COGNITIVE AND BEHAVIOURAL EFFECTS
PATHWAYS TO SUBSTANCE-RELATED DISORDER: A STRUCTURAL MODEL APPROACH
EXPLORING THE INFLUENCE OF TEMPERAMENT, CHARACTER, AND CHILDHOOD ADVERSITY IN A NATIONAL COHORT OF PRISONERS

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(Received 22 January 2007; first review notified 7 June 2007; in revised form 21 November 2007; accepted 13 December 2007; advance access publication 18 February 2008)

Abstract — Aims: Using Cloninger’s model of personality, we aimed to specify the relative influence of the more biologically determined variables, temperament and character and more environmentally driven influence, childhood adversity in the development of addiction; and to compare patterns found among alcoholics with those found among drug addicts. Methods: We studied a group of prisoners, at a high risk of substance abuse and past history of childhood adversity. Using a stratified random strategy we selected (i) 23 prisons among the different types of prison in France, (ii) 998 prisoners. Each prisoner was assessed by two psychiatrists—one junior, using a structured interview (MINI 5 plus), and one senior, completing the procedure with an open clinical interview. At the end of the interview the clinicians met and agreed on a list of diagnoses. Cloninger’s Temperament and Character Inventory was used to measure personality. Structural equations models, which have been advocated to disentangle the respective influence of complex risk factors, were used. Results: the “novelty seeking” temperament was a crucial vulnerability factor, for both alcoholics and drug addicts, in the same proportion. Character and childhood adversity played a significant part only in the development of drug abuse. Conclusions: In a prison population, a common biological loaded factor, novelty seeking is found both at the core of alcohol- and drug-related disorder whereas environmentally loaded factors play a greater role in drug problems.

INTRODUCTION
Personality is usually defined as the combination of stable patterns of behavior characteristic of an individual. This gives individual differences in personality profiles. To compare these patterns in a homogeneous way, it was important to use a global construct, where these patterns are clearly distinct. Cloninger’s biosocial model of personality offers such a structure (Cloninger, 1994). The Temperament and Character Inventory (TCI) is a self-questionnaire developed by Cloninger to explore seven dimensions (three temperaments and four characters) in line with his biosocial model of personality. Cloninger’s biosocial model has the advantage of combining the hypothesized genetic and neurobiological bases of personality (the so-called “temperaments”: novelty seeking (NS), harm avoidance (HA), and reward dependence (RD)) and their interactions with learning and environment-mediated factors (the so-called “characters”: persistence (PE), self-directedness (SD), cooperativeness (CO), self-transcendence (ST)).

Furthermore, specific combinations of these patterns may predispose to specific psychiatric comorbidities, especially substance disorder. Indeed, the prevalence of personality disorders is estimated to be three times higher in substance users (Verheul and Van den brink, 2005).

Studies have focused on the TCI profiles of substance abusers. Previous reports have shown that the most salient variable characterizing substance users is a pronounced novelty-seeking temperament (Cloninger, 1987) in several classes of addiction in comparison to controls: for alcohol and tobacco (Henderson and Galen, 2003; Henderson et al., 1998; Le Bon et al., 2004b; Masse and Tremblay, 1997; Ravaja and Keltikangas-Jarvinen, 2001); for alcohol, nicotine, and cannabis (Van Ammers et al., 1997); for nicotine (Pomerleau et al., 1992); for opiates (Vukov et al., 1995); for cocaine (Ball et al., 1997). In addition, harm avoidance ratings were lower in early onset alcoholism (Cloninger, 1988).

Some studies also set out to differentiate drugs of choice among users, and in most cases, these studies have failed to predict drug of choice in relation to personality patterns (for a complete review, see Le Bon et al., 2004a). However, some papers have reported different personality profiles according to the substance of choice (Cloninger, 1987). Drug users and alcoholics show the most contrasted characteristics (Conway et al., 2002; De Wit and Bodker, 1994; Le Bon et al., 2004b) (Conway et al., 2003; O’Connor et al., 1995).

As several hypotheses of the Cloninger personality model concerning temperament may have some important implications in addictive disorders (e.g., involvement of the dopaminergic system in Novelty Seeking), some interesting studies have been conducted to compare temperament and character profiles in alcohol and substance abuse/dependence disorders.

For example, a recent study using TCI temperaments reported that heroin addicts scored higher than alcoholics on novelty-seeking and self-directedness, and that exploratory excitability (a subdimension of novelty-seeking) was the best variable to segregate these groups. (Le Bon et al., 2004b).

