8.52, p<.001. In the OLS regression model, both traits retained independent prediction of externalizing problems, with a much larger coefficient for disinhibition (ß=.41, 95% CI=[.37, .46], p_H<.001) than callousness (ß=.08, 95% CI=[.03, .13], p_H=.01; Z_{diff}=7.59, p<.001). R^2 for this model was .26.

Age 16 (T2).—As at T1, both traits were associated with externalizing at T2, *r*s=.48 for disinhibition and .21 for callousness (*p*s<.001). The regression analysis showed a significant effect for disinhibition (ß=.49, 95% CI=[.44, .54], p_H<.001), but not callousness (ß=−.02, 95% CI=[−.07, .03], p_H>.99; Z_{diff}=11.17, p<.001), with an overall model R^2 of .27.

Prospective prediction (T1 to T2).—The T1 traits were associated with T2 externalizing at the zero-order level, *r*s=.33 for disinhibition and .17 for callousness, *p*s<.001. In the regression model including T1 externalizing scores as a covariate, T1 disinhibition significantly predicted T2 externalizing, ß=.18, 95% CI=[.13, .24], p_H<.001, whereas callousness did not (ß=−.02, 95% CI=[−.07, .04], p_H>.99; Z_{diff}=4.28, p<.001). When residualized T1 scores were included instead, a similar pattern emerged, with disinhibition predicting significantly, ß=.34, 95% CI=[.29, .39] (p_H<.001), but not callousness, ß=.01, 95% CI=[−.04, .07], p_H>.99; Z_{diff}=7.31, p<.001). R^2s for both models were .24.

Discussion

The current study evaluated the generality versus specificity of two trait-liability factors — disinhibition and callousness — in predicting externalizing outcomes of conduct disorder, ADHD, and substance use symptoms across adolescence. Disinhibition reflects an impulsive, unrestrained cognitive and behavioral style that is thought to confer liability for all disorders in the externalizing spectrum (see Patrick et al., 2009); callousness entails a lack of social-emotional sensitivity that has largely been studied as a risk factor for persistent and severe conduct problems (Frick, 2012). Consistent with these conceptualizations and prior cross-sectional findings (Sica et al., 2019), disinhibition prospectively predicted the onset or exacerbation of symptoms of conduct disorder, ADHD, alcohol use disorder, and illicit substance use, as well as increases in general externalizing scores, from age 14 to 16, in addition to showing concurrent relations with these variables. In contrast, callousness did not show robust patterns of association with ADHD symptoms, alcohol use disorder symptoms, substance use, or general externalizing; it was selectively related to conduct disorder symptoms, both concurrently and prospectively. Of

note, supplemental analyses of the subdimensions of conduct disorder symptoms revealed concurrent associations for callousness with both aggressive and rule-breaking symptoms, as well as using the residualized prospective approach. However, callousness was not related to either symptom subdimension in the traditional prospective models. Disinhibition was concurrently as well as prospectively associated with both aggressive and rule-breaking symptoms.

Implications for Psychological Science

Our results have several implications for ongoing research on the effective assessment of risk for psychopathology. One is that different liability factors operate at differing levels of specificity. In the current study, trait disinhibition was concurrently and prospectively related to each form of adolescent externalizing problems, as well as a common factor reflecting their shared variance. This finding accords with the adult externalizing spectrum model (Krueger et al., 2002, 2007), which posits a factor common to all externalizing disorders that is genetically linked to disinhibitory traits. Young et al. (2009) presented evidence that this common factor is associated with poor executive function in adolescents, suggesting that what externalizing disorders share is a deficit in cognitive control that is expressed, premorbidly, as trait disinhibition. In contrast to disinhibition's role as a transdiagnostic liability for externalizing problems, we found callousness to be more specifically predictive of conduct disorder symptoms. In parallel, the externalizing spectrum model includes a callous-aggression subfactor that accounts for covariance among different indices of antisocial behavior not attributable to the general externalizing factor (Krueger et al., 2007). Although a formal bifactor externalizing spectrum model including personality traits has not been defined in youth samples (see Tackett, 2010), Herzhoff et al. (2017) found that in children, low levels of conscientiousness — similar to high levels of disinhibition — accounted for patterns of comorbidity between oppositional-defiant disorder, conduct disorder, and ADHD, whereas low agreeableness (related to high callousness) specifically explained the relation between oppositional-defiant and conduct disorders. Our results similarly indicate that the associations between disinhibition and different forms of externalizing problems are attributable to the shared variance among these syndromes. The present study is consistent with prior research in adults and children suggesting that disinhibition and callousness can help to elucidate the structural patterns of comorbidity among forms of externalizing psychopathology.

