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Externalizing Behavior and Emotion Dysregulation are Indicators of Transmissible Risk for Substance Use Disorder

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Abstract

Background—Psychological items discriminating children of fathers diagnosed with an illicit drug-related substance use disorder and normal controls are indicators of a unidimensional construct termed transmissible liability index (TLI) (Vanyukov et al., 2009). TLI is a highly heritable (Vanyukov et al., 2009; Hicks, Iacono, McGue, 2012) and valid (Vanyukov et al., 2009; Hicks et al., 2012; Kirisci et al., 2013a) measure of childhood liability to substance use disorders (SUD).

Aims—This longitudinal study determined whether TLI has incremental validity for predicting SUD beyond commonly measured psychological indicators of risk.

Methods—TLI and measures of executive cognitive capacity, emotion dysregulation and externalizing disturbance were administered to boys at ages 10–12 and 16. SUD outcome determined at age 22 was assessed as (1) any SUD, (2) the number of drug-specific SUDs, and (3) SUD severity.

Results—TLI predicted SUD beyond the contribution of measures of emotion dysregulation, executive cognitive capacity and externalizing disturbance. The association of emotion dysregulation and externalizing behavior at age 10–12 and 16 with SUD at age 22 was also reduced to non-significance after controlling for transmissible risk measured by TLI.

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Contributors

Levent Kirisci conceptualized the study, performed the statistical analyses, and prepared portions of the manuscript. Ralph Tarter wrote major sections of the narrative. Ty Ridenour assisted in manuscript preparation and data analyses. Maureen Reynolds contributed to conceptualization of the project and preparation of the Discussion section of the report. Michelle Horner conducted the literature review and assisted in preparation of the manuscript. Michael Vanyukov spearheaded development and validation of the transmissible liability index. All authors have approved the final manuscript.

Conflict of Interest

The authors report no conflict of interest.

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Conclusions—TLI's incremental validity beyond these latter indicators of risk points to its utility for identifying vulnerable youths requiring intervention.

Keywords

vulnerability; substance use disorder; children; risk; family history

Substance use disorder (SUD) in parents is well known to be associated with psychological dysregulation in their children (Vanyukov et al., 2009). Diverse characteristics have been shown to comprise indicators of a unidimensional construct corresponding to the transmissible component (correlated between generations) of non-drug-specific liability to SUD (Vanyukov et al., 2009). This construct, termed the *transmissible liability index (TLI)*, has been shown to be a valid childhood measure of liability for SUD, predicting the age of substance use initiation, SUD risk, and the rate of SUD development (Vanyukov et al., 2009; Hicks et al., 2012; Kirisci et al., 2013a). TLI is highly heritable (Vanyukov et al., 2009; Hicks et al., 2012), consistent with its derivation as a measure of transmissible liability. Moreover, TLI predicts all DSM-IV SUD categories (Ridenour, Tarter, Kirisci, & Vanyukov, 2011), consistent with results demonstrating that genetic and phenotypic commonalities among substance-specific SUD liabilities (Kendler, Jacobson, Prescott, & Neale, 2003a; Kendler, Prescott, Myers, & Neale, 2003b; Tsuang et al., 1998). Further indicating that TLI is a measure of common (general) SUD liability, it has been shown that cannabis use during adolescence mediates the association between TLI score in childhood and diagnosis of alcohol use disorder in adulthood, and alcohol use mediates the association between TLI and cannabis use disorder (Hicks et al., 2012). Indeed, the order of drug use initiation specified in the “gateway hypothesis” (Kandel & Yamaguchi, 2002) is less informative than TLI for modeling SUD development between childhood and adulthood (Tarter et al., 2012a).