Another study showed that novelty seeking was not different among different substance abusers (Conway et al., 2003).

We are unaware of the existence of any results concerning TCI characters and drug of choice. Character variables are
believed to be mainly influenced by life events and education. We can assume that characters in individuals with substance use disorders deviate from the norm, as childhood history of adversity is commonly reported in these individuals.

Another unsolved question concerning personality and substance use disorders is the respective influence of temperaments and characters in the development of substance use disorders. About half the variance for the risk of alcoholism has been related to genetic factors, and environment factors are also known to play an important role (Schuckit et al., 2006). However, the impact of genetic factors may be only optimally understood in the context of additional environmental factors. Structural equations models, an original statistical method, have recently been advocated to explore addiction (Schuckit et al., 2006), and they make it possible to compute the weight of different factors in these complex models in a unique way. Although they do not substitute to more specific genetic epidemiological study, they may allow differentiating the influence of risk factors of different origin (some more genetically determined, some more environmentally determined) according to a more traditional epidemiological approach.

Prevalence of alcoholism and substance use disorders is very high in prison (Andersen, 2004; EMCDDA, 2004). Moreover, prisoners generally have a considerable history of adverse childhood events (Andersen, 2004). Consequently, prison is a relevant setting in which to study the link between personality, childhood adversity, and substance use disorders. A national randomized study about mental health in prison was ordered by the French health authority in 2002, and it found a high prevalence of substance-related disorders and adverse life events.

We used this cohort:

1. to observe the distribution between innate (temperament) and acquired (character and childhood history) risk factors of personality in an integrated model of risk of substance use disorders;
2. to compare these patterns of distribution between individuals with alcohol abuse and dependence (AAD) and those with drug abuse and dependence (DAD).

METHODOLOGY

Study design
In the year 2002, the French ministries of health and justice decided to determine prevalence estimates for mental disorders in French prisons. A cross-sectional study was conducted on 1000 prisoners selected from 23 prisons, using a stratified random sample strategy, between September 2003 and July 2004.

Selection of prisons
There are three types of prison in France. Maisons d’Arrêt are intended for remand prisoners or for prisoners with short sentences. Prisons centrales are high-security units intended for prisoners with long sentences. Centres de détention are intermediate.

Selection of prisoners
It was estimated that 1000 prisoners must be included in the study to detect a pathology with a prevalence of 20% with a 95% confidence interval of ±2.5%. A total of 998 subjects were indeed sampled from these prisons between September 2003 and July 2004: 100 women, 100 men from France’s overseas départements, and 798 men from metropolitan France. This number of subjects was chosen (i) to allow a good feasibility according to the budget of the study and (ii) to avoid a design effect in the calculation of statistical power. The 998 prisoners were selected using a stratified random sampling strategy. 23 prisons centers were randomized among the 188 prisons existing in France at the time of the study: 13 maisons d’arrêt (two having a capacity of more than a 1000 prisoners, 3 between 400 and 1000, 4 between 100 and 400, and 4 less than 100), 5 centres de détention (2 national and 3 regional centers), 2 prisons centrales, 1 male center in a French overseas département, and 2 prisons for women were chosen at random (for women, no prison centrale was selected). Prisoners were then selected at random in the population of each selected prison. The percent of prisoners selected in each prison was between 1.4% (for “maison d’arrêt”) and 5.1% (for “maison centrale”) according to the real size of each center, which corresponds to the recruitment of 50 prisoners by center (except for the 4 centers of less than 400 prisoners who were the number was 37 prisoners and 13 prisoners for the 4 centers of less than 100).

After fully describing the study to the subjects, written informed consent was obtained.

Data collection and diagnosis procedure
Each prisoner was interviewed for approximately 2 h by a group of two clinicians (clinical psychologist or psychiatrist). At least one of these clinicians had to be a senior psychiatrist; neither could belong to the prison medical team.

The interviews began with the collection of the prisoners’ signed informed consent. Diagnoses were then collected according to a semi-structured procedure validated in a previous study (Loze et al., 2002): one of the clinicians uses a structured clinical interview, which generates DSM IV diagnoses (MINI plus v 5.0 (Sheehan et al., 1998)); the second clinician, more experienced, completes the procedure with an open clinical interview, intended to be clinically more relevant. The interview continues with the clinician-version of Cloninger’s Temperament and Character Inventory (Cloninger, 2000), and the various questions on sociodemographic data, legal status, previous treatment, and history of trauma. At the end of the interview, each clinician independently summarizes his/her list of diagnoses and scores the Clinical Global Impression severity scale; then they both meet and conclude with a consensus list of diagnoses and a CGIs score.