In addition, our findings point to distinct roles for disinhibition and callousness in broader versus narrower dimensions of psychopathology represented in the Hierarchical Taxonomy of Psychopathology (HiTOP; Kotov et al., 2017), a quantitative-empirical model that classifies clinical problems according to both higher-order, transdiagnostic factors (e.g., spectra) and more specific symptomatic expressions (e.g., physical aggression). Notably, the initial (2017) depiction of the HiTOP model did not include a broad externalizing factor as a counterpart to its internalizing dimension. Instead, separate "disinhibited-externalizing" and "antagonistic-externalizing" spectra were represented, with the concept of an overarching ("super-spectrum"; Perkins et al., 2020a) externalizing factor alluded to, but not formally specified. However, the HiTOP model is considered provisional and open to empirical revision, and — consistent with our results — a recent review paper described empirical

support for the existence of a broad externalizing super-spectrum (Krueger et al., 2021).[6] As defined here, trait disinhibition may serve as a general liability for this super-spectrum. Callousness, on the other hand, appears likely to operate at the Antagonistic-Externalizing spectrum level, increasing risk for antisocial behaviors in particular. Other liability factors may also contribute to the differential manifestations of externalizing; for example, dispositional reward sensitivity, in conjunction with disinhibition, may promote risk for substance use problems, but not other forms of externalizing (see Joyner et al., 2019). Further research is needed to investigate how these liability factors act independently and in concert to promote risk for psychopathology.

Besides relating to clinical symptoms, disinhibition — but not callousness — was related to a greater likelihood of having tried an illicit substance at ages 14 and 16, suggesting a link to the early initiation of substance use. Although our study could not delineate the specific time course of disinhibition's effect on emerging substance use pathology, other published work (e.g., Karoly et al., 2013) suggests that executive control deficits may contribute to initiation of substance use, but that these systems interact dynamically with other processes (e.g., incentive sensitization) to influence the subsequent progression of substance use disorders. Again, further research is needed to understand the complex developmental interplay of different liability factors and emergent processes in the ontogeny of psychopathology (Perkins et al., 2020a). Nonetheless, the current work highlights disinhibition's relevance to risky substance-related behavior, even prior to the onset of clinically significant substance use pathology. Despite the moderate correlation between disinhibition and callousness, the two are differentiated in their level of generality versus specificity to behaviors that precede and/or characterize clinical problems. Although some prior work has demonstrated prospective links between callousness and substance use (Baskin-Sommers et al., 2015; Thornton et al., 2019; Wymbs et al., 2012), our results suggest that such effects may be attributable to disinhibition, which is rarely measured in research on callousness in youth. These findings confirm the critical role of disinhibition in the development of externalizing problems, pointing to the need for further examination of this important but understudied liability factor in youth.

Implications for Clinical Practice

Assessment of liability for psychopathology is critical, as vulnerable individuals who have not yet developed significant clinical problems are likely to benefit the most from prevention and early intervention programs (Dadds, 2004). As an example of how liability assessment can guide clinical practice, callousness has been incorporated into DSM-5 through the "limited prosocial emotions" specifier for conduct disorder (APA, 2013), which differentiates youths likely to show more persistent, severe antisocial behavior and poorer response to standard psychosocial treatments (Frick et al., 2014; Hawes et al., 2014). The limited prosocial emotions specifier is therefore prognostically useful as a trait-based marker that sheds light on the likely course of psychopathology and need for specialized treatment

[6]From this standpoint, the term "Disinhibited-Externalizing" in HiTOP is at odds with the term "disinhibition" as used in the current study. Rather than contributing only to non-antagonistic psychopathology, disinhibition is associated with both antagonistic (e.g., conduct disorder) and non-antagonistic (e.g., ADHD and substance use) symptoms, and with the general factor that all externalizing symptoms load on.