Investigations exploring the utility of TLI in the elucidation of SUD etiology have yielded promising results. For example, youths scoring high on TLI exhibit a linear increase in risk following first cannabis use that subsequently culminates in cannabis disorder, whereas youths who score low on TLI exhibit no change in risk after onset of consumption (Kirisci, Tarter, Ridenour, Reynolds, & Vanyukov, 2013b). The extent to which this increment in severity reflects a differentially strong reinforcing experience following substance use among high-risk youths or the influence of substance using peers on socialization remains to be determined. Notably, non-normative socialization mediates the association between TLI scores in childhood and SUD in adulthood (Tarter et al., 2011) and the TLI score in childhood predicts elevated testosterone level and attenuated cortisol reactivity in mid-adolescence presaging SUD in adulthood (Tarter, et al., 2013) suggesting that both pharmacological and social factors potentiate transmissible risk leading to development of SUD. In sum, the emerging research demonstrates the utility of the TLI for elucidating the mechanisms and etiological pathways to SUD.

Whereas these findings indicate that TLI measures transmissible risk for SUD and is heuristic for researching etiology, the relationship between TLI and psychological processes commonly reported to contribute to SUD liability has not been investigated. Accordingly,

this study evaluated the association between TLI and psychological processes most often implicated in SUD risk, pertaining to cognition, emotion and behavior, namely executive cognitive capacity, emotion dysregulation and externalizing disturbance. It was hypothesized that these latter variables are facets of SUD liability measured by TLI. Hence, the hypothesis was tested that TLI in childhood and adolescence not only accounts for the relationships of these variables with the SUD outcome, but predicts that outcome over and above their contribution.

Methods

2.1 Participants

The participants in this study were part of a longitudinal study of the etiology of SUD consequent to use of illicit drugs, conducted under the aegis of the NIDA-funded Center for Education and Drug Abuse Research (CEDAR) established in 1990. Using the family/high-risk paradigm, boys (N=490) were enrolled when they were 10–12 years of age and followed up at ages 16 and 22. The boys currently undergoing assessments until age 30, at which time the project will be completed. Because comprehensive protocols are administered, the subjects were enrolled over many years, hence the sample is in varying stages of the follow-up. This report pertains to the portion of the sample that has attained age 22 because insufficient subjects have yet been followed up beyond that point to enable valid statistical analysis. The sample was confined to boys because TLI was under development for girls. Recruitment was conducted through the biological fathers (probands) who either qualified for DSM-III-R lifetime SUD diagnosis consequent to consumption of an illegal compound (N=249) or had no adult psychiatric disorder (N=241). DSM-III-R criteria were used to ascertain the sample because this longitudinal project was initiated prior to publication of the DSM-IV. Multiple recruitment sources were used to minimize bias that could potentially occur if all of the subjects were recruited from one source. The SUD fathers were recruited using public service announcements, advertisement and a market research firm that conducted random-digit dialing. Approximately 25% of the SUD+ men were accrued from treatment facilities. Proband fathers without SUD were recruited using the same procedures except that none were obtained from treatment facilities.

Boys were excluded from study if they had lifetime history of psychosis, chronic illness, neurological disability, uncorrectable sensory handicap, full scale IQ below 80 on the WISC-III-R, or signs of fetal alcohol effects determined upon physical examination conducted by a trained registered nurse.

Table 1 presents the baseline personal and demographic characteristics of the sample (N=305) and those who attrited (N=185). Attrition, defined as either a failure to locate the individual or refusal to participate at the age 22 evaluation, was 38%. As can be seen, the participants who attrited scored about three points lower on the Hollingshead index of socioeconomic status (SES) and almost seven points lower on Full Scale IQ measured by the Wechsler Intelligence Scale for Children (WISC-III-R). No differences were observed between the retained and attrited segments on TLI (the predictor variable), grade in school, or ethnicity.

