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Using Cloninger's Temperament Scales to Predict Substance-Related Behaviors in Adolescents: A Prospective Longitudinal Study

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Abstract

Background and Objectives—We tested one of Cloninger's temperament theories – that high novelty seeking (NS), along with low harm avoidance (HA), reward dependence (RD), and persistence (PE), predicts early-onset substance problems.

Methods—In a community-based sample of 777 adolescents examined at two time points (mean age 13 and 18, respectively), we examined whether Cloninger's four temperament dimensions at wave 1 predicted five substance-related outcomes at wave 2: age of initiation for cigarettes, alcohol, and illicit drugs, number of substance classes tried, and total number of DSM-IV substance use disorder (SUD) symptoms.

Results—Cloninger's predicted temperament pattern did significantly predict the number of SUD symptoms at wave 2. For initiation of cigarettes/illicit drugs and number of substance classes tried, HA/NS/PE fit the pattern, but RD did not. For onset of alcohol, only NS and PE fit Cloninger's prediction. Results for NS and PE were most consistent.

Conclusions and Scientific Significance—Overall, this study provides evidence that Cloninger's theory may hold true for predicting problem use more than for predicting “use” or experimentation. In addition, youth with high novelty seeking and low persistence may find substances especially reinforcing, and identifying these youth and intervening before initiation has occurred may reduce the risk of future substance-related problems.

INTRODUCTION

Adolescent substance-related behaviors are an important public health concern, as over 200,000 adolescents are admitted to publicly funded substance abuse treatment programs each year.¹ Personality, and the inherited aspects of personality known as temperament, may be important factors contributing to the development of substance use disorders (SUDs). For example, meta-analyses examining “Big Three”^{2,3} and “Big Five”^{4,5} traits—including neuroticism, extraversion, disinhibition, conscientiousness, agreeableness, and openness—have found that adults with SUDs score higher on neuroticism and disinhibition, and lower

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Declaration of Interest

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on agreeableness and conscientiousness.^{6–8} This suggests that certain traits may serve as risk factors for developing SUDs.

Utilizing a psychobiological model of personality, Cloninger developed the tridimensional personality questionnaire (TPQ)⁹ and subsequently his revised version, the temperament and character inventory (TCI).¹⁰ The TCI assesses four biologically based, heritable dimensions of temperament: harm avoidance (HA; being cautious and pessimistic), novelty seeking (NS; being impulsive and thrill-seeking), reward dependence (RD; forming attachments with others and/or being sentimental), and persistence (PE; being persevering and ambitious).

To some extent, cross-sectional studies have established a relation between the TCI temperament dimensions and various substance-related behaviors. For example, increased HA has been observed in those dependent on tobacco,¹¹ alcohol,¹² and heroin.¹² However, other studies did not obtain consistent results for HA.^{13,14} There are few studies reporting associations with RD—lower levels were associated with drug dependence¹⁵ and adolescent substance use¹⁶ but not heroin/alcohol dependence¹²—and even fewer results for PE, where in one study lower levels were associated with daily smoking,¹¹ but in another study PE did not differentiate heroin- or alcohol- dependent patients from controls.

The most common and consistent findings for the relation between the TCI and substance-related behaviors are with NS. Studies have found that when compared to controls, those with SUDs score higher on measures of NS, and increased levels have been associated with dependence on various substances.^{11,12,14,15,17–19} Studies examining adolescent samples have focused mostly on drinking, and have found associations with frequency of drinking^{13,20–22} as well as initiation of drinking and problem drinking.^{13,22,23}

However, it is the *pattern* of Cloninger's traits that may be even more important in predicting substance-related behaviors, including the early (adolescent) onset of such behaviors. Cloninger theorized that low HA, along with high NS, low RD, and low PE, would predict early-onset substance problems.²⁴ This theory has not been well-studied in adolescents. Results from two cross-sectional studies with adolescents supported this theory.^{16,23} Yet, ideally, this question would be examined with longitudinal data, and to our knowledge only two studies have: Cloninger et al. found that low HA and high NS at age 11, but not RD, predicted early onset of alcohol abuse when subjects were examined again at age 27. Another study examined boys at age 6 and similarly found that low HA and high NS predicted early onset of cigarette, alcohol, and drug use at age 10–15.²⁵

In the above studies, low HA and high NS predicted early onset of substance use and alcohol abuse, but results were mixed for RD. Also, each of these studies utilizes data from before the TPQ's revision and thus none examine the PE trait. Finally, it would be useful to examine other substance-related outcomes such as breadth of substances tried or development of SUD symptoms. Study results often vary depending on the outcome variable selected, and mechanisms responsible for adolescents trying a substance for the first time may differ from those responsible for trying multiple types of substances or for developing SUD symptoms.