(Frick et al., 2014). Consistent with this view, callousness in the current study demonstrated significant prospective prediction of conduct disorder symptoms, over and above age, sex, assessment site, and disinhibition. This finding is especially noteworthy given that it was observed from ages 14 to 16, when criminal behavior typically peaks and begins to decrease (see Farrington, 1986; Loeber et al., 2012). Assessment of callousness at this age may help to identify youth at risk for a relatively severe and persistent trajectory of antisocial behavior, irrespective of their general externalizing proneness.

However, the current study also suggests that measuring a *set* of liability factors in community youths can be useful in identifying those at maximal risk. In the current work, disinhibition evidenced even stronger prediction of conduct disorder symptoms than callousness, and it also predicted other externalizing outcomes unrelated to callousness. Our results provide support for recent calls for a multidimensional trait approach to characterizing antisocial behavior and other forms of externalizing (e.g., Lilienfeld, 2018). Assessment of these and other liability factors in early adolescence — if not earlier — is essential to targeted prevention efforts and tailored treatment strategies aimed at decreasing the personal and societal costs of externalizing psychopathology.

Strengths, Limitations, and Directions

This study has several strengths that increase confidence in the present findings. First, the use of an existing dataset allowed for cost-effective analysis of a large adolescent sample with a relatively high longitudinal retention rate. Due to the IMAGEN project's inclusion of in-depth clinical interviews at both time points, we were able to operationalize multiple forms of externalizing psychopathology as symptom counts. Relative to dichotomous diagnoses, this approach increases reliability and validity (Markon et al., 2011) and allows for more nuanced analysis of traits and psychological outcomes in a non-clinical sample. Finally, given that the IMAGEN project did not include purpose-built measures of disinhibition and callousness, a noteworthy aspect of this study is our development of an IMAGEN-Callousness scale to complement the previously constructed IMAGEN-Disinhibition scale (Brislin et al., 2019). Through harmonization with other established scales indexing these same latent constructs, this approach allowed for an extension of the existing literature on disinhibition and callousness as risk factors for externalizing problems, which would not otherwise have been possible using IMAGEN data. Our approach has implications for ongoing research using large consortium datasets; a more extensive treatment of this issue is provided in the Supplemental Discussion.

Some limitations of the current study also warrant mention. One is that the IMAGEN sample did not include assessments prior to age 14 and is 95% White. Although our results provide compelling evidence for the utility of disinhibition and callousness as risk markers among White European adolescents, it will be important to extend this research to younger samples and examine the effects of sociocultural differences and discrimination within more diverse populations. A greater understanding of these liability factors in childhood, particularly early childhood (Dadds & Frick, 2019), and their relations to psychopathology across the lifespan will provide a clinical benefit, as interventions for externalizing psychopathology appear more effective in early childhood (see Dadds, 2004). Disinhibition and callousness

themselves, as stable, brain-based, and genetically influenced liability factors, may not be sufficiently malleable to serve as primary targets for intervention. As a result, research on variables that moderate trait-psychopathology relations, including environmental factors, will be of critical importance for identifying viable targets for intervention at differing points along the ontogenetic pathway from liability to active psychopathology (Perkins et al., 2020a).

Second, we were unable to test for possible interactions between disinhibition and callousness in our main analyses due to the complexities of modeling these effects in regression analyses for count variables (e.g., negative binomial regression). We hope to examine interactions in future work, such as in clinical samples in which symptom variables are less skewed and more amenable to other statistical approaches. Of note, disinhibition and callousness did not interact in predicting continuous externalizing factor scores, either cross-sectionally or prospectively (p_{H}s>.27). Nonetheless, further research could test whether other traits (e.g., boldness or low threat sensitivity; Patrick et al., 2019) moderate the longitudinal course of externalizing (see Baroncelli et al., 2022).