All interviewers had specific training in the methodology and the instruments used in this study.

Clinical-administered version of Cloninger’s Temperament and Character Inventory
Cloninger’s biosocial model of personality has the advantage of combining hypothesized genetic and neurobiological bases of personality (the three temperaments: Novelty Seeking, Harm Avoidance, and Reward Dependence) believed to interact with social learning and environment components (the four characters, which mature in adulthood from conceptual learning; self-directedness, cooperativeness, self-transcendence, and persistence, which are less developed in immature personalities and personality disorders).
The three main dimensions of temperament are given below:

1. Novelty seeking (NS) is a tendency toward excitement in response to novel or rewarding stimuli. This dimension is the sum of four subscales measuring more specific related traits: Exploratory excitability (11 items), Impulsiveness (10 items), Extravagance (9 items), and Disorderliness (10 items).
2. Harm avoidance (HA) reflects a tendency to inhibiting behavior when faced with new situations. It also involves a tendency to respond strongly to signals of adverse stimuli. This dimension is assessed by means of four subscales: Anticipatory worry (11 items), Fear of uncertainty (7 items), Shyness (8 items), and Fatigability (9 items).
3. Reward dependence (RD) reflects a tendency to sustain rewarding behaviors or to respond intensely to signals of reward and to sustain behaviors previously associated with reward. This dimension encompasses three subscales: Sentimentality (10 items), Attachment (8 items), and Dependence (6 items).

These personality traits are theoretically related to underlying neurotransmitter systems, especially NS to dopaminergic function and HA to serotonergic function, in addition to GABA and glutamatergic systems (Johnson et al., 2006).

The character dimensions, which are believed to be more environmentally influenced than temperaments, reflect “individual differences in self-object relationships” (Cloninger et al., 1998). The character dimensions in the TCI are as follows:

1. Self-directedness (SD) refers to self-acceptance, responsibility, and to the tendency to adapt behavior according to personal goals, to be autonomous. This dimension is assessed as the sum of five subscales measuring more specific related traits: Responsibility (8 items), Purposefulness (8 items), Resourcefulness (5 items), Self-acceptance (11 items), and congruent second nature (12 items).
2. Cooperativeness (C) refers to the ability to identify with and accept other people, to be an integral part of a group. This dimension includes Social acceptance (8 items), Empathy (7 items), Helpfulness (8 items), Compassion (10 items), and Pure-heartedness (9 items).
3. Self-transcendence (ST) refers to having a strong belief system and to feel part of nature and the universe. This dimension encompasses three subscales: self-forgetfulness (11 items), transpersonal identification (9 items), and spiritual acceptance (13 items).
4. Persistence (PS) corresponds to a tendency to sustain behaviors despite frustration and fatigue. It has a single 8-item scale.

The two main dimensions of character (SD and CO) assess traits of maturity, respectively the ability for individual and social adaptation. Consequently, they are negatively correlated with the risk of personality disorder for a given individual.

Standardized Cronbach coefficient $\alpha$ was 0.58 for the entire TCI, and ranged from 0.54 to 0.62 for the three temperaments and from 0.50 to 0.60 for the four characters. We studied the psychometric properties of the French translation of this clinician-administrated version of the TCI in a previous study in a subgroup of 560 male prisoners (Pelissolo et al., submitted), who were tested by trained clinicians, using factor analyses. Results showed that the 20 items relating to the general personality criteria have acceptable internal consistency (Cronbach alpha coefficient was equal to 0.77 [0.74; 0.79]). Scree plot of the eigenvalues of the correlation matrix of the 20 items used to determine the four core features that determine the existence and level of severity of a personality disorder were calculated. Even if five eigenvalues were greater than 1 (Keyser rule) and three of them appeared greater than what could be expected “by chance, the first eigenvalue was substantially higher than all the others. This property is compatible with the fact that all 20 items are related in a first approximation to a single latent construct (Falissard, 1999), which could be labeled here as “personality disorder.” The three-factor structure of the temperament items used to subtype personality disorder is correctly identified by a maximum likelihood factor analysis model with varimax rotation. (Falissard, 1999; Pelissolo and Ecochard, submitted).