2.2 Measures

2.2.1 Transmissible Liability Index (TLI) (ages 10–12 and 16)—TLI was derived using a previously described multistage procedure (Vanyukov et al., 2003a; Vanyukov et al., 2003b). First, investigators at the Center for Education and Drug Abuse Research (CEDAR) catalogued the psychological traits (N=34) most frequently reported in the empirical literature to be associated with risk for SUD. Next, items (N=441) from a large battery of psychological questionnaires and psychiatric interviews administered to the parents, teachers and the boys contained in CEDAR's database were assigned to these traits. Exploratory factor analysis (EFA) was performed on the items in each provisional trait. Items having loading $>.4$ were retained and submitted to confirmatory factor analysis (CFA). The constructs that satisfied the criterion of unidimensionality were contrasted between boys having SUD+ and SUD– fathers. The items contained in the thirteen constructs that discriminated the sons in these two groups were then submitted to EFA and further pruning if they had loading below $.4$. CFA was conducted on the remaining items to verify unidimensionality of the resulting construct. Lastly, item response theory (IRT) was conducted to calibrate the items, estimating their item threshold and item discrimination parameters. The threshold parameter relates the probability of endorsing a particular characteristic (item) to severity of SUD liability whereas the discrimination parameter specifies the ability of the item to differentiate individuals according to severity of SUD liability. In sum, from a roster of 155 items dispersed in 13 constructs discriminating children of SUD+/- parents, the final sets consisted of 45 and 65 items at ages 10–12 and 16, respectively (Tables 2 and 3), having internal consistency of $.93$ and $.92$. It should be emphasized that, according to the measurement model applied (Vanyukov et al., 2003a), regardless of what original scale or construct an item originates from, TLI derivation procedure ensures that this item is calibrated and applied as an indicator of the transmissible component of SUD liability rather than any other trait's (e.g., attention, antisociality, mood, externalizing behavior, etc.) for which it could also serve as an indicator.

2.2.2 Executive cognitive function (ECF) (ages 10–12 and 16)—Boys were administered computerized versions of the *Stroop Color Word Test* (Stroop, 1935), *Porteus Mazes Test* (Porteus, 1965), *Vigilance Test* (Schneider & Detweiler, 1987), *Motor Restraint Test* (Parsons, Tarter, & Edelberg 1972). In addition, the *Forbidden Toys Test* (Silverman & Ragusa, 1992), and *Block Design Test* (Wechsler, 1991) were administered according to standard procedure. The protocol assesses the various aspects of executive cognitive capacity related to attention control, working memory, planning, and goal persistence. The aggregate raw scores were submitted to exploratory factor analysis followed by confirmatory factor analysis. Consistent with prior research (Mezzich et al., 2007), ECF is a unidimensional construct. The variance explained by the first factor was 31% and 37% at ages 10–12 and 16, respectively. The individual's ECF score was used in the analyses.

2.2.3 Emotion regulation (ages 10–12 and 16)—The difficult affective temperament index was derived according to the procedures described by Windle (1992), using the revised Dimensions of Temperament Survey (DOTS-R). The scores on the mood quality, flexibility-rigidity and approach-withdrawal scales were summed. The DOTS-R was

administered to mothers at baseline and to the children when they attained 16 years of age. Cronbach alpha coefficient of internal consistency is .78 and .76 at ages 10–12 and 16.

2.2.4 Externalizing behavior (ages 10–12 and 16)—The mothers were administered the *Schedule for Affective Disorders and Schizophrenia* (K-SADS-E) (Orvaschel, Puig-Antich, Chambers, Tabrizi, & Johnson, 1982) when their sons were 10–12 years old. The K-SADS-E was administered to the boys when they were 16 years old. Endorsed symptoms in the conduct disorder, attention deficit hyperactivity disorder and oppositional defiant disorder sections of the interview were summed. Alpha coefficient at age 10–12 and age 16 was .88 and .89.