In addition, the IMAGEN sample is unselected, with participants recruited from high schools. We contend that this is a strength in some respects, as the results are more likely to be generalizable to community settings (e.g., informing universal screening procedures to identify adolescents at risk for externalizing) and avoid confounds inherent to clinical samples (e.g., higher level of impairment among those seeking clinical services). However, unselected samples are not sufficient to fully elucidate clinical phenomena of interest, given relatively low base rates; complementary work with enriched or clinical samples is necessary to characterize developmental trajectories of psychopathology.

Another limitation of the current work concerns the measures used to quantify psychopathology. Although the interview-based DAWBA allows for assessment of specific symptoms of conduct disorder, it provides more limited coverage of ADHD symptoms, focusing on personal distress and problems at home/school resulting from “overactivity or poor concentration.” As a result, we could not examine specific symptoms or presentations of ADHD. Subsequent research should include a more in-depth assessment of ADHD to further our understanding of its position within the externalizing spectrum.

Finally, given that there is no consensus regarding how to handle missing data in negative binomial regression models, we employed listwise exclusion to deal with missing data, for demographic covariates in particular (see Method and Supplemental Figure A). This approach may have operated to reduce the representativeness of participants included in our analyses. The attrition sample was higher in disinhibition at T1 and more likely to be male than the longitudinal sample, indicating some attrition bias. The finding for disinhibition was expectable due to elements of this trait (e.g., irresponsibility, impulsiveness) that might affect return rates. Participants who had to be excluded due to missing data for T1 also scored significantly higher in disinhibition than those who were retained, but the score difference in this case was markedly smaller — suggesting less trait-related bias contributing to missingness within this initial assessment than between T1 and T2. The issue of bias in missing values must be acknowledged as a limitation of the current work. However, this

limitation is mitigated somewhat by the fact that it would be expected to operate against study hypotheses rather than in favor of them (i.e., the loss of participants scoring higher on disinhibition would tend to reduce predicted associations for this trait). In addition, supplemental analyses using multiple imputation revealed highly similar patterns of results to those presented here.

Conclusions

The current study examined two liability factors relevant to externalizing psychopathology — disinhibition and callousness — and found that these traits operate at differing levels of specificity in predicting concurrent and prospective psychopathology in and across adolescence. Disinhibition is a broad liability factor for the development of externalizing symptoms, with close relations to executive function difficulties (especially inhibitory control), whereas callousness acts more specifically as liability for antisocial behavior and appears more closely tied to affective and affiliative systems. Our study provides important insight into the development of externalizing and establishes a roadmap for subsequent research on the effective assessment of vulnerability to clinical problems and early intervention in maladaptive trajectories for those at greatest risk.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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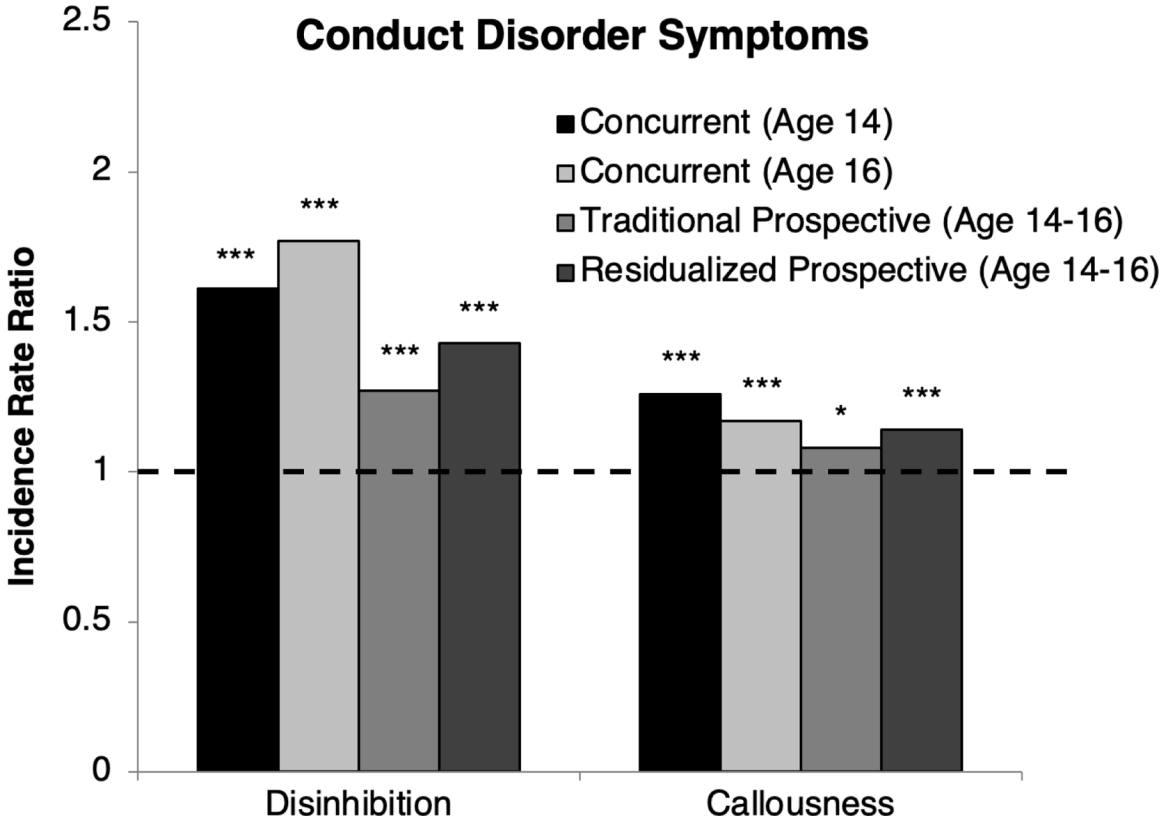