Utilizing a large community sample of adolescents, this study sought to address these issues and examine whether our results would be consistent with Cloninger's theory, that is, that low HA, high NS, low RD, and low PE would predict early-onset substance problems. We investigated whether all four temperament dimensions, measured in early adolescence, predicted five different substance-related outcomes in later adolescence: age of initiation for cigarettes, alcohol, and illicit substances, the number of substance classes tried, and the number of DSM-IV SUD symptoms.

METHODS

Sample

Subjects for this study come from the Colorado Twin Registry (CTR), a community-based registry, and part of the NIDA-funded Center on Antisocial Drug Dependence at the University of Colorado. The CTR includes the Community Twin Sample, recruited through the Colorado Departments of Health, Education, and Motor Vehicles, and the Longitudinal Twin Sample, recruited only through the Department of Health. Twins participated in structured interviews given by trained interviewers at wave 1, then once more at wave 2. Details on the sample and its collection are available elsewhere.²⁶ Twins were age 11–18 ($M = 14.5$, $SD = 2.1$) at wave 1 and 17–29 ($M = 19.6$, $SD = 2.5$) at wave 2. IRB approval has been obtained for analyses with these data.

Studies have shown that results from a community sample of twins may be generalized to a non-twin community sample. For example, there are minimal differences between twins and singletons in terms of cognitive ability,²⁷ psychopathology,²⁸ and personality,²⁹ and Young et al.³⁰ found that rates of adolescent substance use in twins were similar to those of nationally representative samples.

The sample for these analyses included one member of each twin pair (chosen randomly) who was age 15 or under at wave 1. This age was selected for two reasons: (i) the chosen instrument, the JTIC, is designed for those 15 and under and (ii) we wanted subjects who had not yet begun extensive drug experimentation at wave 1. These selection processes resulted in a total of 777 twins (370 males and 407 females). Mean age of the final sample was 13.1 ($SD = 1.2$, range 11–15) at wave 1; at wave 2, mean age was 18.2 ($SD = 1.7$, range 16–24). The mean interval between waves was 5.09 ($SD = 1$, range = 3–10). The sample was 52% female, and was 88% Caucasian, 9% Hispanic, and 3% other ethnicity.

Measures

To assess substance-related behaviors, subjects were given the Composite International Diagnostic Interview-Substance Abuse Module (CIDI-SAM)³² at waves 1 and 2. The CIDI-SAM is a structured, face-to-face interview designed to be administered by trained lay interviewers, and it provides DSM-IV symptom and diagnostic information for 11 drug classes. The reliability and validity of the CIDI-SAM, as well as its validity for use with adolescents, has been demonstrated.^{33,34} The CIDI-SAM allows us to compute symptom counts, generate DSM-IV abuse and dependence diagnoses, and examine information about onset and use of substances.

To assess temperament at wave 1, subjects were given the junior temperament and character inventory (JTIC),³¹ a child and adolescent version of the adult temperament and character inventory (TCI).¹⁰ The JTIC is a self-report, true-false instrument designed to reflect a psychobiological model of personality. The JTIC includes four heritable dimensions of temperament: HA, NS, RD, and PE; it also includes three character dimensions (self-directedness, cooperativeness, and self-transcendence), data for which were not available. HA assesses behavioral inhibition and a tendency toward caution and pessimism (example item: “I get tense and worried in unfamiliar situations...”). NS assesses one's propensity toward exploratory excitability, impulsivity, and pursuit of novelty (example item: “I often try new things for fun or thrills...”). RD assesses one's sentimentality and/or attachment to others (example item: “I don't open up much even with friends...”). PE assesses one's tendency to persevere even with intermittent reinforcement (example item: “I work long after others give up...”).