2.2.5 Substance Use Disorder (SUD) (age 22)—Substance use disorder (SUD), the outcome variable, was assessed in three ways. First, a categorical diagnosis of “any SUD” was recorded as present or absent. The diagnosis was formulated by a clinical committee consisting of two psychiatrists and master-level clinical associates who administered the SCID (Spitzer, Williams, Gibbon, & First, 1990). Second, the number of lifetime SUD diagnoses was computed. And third, SUD severity was quantified using the two-step procedure described by Kirisci et al. (2006). At the outset, CFA was conducted to document unidimensionality of the different DSM SUD diagnoses and to form the SUD severity scale. Next, a two-parameter IRT model was to derive a SUD severity index and estimate severity.

2.3 Procedure

The project was described to the parents and their children upon arrival at the laboratory. Written informed consent was obtained from the parents and written assent was obtained from the child. The parents and their children were also informed that privacy was protected by a Certificate of Confidentiality granted to the Center for Education and Drug Abuse Research (CEDAR) by the National Institute on Drug Abuse. Before beginning the evaluation the boys underwent breath alcohol and urine drug screens. None of the subjects tested positive. The protocol was administered by trained Master-level research assistants. At the conclusion of the session, the subjects were compensated with gift certificates valued at the rate of \$10 per hour of participation time.

2.4 Data Analysis

The analyses were conducted in three stages. First, logistic regression analysis was performed to determine whether the variables (TLI, emotion dysregulation, externalizing disturbance, executive cognitive capacity) at ages 10–12 and 16 predict SUD diagnosis. Linear regression was utilized to predict SUD severity, with R^2 as the indicator of effect size. Negative binominal regression analysis was conducted to predict the number of SUD diagnoses. Next, the analyses were repeated using TLI as a covariate. To avoid circularity, items that were identical to TLI were removed from the three psychological constructs (noted with an asterisk in Tables 2 and 3). Using TLI as an independent variable, the first stage of analysis was directed at predicting the three types of SUD outcomes. Next, emotion regulation, externalizing behavior, and executive cognitive capacity were used to predict the residuals from that analysis, using linear regression. The change in R^2 was the indicator of effect size. The same analytic procedures were employed to predict the SUD outcome

variables controlling for emotion regulation, externalizing disturbance, and executive cognitive capacity. Last, the impact of overlapping items was investigated using the same two-stage procedure: (1) obtaining the residuals from the prediction of SUD outcomes controlling for the effects of the psychological constructs (cognitive, emotion, behavior) and, (2) deploying TLI to predict the residuals. In this manner, it could be determined whether the overlapping items have any impact on TLI's prediction of the SUD outcomes.

Results

As can be seen in Table 4, TLI at ages 10–12 and 16 predicts SUD, number of SUDs and SUD severity at age 22. Externalizing disturbance and emotion dysregulation at ages 10–12 and 16 also predict all three SUD outcomes. Executive cognitive capacity at ages 10–12 and 16 does not predict any of the SUD outcome variables. The R^2 for SUD severity is .02 and .15 for TLI, .01 and .05 for emotion dysregulation, .01 and .09 for externalizing behavior, and .001 and .001 for executive cognitive capacity at ages 10–12 and 16, respectively.

As shown in Table 5, the associations between emotion dysregulation and SUD and between externalizing disturbance and SUD decline to non-significance upon controlling for TLI. These results demonstrate that TLI accounts for the contribution of emotion dysregulation and externalizing disturbance to SUD risk prediction.

Last, the association between TLI in childhood and adolescence and SUD at age 22 was examined, controlling for the influence of emotion dysregulation, externalizing disturbance, and executive cognitive capacity. The results of this analysis, shown in Table 6, indicate that TLI at age 10–12 still predicts SUD and number of SUDs upon controlling for emotion dysregulation. TLI at age 16, but not at age 10–12, also predicts SUD severity upon controlling for emotion dysregulation. Thus, 5 of 6 predictions were sustained when using emotion dysregulation as a covariate.