Figure 1.

Incidence rate ratios for disinhibition and callousness as predictors of conduct disorder symptoms in negative binomial regression models. Traditional prospective models included age 14 conduct disorder symptoms as a covariate; residualized prospective models instead included as a covariate a residualized score that represented variance in age 14 conduct disorder symptoms that was independent from age 14 disinhibition and callousness. All models included the other trait, age, sex, and assessment site as covariates. ***$p_H < .001$, **$p_H < .01$, *$p_H < .05$.

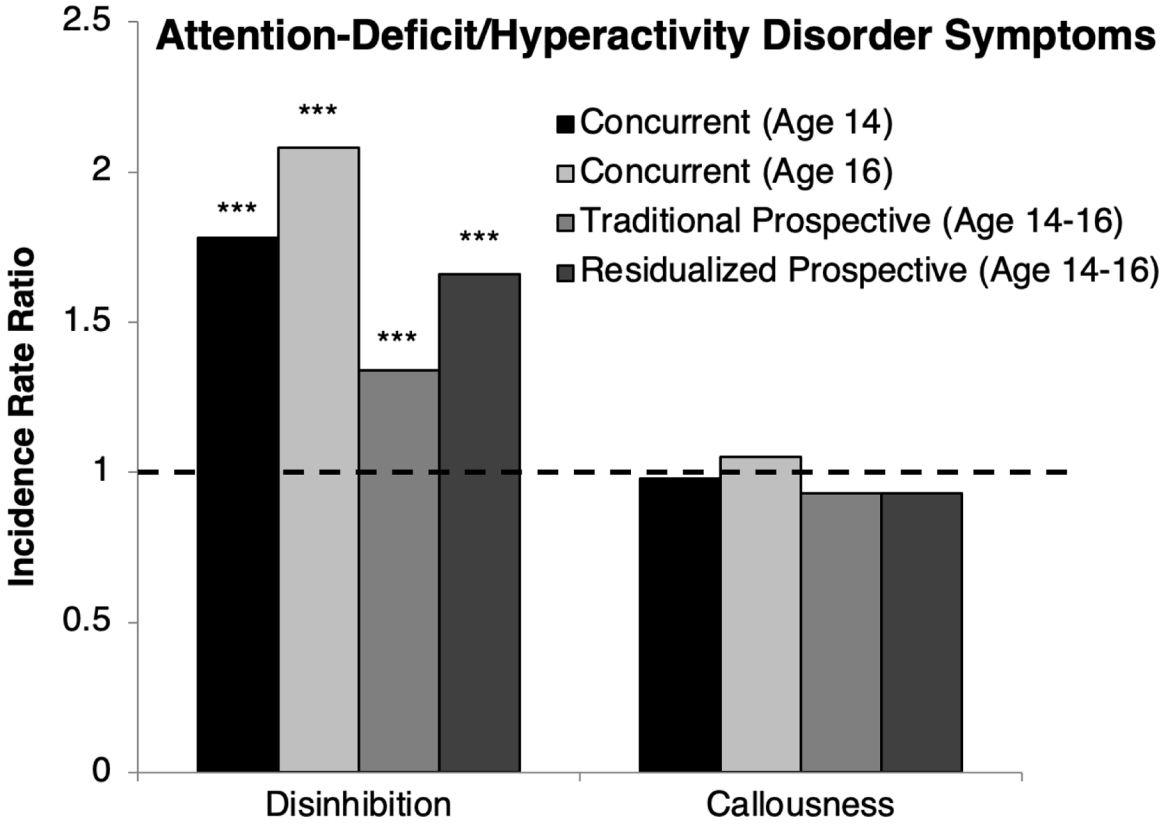

Figure 2.

Incidence rate ratios for disinhibition and callousness as predictors of attention-deficit/hyperactivity disorder (ADHD) symptoms in negative binomial regression models. Traditional prospective models included age 14 ADHD symptoms as a covariate; residualized prospective models instead included as a covariate a residualized score that represented variance in age 14 ADHD symptoms that was independent from age 14 disinhibition and callousness. All models included the other trait, age, sex, and assessment site as covariates. ***$p_H < .001$, **$p_H < .01$, *$p_H < .05$.