Sample validation

Acceptance of the study by prison authorities was generally very good. A high percentage (57%) of prisoners were available and accepted the interview; a total of 998 prisoners were interviewed. Collaboration with prisoners was good to very good 88% of the time and average 10% of the time. There was no problem of speaking/understanding French in 85% of cases.

Each prisoner received diagnoses from two clinicians. Inter-rater disagreement on diagnosis assessment for the total sample was estimated. All the Cohen’s Kappa values corresponded to “good” to “excellent” agreement (Cicchetti and Sparrow, 1981), with the highest score for alcohol dependence (0.91) and drug dependence (0.95). In this study, we used only these consensus diagnoses. Prevalence estimations taking into account the stratified nature of the randomization process have been calculated elsewhere.

Ethics

This study was considered as having a direct individual benefit according to CCPPRB decision, since a procedure to signal prisoners to the prison medical team was provided for in two cases: in case of a psychiatric emergency (particularly high risk of suicide), with or without the permission of the patient, and in case of psychiatric disorders that were deemed serious, only with the permission of the prisoners. A specific form was designed for this procedure. About 22% of prisoners were signaled to the prison medical team (with the agreement of the prisoners; patients already followed for psychiatric reasons were not signaled).

Statistical analysis

Structural equations models were used for the multivariate analysis. Structural equations models are a generalization of linear regression and factor analysis models. These models enable the simultaneous performance of several multiple linear regressions. Variables present in the regressions may be either observable or latent. In the latter situation, originally found in factor analysis models, the variable is deduced from a group of observed correlated variables. The latent variable is considered to be an underlying common factor, which explains the pattern of correlation observed in the group of observed variables. Practically speaking, parameters estimated in a structural equations model correspond to the change in standard deviation (SD) of a dependent variable when an independent variable changes by 1 SD (the other variables remaining constant). For
the present study, coefficients below 0.10 were considered as negligible (and represented with dashed arrows) even if they were statistically significant.

The complexity and the large number of structural equations models that can be put forward for the same set of data makes the recourse to statistical indices quantifying fit and quality of the model unavoidable. Three were selected: Steiger’s RMSEA (root mean square error approximation), where a value smaller than 0.1 is considered as a good fit and very good when it is smaller than 0.05 (Steiger, 1998), Bentler and Bonnet’s NFI (normed fit index) where a value over 0.95 is considered as a good fit (Bentler, 1990), and Akaike’s information criterion (AIC) (Akaike, 1974). AIC adopts a balanced approach taking into account the quality of the model, and it discourages “overfitting.” Indeed, a model with many parameters will provide a very good fit to the data, but will have few degrees of freedom and be of limited utility. The AIC methodology attempts to find the minimal model (that is with the lowest AIC value) that correctly explains the data, which can be contrasted with more traditional approaches to modeling, such as starting from a null hypothesis.

We used two models (one for alcohol abuse/dependence and one for drug abuse/dependence, constructed in similar ways) to describe how the interaction paths between childhood adverse events and Cloninger’s Temperaments and Characters contribute to the development of alcohol or drug abuse/dependence (see Figure 1 for the baseline structural equations model). These models were constructed according to a primary personality disorder model, in which the personality disorder induces secondary substance use. In these models, AAD represents alcohol abuse and/or dependence and DAD represents substance abuse and/or dependence. We hypothesized that the relationships between different exogenous variables exploring childhood history (separated from parents more than 6 months (separated), having been followed by a juvenile magistrate (juv.mag.), having been placed (placement), or having been mistreated ill-treated in childhood (mistreated)) can be explained by the presence of an underlying latent variable, labeled CA, childhood adversity. This latent variable was built independently, using a factor analysis. The variables for the model were chosen after a one-dimensional analysis among the seven variables assessed in this study related to childhood events. The Temperaments were represented by three variables: harm avoidance (HA), reward dependence (RD), and novelty seeking (NS). Character was represented by a single variable CHAR, corresponding to the sum of the four characters. Indeed, Cloninger describes character as a unidimensional construct, a marker of severity of the underlying personality disorder (Cloninger, 2000) and thus in our model we chose to stay in line with this opinion.

In these models, childhood adversity could indirectly influence the development of a substance use disorder through character and temperaments, but also directly. Correlations between these variables were also computed.

Statistical power was computed for a null assumption of good fit corresponding to an RMSEA of 0.05 and an alternative assumption of bad fit for an RMSEA equal to or higher than 0.1 (Loehlin, 2004). A power higher than 90% was obtained. All the tests were performed with $\alpha = 5\%$.