TLI at ages 10–12 and 16 also predicts SUD upon controlling for externalizing behavior. TLI does not, however, predict number of SUDs and SUD severity at age 10–12 when controlling for externalizing disturbance, but remains predictive at age 16. Thus, TLI has incremental predictive accuracy in 4 of 6 analyses. TLI at ages 10–12 and 16 predicts all SUD outcome variables upon controlling for the influence of executive cognitive capacity. Overall, these results indicate that TLI exceeds the accuracy of externalizing disturbance, emotion dysregulation and executive cognitive capacity for predicting SUD.

Table 6 summarizes the results obtained when controlling for the psychological constructs without removing the items overlapping with TLI indicators. All the previous relationships were sustained, with one exception: TLI did not predict SUD outcome upon controlling for externalizing disturbance at age 10–12.

Discussion

This prospective study demonstrated that measures of emotion dysregulation and externalizing disturbance generally do not predict SUD upon controlling for the influence of TLI, designed as a specific measure of liability to addiction. These findings are consistent

with the relationship and potential contribution of emotion dysregulation and externalizing behavior to variation in SUD liability as captured by TLI measurement. It has also been shown (e.g., Krueger et al, 2002) that SUD can be viewed as part of an interrelated group of behaviors covered by the general term “externalizing spectrum”. Nevertheless, despite sharing variance in common with other behaviors from that group (largely manifestations of antisociality), liability to addiction possesses certain specificity. Consistent with that, TLI predicts SUD after accounting for the influence of externalizing behavior and emotion dysregulation, which demonstrates its incremental validity. Whether TLI is informative in practical settings remains to be investigated; however, it is noteworthy that a prior study has shown that each standard deviation unit increase in TLI score is associated with a 70% increase in risk for SUD (Vanyukov et al., 2009).

Whereas TLI evaluates the component of SUD risk having intergenerational continuity, other factors related primarily to environmental variables have also been shown to comprise a continuous scale that predicts SUD (Kirisci et al., 2009). This scale is derived as orthogonal to TLI, in accordance with the model partitioning liability variance into its transmissible and non-transmissible components (Vanyukov, Moss, & Tarter, 2003; Rice, Cloninger, & Reich, 1980), thus placing an individual liability phenotype in a Cartesian coordinate system (Tarter, Kirisci, Ridenour, & Bogen, 2012b). One key feature of this schema is that it informs prevention targets. For example, a high TLI score and a low score on the non-transmissible risk scale point to the need for family-focused intervention, whereas a low TLI score and a high score on the non-transmissible risk scale indicate the need for intervention targeted at extrafamilial factors.

Several limitations of this study are noteworthy. It is important to emphasize that the findings may be limited to the instruments used to measure executive cognitive capacity, emotion regulation, and externalizing behavior. Also, because the sample was accrued using the high-risk family paradigm, it is possible that the results are not representative of the general population. In addition, because the sample was confined to boys, the results should not be assumed to extend to girls. The sample was tracked until age 22. Thus, at the time of the outcome assessment, the boys had not completely passed through the period of risk. While TLI has excellent psychometric properties (Vanyukov et al., 2009), it is possible that inclusion of additional items would enhance its accuracy as a measure of transmissible risk for SUD. Furthermore, in this study, we did not compute incremental contribution of TLI at age 10–12 and 16 together. We were only interested in computing incremental contribution of TLI at age 10–12 and 16, separately.

These limitations notwithstanding, this study demonstrates that TLI in 10–12 and 16 year old boys predicts SUD, number of SUDs and severity of SUD at age 22. The study provides further support for using TLI to objectively quantify SUD risk but potentially also has practical utility for detecting youths requiring prevention intervention.

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Highlights

1. Transmissible liability index (TLI) measured at ages 10–12 and 16 predicts SUD, number of SUDs and severity of SUD at age 22 after controlling for the influence of externalizing behavior and emotion dysregulation.
2. This study provides further support for using TLI to objectively quantify SUD risk but potentially also has practical utility for detecting youths requiring prevention intervention.