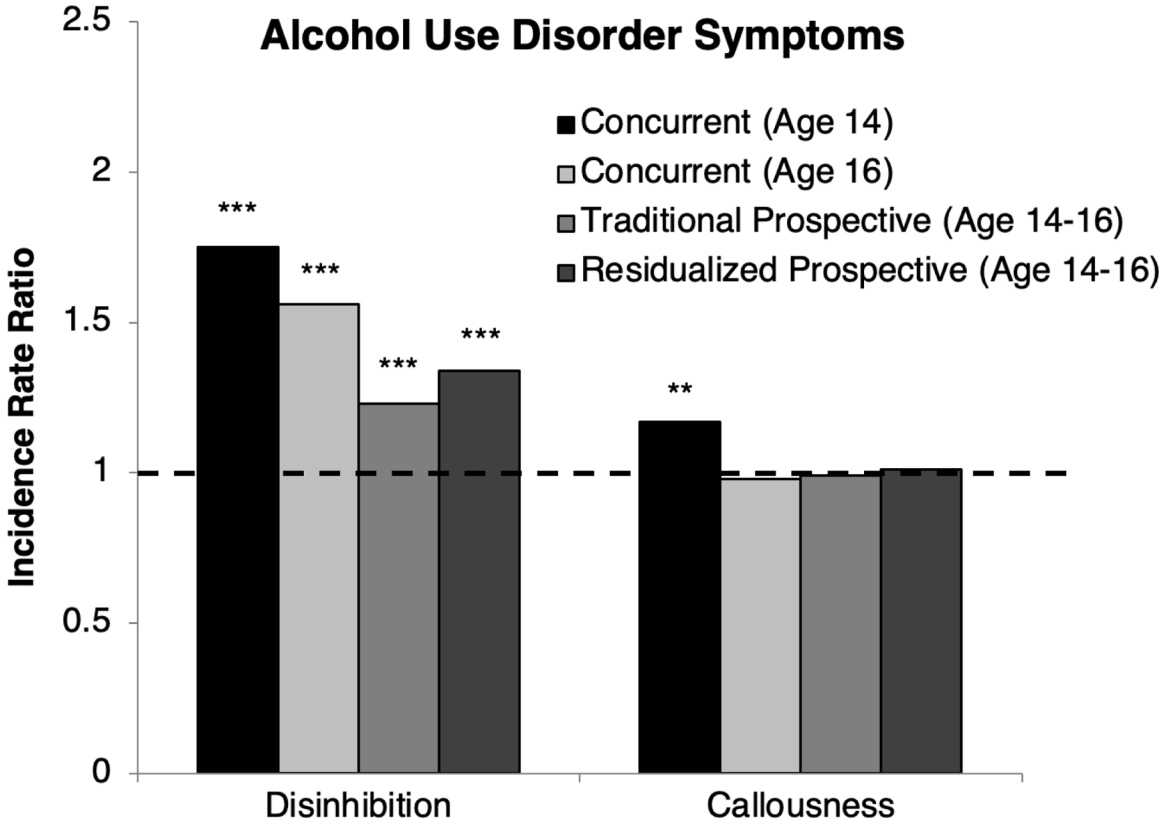

Figure 3.

Incidence rate ratios for disinhibition and callousness as predictors of alcohol use disorder (AUD) symptoms in negative binomial regression models. Traditional prospective models included age 14 AUD symptoms as a covariate; residualized prospective models instead included