The JCTI has 55 questions devoted to assessing these four dimensions of temperament: 22 for HA, 18 for NS, 9 for RD, and 6 for PE. PE used to be included as a subscale of RD, but was eventually found to stand on its own psychometrically.¹⁰ Scale scores for these four dimensions were derived by summing across items (reverse scored where appropriate) and dividing by the number of items answered. Thus, the observed score (ranging from 0 to 1) reflects the proportion of items positively endorsed for each subscale. Validity and reliability of the JCTI temperament dimensions for use with child and adolescent populations has been demonstrated in clinical³⁵ and community samples.³⁶

All dependent variables were created using data from the CIDI-SAM, which examines 11 classes of substances: tobacco, alcohol, cannabis, amphetamines, cocaine, opioids, sedatives, PCP, hallucinogens, inhalants, and club drugs. To create an index of substance initiation, we examined first cigarette use, first alcohol use, and first use of the remaining non-tobacco drugs, referred to in this study as “illicit drugs.” For cigarettes and alcohol, we utilized the reported “age first smoked cigarette” and “age at first drink.” For illicit drugs, we utilized the lowest reported “age first used” across all non-tobacco drug classes.

To get the number of substance classes tried, for each subject we added up the total number of substance classes reported as “tried” by wave 2 (range 0–11). This measure provides an index of substance experimentation. Finally, to get the number of SUD symptoms, we examined all the DSM-IV abuse and dependence items that were endorsed across all 11 classes of substances at wave 2, and added them up. This measure provides an index of potential progression from substance use to “problem use.” This outcome measure was chosen because we sought a way to assess the adolescents’ development of abuse and dependence symptoms that was both comprehensive and statistically powerful, particularly in a young community sample with low prevalence of SUD. Such an outcome measure focuses on progression to problem use in general, rather than on any specific substance, and analyzing symptom counts (rather than DSM-IV diagnoses) is statistically more powerful.

Analysis

For the analyses, we used multiple regression models to examine whether scores on the four JCTI temperament scales at wave 1 predicted five dependent variables measured at wave 2: age of initiation for cigarettes, alcohol, and illicit substances, the number of substance classes tried, and the total number of DSM-IV SUD symptoms.

For the first three sets of analyses examining age of onset data, we conducted Cox regression analysis, also known as a Cox proportional hazards model, where the time variable was the number of years (from birth) until initiation and where those who had not yet initiated substances by wave 2 were designated as censored observations. For the remaining sets of analyses, where the dependent variables were comprised of symptom counts and the distribution was non-normal with a high number of zeros, we conducted Poisson regression analysis. To test Cloninger’s theory, all predictor variables were examined together in each regression model to test the predictive value of each while accounting for the others.

RESULTS

JTCI Temperament Dimension Scores

Wave 1 mean scores for all four temperament dimensions are presented in Table 1 for the entire sample as well as separately for males and females. Females scored significantly higher on HA and RD, males scored significantly higher on NS, and there were no significant sex differences for PE.

Substance Patterns at Waves 1 and 2

At wave 1, when subjects were ages 11–15 (mean = 13.1), 77% of subjects had never tried any substance, which decreased to 26% by wave 2 (mean age = 18.2). For the dependent variables, measured at wave 2, the mean age of cigarette initiation was 14 (SD = 2.4), the mean age of alcohol initiation was 15.5 (SD = 1.9), and the mean age of onset for illicit drugs (based on the earliest illicit drug class tried) was 16.2 (SD = 1.8). The mean number of substance classes tried (11 possible) was 1.37 (SD = 1.3, range 0–8), with 95% of the sample having tried 0–3 substances—26% percent had tried 0 substances, 40% tried 1, 14.5% tried 2, 14.5% tried 3, and 5% had tried 4+ substances. Of those who had used, alcohol was the most tried (54%), followed by tobacco (19%), cannabis (19%), then other substances (8%). Finally, the mean total number of SUD symptoms was 2.53 (SD = 4.5, range 0–27).

Longitudinal Analyses

Predicting Cigarette Initiation—For Cox regression, B represents the regression coefficient, where a positive value indicates increased hazard (risk), and $\text{Exp}(B)$ represents the hazard ratio, or the magnitude of risk. Due to the sex differences in the JTIC scores, the analyses were conducted while controlling for sex. Results showed that, for onset of cigarette use, HA, NS, PE, and sex variables were significant, but RD was not (Table 2). In other words, lower HA, higher NS, and lower PE increased risk for earlier initiation of cigarette use.