Table 1
Baseline (age 10–12) Characteristics of Retained and Attrited Segments of the Sample

	Retained (n= 305)		Attrited (n=185)		F	P
	Mean	SD	Mean	SD		
School grade	4.57	1.12	4.51	1.01	.28	.594
Socioeconomic status	41.95	13.50	38.89	12.84	6.14	.014
Full Scale IQ	110.30	15.82	103.58	15.21	21.43	<.001
	n	%	n	%	χ^2	p
White	232	76.1	137	74.1	1.09	.580
Black	65	21.3	40	21.6		
Other	8	2.6	8	4.3		
SUD+ parent	147	48.2	94	50.8	.31	.575
SUD- parent	158	51.8	91	49.2		

Table 2

Items comprising the transmissible liability index (TLI) items at age 16 based on child (C), mother (M), and teacher (T) reports

1	Lying (M)
2	Stealing (M)
3	Impulsive (M)
4	Did you often annoy people on purpose to get even? (C)
5	Did you often do things to annoy people like grabbing another child's hat? (C)
6	Did you blurt out answers to questions before they had been completed or did you get into trouble because you would rush into things without thinking? (C)
7	Were things so bad that you were thinking a lot about death or that you would be better off dead?(C)
8	Did he often do things to annoy people like grabbing another child's hat? (M)
9	* Did he often annoy people on purpose to get even? (M)
10	* Did he have difficulty staying in line in the supermarket or waiting for his turn while he was playing with other children? (M)
11	* Did he blurt out answers to questions before they had been completed or did he get into trouble because he would rush into things without thinking? (M)
12	* Did he get into trouble a lot for talking out of turn in school or talking without the teacher calling on him or for bothering people? (M)
13	* Did he get into trouble because he would do things without thinking about them first, for example running into the street without looking? (M)
14	I interrupt on people when they are speaking. (C)
15	He/she interrupts on people when they are speaking. (T)
16	Excitable, impulsive best describes the child. (T)
17	Engages in physically dangerous activities without considering possible consequences (not for the purpose of thrill-seeking), e.g. runs into street without looking. (T)
18	Has difficulty awaiting turn in games or group situations. (T)
19	Often blurts out answers to questions before they have been completed. (T)
20	Often interrupts or intrudes on others, e.g., butts into other children's games. (T)
21	Impulsive or acts without thinking. (M)
22	Destroys things belonging to his/her family or others. (M)
23	Disobedient at school. (M)
24	Steals at home. (M)
25	Bites fingernails (M)
26	Picks nose, skin or other parts of body. (M)
27	Impulsive or acts without thinking. (T)
28	Talks out of turn. (T)
29	Aches or pains (not stomach or headaches (without known medical causes. (T)
30	Headaches (without known medical cause. (T)
31	Deliberately harms self or attempts suicide. (T)
32	I move a great deal in my sleep. (C)
33	I don't move around much at all in my sleep. (C)
34	I get hungry about the same time each day. (C)
35	I usually eat the same amount each day. (C)

- 36 I eat about the same amount at supper from day to day. (C)
- 37 My appetite seems to stay the same day after day. (C)
- 38 * My child moves a great deal in his/her sleep. (M)
- 39 * In the morning, my child is still in the same place as he/she was when he/she fell asleep. (M)
- 40 * My child doesn't move around much at all in his/her sleep. (M)
- 41 * It takes my child a long time to adjust to a new thing in the home. (M)
- 42 * It takes my child a long time to adjust to new schedules. (M)
- 43 * Changes in plans make my child restless. (M)
- 44 * My child resists changes in routine. (M)
- 45 Did you skip classes or school without an excuse? (C)

* Items were common with Emotion Regulation and Externalizing Behavior scales

Table 3

Items comprising the transmissible liability index (TLI) items at age 16 based on child (C), mother (M), and teacher (T) reports