For statistical analyses, SAS 9.1 software was used, and Proc CALIS procedure was used for the structural equations models. We used polycor Package version 0.7–2, with software R 2.4.0 (Hectcor function) to define a heterogeneous correlation matrix, consisting of Pearson product–moment correlations between numeric variables, polyserial correlations between numeric and ordinal variables, and polychoric correlations between ordinal variables.

**RESULTS**

**Cohort description**
Just under 80% of prisoners were under 50 years (mean age in years: $39 \pm 13$), and just above 80% had no education or...
Table 1. Cohort description (N = 998)

<table>
<thead>
<tr>
<th>Covariates</th>
<th>General population</th>
<th>AAD population</th>
<th>DAD population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 998</td>
<td>N = 167</td>
<td>N = 270</td>
</tr>
<tr>
<td>Demographic status</td>
<td>% (N)</td>
<td>% (N)</td>
<td>% (N)</td>
</tr>
<tr>
<td>Gender (ref. Male)</td>
<td>90.1 (899)</td>
<td>95.2 (N = 159)</td>
<td>93.0 (N = 254)</td>
</tr>
<tr>
<td>Age class (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>28.9 (287)</td>
<td>47.3 (78)</td>
<td>50.5 (137)</td>
</tr>
<tr>
<td>30–39</td>
<td>27.4 (272)</td>
<td>28.5 (47)</td>
<td>36.2 (98)</td>
</tr>
<tr>
<td>40–49</td>
<td>23.6 (235)</td>
<td>16.7 (27)</td>
<td>10.7 (29)</td>
</tr>
<tr>
<td>50–59</td>
<td>12.2 (121)</td>
<td>6.7 (11)</td>
<td>2.6 (7)</td>
</tr>
<tr>
<td>≥60</td>
<td>7.9 (79)</td>
<td>1.2 (2)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>41.2 (410)</td>
<td>53.3 (88)</td>
<td>63.1 (171)</td>
</tr>
<tr>
<td>Married</td>
<td>36.0 (358)</td>
<td>30.3 (50)</td>
<td>25.1 (68)</td>
</tr>
<tr>
<td>Widowed or divorced</td>
<td>22.7 (226)</td>
<td>16.4 (27)</td>
<td>11.8 (32)</td>
</tr>
<tr>
<td>Education</td>
<td>45.7 (453)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No education</td>
<td>35.3 (350)</td>
<td>53.9 (89)</td>
<td>51.8 (140)</td>
</tr>
<tr>
<td>Low education</td>
<td>11.6 (115)</td>
<td>40.0 (66)</td>
<td>37.8 (102)</td>
</tr>
<tr>
<td>High school diploma</td>
<td>7.5 (74)</td>
<td>4.8 (8)</td>
<td>8.5 (23)</td>
</tr>
<tr>
<td>University</td>
<td>1.2 (2)</td>
<td>1.8 (5)</td>
<td></td>
</tr>
<tr>
<td>Length of sentence</td>
<td>0.1 (1)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>&lt;1 month</td>
<td>4.0 (29)</td>
<td>0.0 (0)</td>
<td>0.0 (0)</td>
</tr>
<tr>
<td>1–6 months</td>
<td>11.4 (83)</td>
<td>12.0 (13)</td>
<td>8.1 (15)</td>
</tr>
<tr>
<td>6 month to 1 year</td>
<td>33.6 (244)</td>
<td>32.4 (35)</td>
<td>22.8 (42)</td>
</tr>
<tr>
<td>1–5 years</td>
<td>50.8 (369)</td>
<td>39.8 (43)</td>
<td>45.1 (83)</td>
</tr>
<tr>
<td>5 years or more</td>
<td>15.7 (17)</td>
<td>23.9 (44)</td>
<td></td>
</tr>
<tr>
<td>Previous history of imprisonment (ref. Yes)</td>
<td>46.7 (463)</td>
<td>63.0 (104)</td>
<td>67.2 (182)</td>
</tr>
<tr>
<td>Judge seen in childhood (ref. Yes)</td>
<td>26.6 (263)</td>
<td>43.0 (71)</td>
<td>45.7 (123)</td>
</tr>
<tr>
<td>Placement (ref. Yes)</td>
<td>22.0 (217)</td>
<td>28.7 (47)</td>
<td>35.6 (96)</td>
</tr>
<tr>
<td>Separation from one parent more than 6 months (ref. Yes)</td>
<td>43.6 (429)</td>
<td>51.0 (84)</td>
<td>57.2 (155)</td>
</tr>
<tr>
<td>Mistreatment (ref. Yes)</td>
<td>29.6 (293)</td>
<td>38.0 (63)</td>
<td>38.5 (104)</td>
</tr>
<tr>
<td>Alcohol Abuse and Dependence (ref. Yes)</td>
<td>16.7 (167)</td>
<td>/</td>
<td>35.90 (98)</td>
</tr>
<tr>
<td>Drug Abuse and Dependence (ref. Yes)</td>
<td>27.3 (273)</td>
<td>58.7 (98)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean(SD) (N)</td>
<td>Mean(SD) (N)</td>
<td>Mean(SD) (N)</td>
</tr>
<tr>
<td>Character (CHAR)</td>
<td>34.4(4.0) (998)</td>
<td>33.0(4.4) (167)</td>
<td>32.8(4.2) (273)</td>
</tr>
<tr>
<td>Novelty Seeking (NS)</td>
<td>9.7(2.8) (892)</td>
<td>11.4(2.6) (149)</td>
<td>11.2(2.6) (248)</td>
</tr>
<tr>
<td>Reward Dependence (RD)</td>
<td>10.7(2.7) (888)</td>
<td>10.8(2.5) (149)</td>
<td>10.8(2.5) (248)</td>
</tr>
<tr>
<td>Harm Avoidance (HA)</td>
<td>9.5(3.1) (887)</td>
<td>9.9(3.0) (149)</td>
<td>9.7(3.1) (248)</td>
</tr>
</tbody>
</table>