Predicting Alcohol Initiation—When examining alcohol, results show that both NS and PE were significant predictors of earlier alcohol initiation (Table 2). In other words, those scoring higher on NS and lower on PE were at greater risk for initiating alcohol at a younger age. Results for HA, RD, and sex were not significant.

Predicting Initiation of Illicit Substances—Results for illicit substances were very similar to those for cigarettes, in that HA, NS, and PE variables were significant, as was sex, but RD was not (Table 2). In other words, lower HA, higher NS, and lower PE increased risk for earlier initiation of illicit substances.

Predicting Substance Experimentation—Because both the propensity and opportunity to experiment with substances often increases with age, age at wave 1 and the number of years between assessments (wave 1–2 interval) were controlled for, as was sex, for the following two sets of regressions. Also, because 23% of the sample had tried at least one substance by wave 1, to account for the possibility that substance use could influence one's TCI scores we included having tried any substance by wave 1 as a covariate.

Regression results for the total number of substance classes tried (Table 3) were significant for NS, HA, and PE, but not RD. In other words, greater levels of NS and lower levels of HA and PE at wave 1 predicted more substances tried by wave 2.

Predicting the Development of SUD Symptoms—When predicting the total number of SUD symptoms across 11 classes of substances at wave 2, results showed that all variables were significant predictors (Table 4). After controlling for sex, age at wave 1, number of years between assessments, and having tried a substance at wave 1, higher levels of NS and lower levels of HA, RD, and PE at wave 1 predicted more SUD symptoms at wave 2.

DISCUSSION

This longitudinal study sought to examine whether low HA, high NS, low RD, and PE would predict early-onset substance problems, as Cloninger²⁴ predicted. We utilized a large community sample of adolescents to investigate whether these dimensions, measured in early adolescence, predicted five different substance-related outcomes in later adolescence: initiation of cigarettes, alcohol, and illicit substances, the number of substance classes tried, and the number of DSM-IV SUD symptoms.

The substance-related outcome that confirmed Cloninger's theory was the number of SUD symptoms, where high NS, and low HA, RD, and PE at wave 1 significantly predicted more abuse and dependence symptoms at wave 2. For the outcomes "number of substance classes tried" and onset of cigarettes and illicit substances, results almost confirmed Cloninger's theory, where high NS and low HA/PE were significant predictors, but RD was not. The lack of result for RD is consistent with two longitudinal studies examining adolescents.^{25,37} Finally, only high NS and low PE significantly predicted alcohol onset, only somewhat consistent with Cloninger's theory. It is possible that Cloninger's predictions may hold true for predicting early onset of developing SUD symptoms or "problem use," but less so for predicting "use" or experimentation.

The results for NS were the strongest in this study, consistently predicting all substance-related outcomes and resulting in large effect sizes. This suggests that youth who are impulsive and/or who seek novelty and excitement may be at far greater risk for earlier substance initiation, greater experimentation, and developing SUD symptoms in the future. Likewise, low PE score was predictive of all five substance-related outcomes in this study, consistent with Cloninger's prediction. This suggests that youth who are less able to persist in difficult tasks or less ambitious may be at risk for a variety of adolescent substance-related behaviors. Of the studies examining Cloninger's dimensions in adolescents,^{16,25,37} to our knowledge this is the first to examine PE. Studies examining both community and clinical samples may want to further examine PE and its relation to substance-related behaviors. Finally, results for HA were strong for predicting SUD symptoms, weaker for number of substances tried and onset of cigarettes and illicit substances, and non-significant for onset of alcohol use.

On the other hand, RD was not a significant predictor of four of our five outcomes. Instead, low RD predicted only the number of DSM-IV SUD symptoms, suggesting that RD may play a significant role in predicting SUD or "problem use" rather than initiation, ordinary use, or experimentation among adolescents. Conducting a similar study in a clinical sample, where SUD rates are much higher than in this sample, may clarify this issue. Also, low RD, particularly when combined with high NS, is often observed in those with personality disorders, including antisocial personality,³⁸ as well as in children who develop later delinquent behaviors.³⁹ It is possible that RD's involvement in substance-related behaviors may be mediated through antisocial behavior.