as a covariate a residualized score that represented variance in age 14 AUD symptoms that was independent from age 14 disinhibition and callousness. All models included the other trait, age, sex, and assessment site as covariates. ***p_H < .001, **p_H < .01, *p_H < .05.

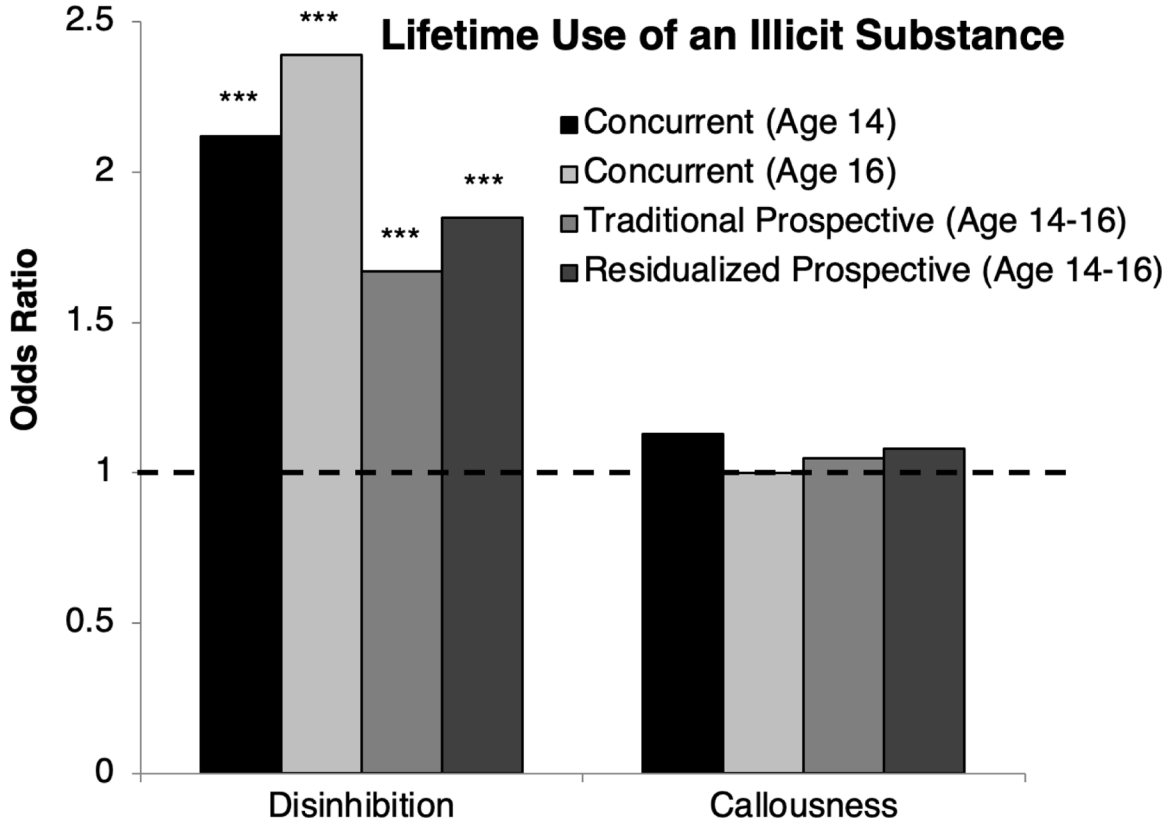

Figure 4.