1	Impulsive or acts without thinking. (T)
2	Talks out of turn. (T)
3	Aches or pains (not stomach or headaches). (T)
4	Headaches. (T)
5	* Did you often do things to annoy people like grabbing another child's hat? (C)
6	* Did you often annoy people on purpose to get even? (C)
7	I interrupt on people when they are speaking. (C)
8	He/she interrupts on people when they are speaking. (M)
9	* Have you stolen or attempted to steal things worth \$5 or less? (C)
10	* Have you stolen or tried to steal things worth between \$5 and \$50? (C)
11	* Did you blurt out answers to questions before they had been completed or did you get into trouble because you would rush into things without thinking? (C)
12	* Did you have difficulty staying in line in the supermarket or waiting for your turn while you were playing with other children? (C)
13	* Did you get into trouble a lot for talking out of turn in school or talking without the teacher calling on you or for bothering people? (C)
14	* Did you get into trouble because you would do things without thinking about them first, for example running into the street without looking? (C)
15	* Did you skip classes or school without an excuse? (C)
16	* Did you lie very frequently or more often than most children your age? (C)
17	Excitable, Impulsive. (T)
18	I destroy things belonging to others. (C)
19	I disobey at school. (C)
20	I act without stopping to think. (C)
21	I bite my fingernails. (C)
22	I pick my skin or other parts of my body. (C)
23	* I get hungry about the same time each day. (C)
24	* I usually eat the same amount each day. (C)
25	* I move a great deal in my sleep. (C)
26	* In the morning, I am still in the same place as I was when I fell asleep. (C)
27	* I don't move around much at all in my sleep. (C)
28	* I eat about the same amount at supper from day to day. (C)
29	* My appetite seems to stay the same day after day. (C)
30	* It takes me a long time to get used to a new thing in the home. (C)
31	* It takes me a long time to adjust to new schedules. (C)
32	* Changes in plans make me restless. (C)
33	* I resist changes in routine. (C)

- 34 Restless or overactive. (T)
- 35 Disturbs other children. (T)
- 36 Fails to finish things he or she starts (short attention span). (T)
- 37 Inattentive, easily distracted. (T)
- 38 Demands must be met immediately -- easily frustrated. (T)
- 39 Mood changes quickly and drastically. (T)
- 40 Temper outburst-behavior explosive and unpredictable. (T)
- 41 Quarrelsome. (T)
- 42 Defiant. (T)
- 43 Uncooperative. (T)
- 44 Did you argue a lot? (C)
- 45 Did you have a bad temper? (C)
- 46 Did you do things a lot without first thinking about the consequences? (C)
- 47 Did you do risky or dangerous things a lot? (C)
- 48 Did you have trouble concentrating? (C)
- 49 Did you prefer doing things with kids much older than you? (C)
- 50 Were your grades below average? (C)
- 51 Did you often not do your school assignments? (C)
- 52 Have you been suspended from school? (C)
- 53 When I realize I have made a mistake, I usually take immediate action. (C)
- 54 I tend to dwell more on pleasant than unpleasant incidents from the past. (C)
- 55 When faced with a decision I usually take time to consider and weigh all aspects. (C)
- 56 I often act without thinking. (C)
- 57 I have had a lot of bad luck. (C)
- 58 I feel that life has handed me a raw deal. (C)
- 59 I know that people have purposely spread false rumors about me. (C)
- 60 I plan and organize my work in detail. (C)
- 61 People rarely try to take advantage of me. (C)
- 62 I have often been lied to. (C)
- 63 I know that certain people would enjoy it if I got hurt. (C)
- 64 When people are friendly they usually want something from me. (C)
- 65 I find it very easy to enjoy life. (C)