These results have implications for identifying youth who may be at risk for future substance-related behaviors. High NS and low PE were both strong predictors of cigarette, alcohol, and illicit drug initiation, experimentation, and the development of SUD symptoms, suggesting that both traits predict a broad spectrum of substance-related behaviors in adolescents. High novelty seekers respond very strongly to the possibility of reward, likely putting them at significant risk for engaging in highly "rewarding" activities such as substance use. When examining PE, youth with low PE display a lack of ambition and an inability to persevere through difficulties, and do not put forth extra effort even in response to an anticipated reward. Perhaps the immediacy of reward from substances is far more

reinforcing for those with low PE, putting them at risk for substance use. Generally speaking, identifying youth who display high NS or low PE and targeting them for early intervention, well before initiation of substances, may be useful.

This study did have some limitations. First, we utilized a community sample; while it is beneficial to conduct assessments in youth before they have begun extensive drug experimentation, our sample did not show high amounts of substance involvement. Our results examining the number of substances tried may, in part, reflect that which was most used—that is, alcohol use. Thus, it is possible that this result, and others, may differ when examining a clinical or selected sample, where one would expect lower onset ages as well as greater breadth of experimentation and more SUD symptoms. In addition, this study utilized substance outcome variables that were generalized across 11 classes of substances, which may yield different results from studies examining substance-specific outcomes. Finally, this study examined temperament in youth age 15 or under, as measured by the JTCI; it is possible examining older youth, utilizing the standard TCI, may yield different results.

In summary, this study found some support for Cloninger's theory of early-onset substance problems, especially with the development of DSM-IV SUD symptoms. High NS and low PE were the most consistent predictors of adolescent substance-related outcomes. Future examination of the TCI and substance-related behaviors in other samples, especially clinical samples with two waves of data, is needed.

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TABLE 1

Mean (SD) JTCI temperament dimension scores

JTCI dimension	Combined sample	Males (<i>n</i> = 370)	Females (<i>n</i> = 407)	<i>T</i>	<i>p</i> -Value
Harm avoidance	.276 (.18)	.252 (.18)	.297 (.19)	3.45	.001
Novelty seeking	.415 (.19)	.445 (.19)	.388 (.18)	-4.25	<.001
Reward dependence	.552 (.23)	.487 (.21)	.612 (.24)	7.77	<.001
Persistence	.692 (.25)	.686 (.25)	.698 (.25)	.655	.513

TABLE 2

Predicting age of initiation

Wave 1 measure	N initiated [*]	N censored [†]	B	SE	p-Value	Exp(B)
Cigarettes						
Sex	200	571	-.307	.153	.044	.736
Harm avoidance	200	571	-.941	.416	.024	.390
Novelty seeking	200	571	2.230	.407	<.001	9.303
Reward dependence	200	571	.018	.326	.957	1.018
Persistence	200	571	-1.351	.289	<.001	.259
Alcohol						
Sex	564	207	-.165	.090	.065	.848
Harm avoidance	564	207	-.397	.243	.102	.672
Novelty seeking	564	207	1.099	.251	<.001	3.001
Reward dependence	564	207	.186	.193	.336	1.205
Persistence	564	207	-.487	.183	.008	.614
Illicit drugs						
Sex	209	562	-.332	.150	.027	.718
Harm avoidance	209	562	-.812	.411	.048	.444
Novelty seeking	209	562	2.572	.398	<.001	13.09
Reward dependence	209	562	-.095	.321	.767	.909
Persistence	209	562	-.578	.292	.048	.561

* Number of subjects who initiated substance

† Number of subjects who had not initiated substance.

TABLE 3Predicting total number of substance classes tried by wave 2 ($n = 777$)

Wave 1 measure	<i>B</i>	<i>SE</i>	<i>p</i> -Value
Sex	-.142	.066	.031
Age at wave 1	.057	.028	.039
Wave 1–2 interval	.114	.028	<.001
Tried by wave 1	-.510	.073	<.001
Harm avoidance	-.386	.181	.033
Novelty seeking	.956	.180	<.001
Reward dependence	-.221	.143	.122
Persistence	-.344	.130	.008

TABLE 4Predicting total number of SUD symptoms at wave 2 ($n = 777$)

Wave 1 measure	<i>B</i>	<i>SE</i>	<i>p</i> -Value
Sex	-.277	.049	<.001
Age at wave 1	.063	.021	.002
Wave 1–2 interval	.191	.020	<.001
Tried by wave 1	-.896	.052	<.001
Harm avoidance	-.386	.134	.004
Novelty seeking	1.45	.131	<.001
Reward dependence	-.707	.105	<.001
Persistence	-.280	.094	.003