Odds ratios for disinhibition and callousness as predictors of lifetime history of illicit substance use in logistic regression models. Traditional prospective models included age 14 substance use history as a covariate; residualized prospective models instead included as a covariate a residualized score that represented variance in age 14 substance use history that was independent from age 14 disinhibition and callousness. All models included the other trait, age, sex, and assessment site as covariates. ***p_H < .001, **p_H < .01, *p_H < .05.

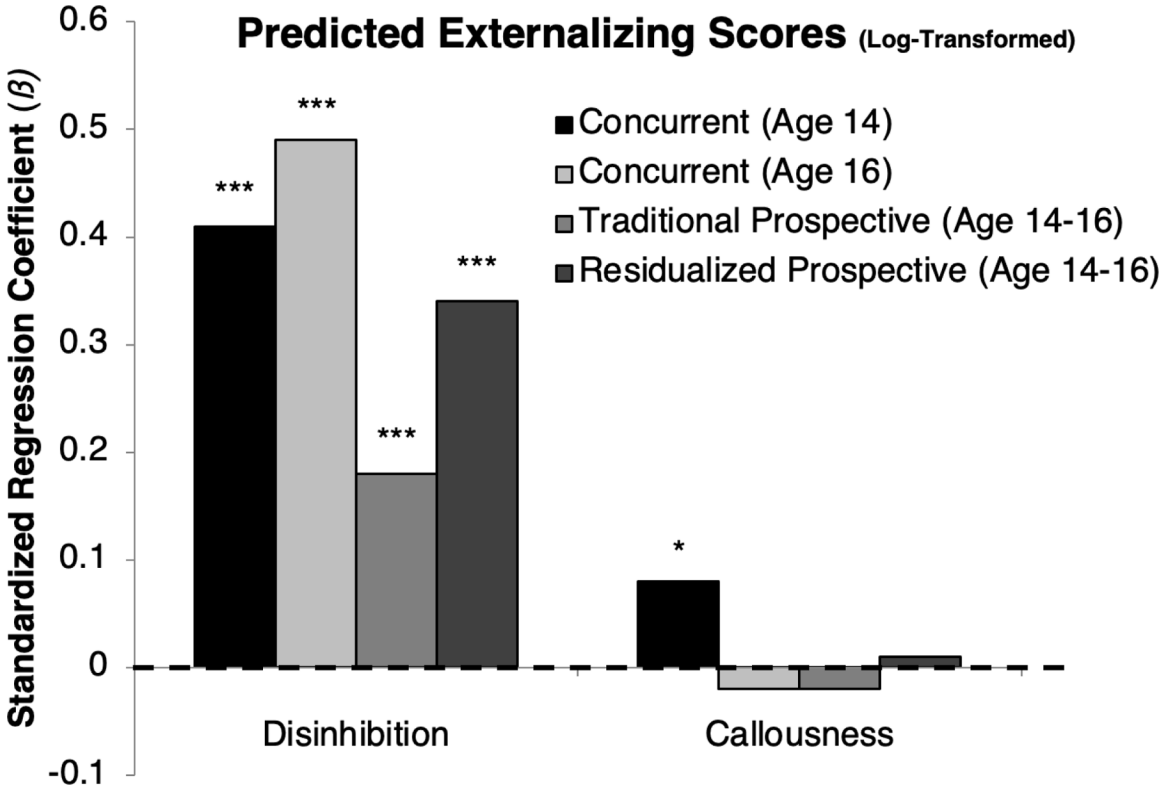

Figure 5.

Standardized regression coefficients for disinhibition and callousness as OLS regression predictors of estimated externalizing factor scores from the bifactor model. Factor scores were log-transformed. Traditional prospective models included age 14 externalizing scores as a covariate; residualized prospective models instead included as a covariate a residualized score that represented variance in age 14 externalizing that was independent from age 14 disinhibition and callousness. All models included the other trait, age, sex, and assessment site as covariates. ***$p_H < .001$, **$p_H < .01$, *$p_H < .05$.