* Items were common with Emotion Regulation and Externalizing Behavior scales

Table 4

Prediction of SUD Outcome at age 22

Predictor	Any SUD		Number of SUDs		SUD Severity	
	OR, p, (95% CI)		OR, p, (95% CI)		B, p, (95% CI)	
Age 10–12						
TLI	1.70, <.001, (1.31, 2.19)		1.32, .002, (1.10, 1.58)		.13, .02, (.02, .25)	
Emotion regulation	1.32, .02, (1.04, 1.70)		1.22, .05, (1.00, 1.48)		.12, .05, (.002, .23)	
Externalizing behavior	1.52, .001, (1.17, 1.96)		1.40, <.001, (1.17, 1.67)		.11, .05, (.002, .26)	
Executive cognitive capacity	1.24, .08, (.98, 1.56)		1.07, .45, (.89, 1.28)		.03, .61, (–.08, .15)	
Age 16						
TLI	2.50, <.001, (1.85, 3.39)		1.60, .001, (1.31, 1.95)		.39, <.001, (.28, .51)	
Emotion regulation	1.61, .001, (1.22, 2.11)		1.38, .002, (1.12, 1.71)		.22, <.001, (.11, .35)	
Externalizing behavior	2.09, <.001, (1.55, 2.83)		1.32, .001, (1.13, 1.56)		.38, <.001, (.27, .49)	
Executive cognitive capacity	1.13, .36, (.87, 1.46)		1.04, .70, (.84, 1.29)		.03, .61, (–.08, .14)	

Table 5

Emotion regulation, externalizing behavior and executive cognitive capacity predict SUD at age 22 controlling for transmissible risk (TLI)

Predictor	Any SUD	Number of SUDs	SUD Severity
	OR, p, (95 % CI)	OR, p, (95% CI)	B, p, (95% CI)
Age 10–12			
Emotion regulation TLI	1.11, .43, (.85, 1.45)	1.15, .17, (.94, 1.42)	.08, .22, (–.05, .20)
Externalizing behavior TLI	1.16, .36, (.84, 1.59)	1.09, .48, (.86, 1.38)	.06, .43, (–.9, .21)
Executive cognitive capacity TLI	1.13, .34, (.88, 1.44)	1.05, .71, (.86, 1.24)	.003, .96, (–.11, .12)
Age 16			
Emotion regulation TLI	.96, .83, (.69, 1.34)	1.05, .71, (.81, 1.36)	–.01, .85, (–.16, .13)
Externalizing behavior TLI	1.39, .06, (.99, 1.96)	1.04, .75, (.84, 1.28)	.11, .11, (–.03, .25)
Executive cognitive capacity TLI	.98, .88, (.74, 1.29)	.98, .86, (.78, 1.22)	–.08, .18, (–.21, .04)

Table 6

Transmissible risk (TLI) predicts SUD at age 22 controlling for emotion regulation, externalizing behavior, and executive cognitive capacity

Predictor	Any SUD	Number of SUDs	SUD Severity
	B, p, (95 % CI), R ²	B, p, (95% CI), R ²	B, p, (95% CI), R ²
Age 10–12			
TLI Emotion regulation	.14, .002, (.02, .11), .02	.14, .02, (.02, .26), .02	.10, .10, (–.02, .21), .01
TLI Externalizing behavior	.10, .03, (.01, .09), .01	.09, .14, (–.03, .20), .01	.06, .28, (–.05, .18), .004
TLI Executive cognitive capacity	.17, <.001, (.04, .12), .03	.17, .002, (.07, .30), .03	.13, .03, (.01, .24), .02
Age 16			
TLI Emotion regulation	.24, <.001, (.07, .15), .06	.29, <.001, (.18, .41), .09	.26, <.001, (.15, .37), .07
TLI Externalizing behavior	.18, <.001, (.04, .12), .03	.22, <.001, (.10, .33), .05	.21, <.001, (.10, .32), .04
TLI Executive cognitive capacity	.36, <.001, (.12, .21), .13	.43, <.001, (.33, .56), .19	.39, <.001, (.29, .52), .15