a low educational level. 46.6% (n = 465) had already been incarcerated and the most frequently committed offense was assault (52.7%). The mean time already spent in prison was 16.5 (±22.3) months. The most frequent consensus diagnoses were lifetime and current mood disorders and current anxiety disorders, with nearly half the prisoners having one of these diagnoses. More than a quarter of prisoners had a history of suicide attempt and just under 50% had had a contact with a psychiatric service. Childhood history of adverse events was frequent and 26.95% of prisoners had had a contact with a children’s judge before the age of 18 years. See data presented in Table 1.

35.2% (n = 351) of prisoners had either alcohol or drug abuse/dependence. 18.44% of prisoners had presented alcohol abuse/dependence in the previous 12 months and 27.9% drug abuse/dependence diagnosis in the previous 12 months. 11.2% (n = 111) had had both diagnoses in the previous 12 months. Cannabis was the most frequently used drug in the previous 12 months (26.7%), other drug use being marginal (2.7 to 5.4%).

The high coefficients associated with the latent variable CA were in favor of its robustness: they were statistically significant and rather high, ranging from 0.43 to 1.00 for both the AAD model and the DAD model. Figures 2 and 3 illustrate the subject.

Influence of childhood adversity and character (environmentally driven factors)

For AAD, there is a moderately significant indirect influence of CA through NS (0.24) and character (0.22). The interpretation is straightforward: the more of adverse childhood events there are, the more unstable is the person’s character and the higher he/she scores on NS. Character has a slight influence on AAD (0.10).

For DAD, there is also a moderate significant indirect influence of CA through NS (0.22) and character (0.24). There is also a significant path between Character and DAD (0.19), that is, the more stable a person’s character, the less likely the person is to develop DAD. A direct influence of CA on AAD (0.20) is in favor of an influence of CA independently of personality profiles.

Influence of temperaments (biologically driven factors)

Only novelty seeking (NS) was significantly correlated to AAD (0.31) or DAD (0.25). Other temperament factors were
Fig. 2. Pathways to alcohol abuse and dependence in a cohort of French prisoners (N = 998).

Fig. 3. Pathways to drug abuse and dependence in a cohort of French prisoners (N = 998).

statistically significant but coefficients were well above 0.1, and thus clinically irrelevant. Interestingly, the only temperament also influenced by the latent variable CA was also NS.

DISCUSSION

This study highlights several points:

First, we observed different distributions of temperament and character factors of personality in the development of AAD and DAD. Indeed, only NS and character variable (mainly for DAD) had an influence on the development of an alcohol abuse/dependence disorder. For drug abuse/dependence disorder, a direct influence of childhood adversity contributed to its development.

Second, we observed a discrepancy regarding one of the assumptions of Cloninger’s model concerning NS. As expected by the theory, which considers character as mainly influenced by environment and temperaments by a neurobiological/genetic basis, we observed an expected significant correlation between childhood adversity and character, but also with NS, a
dimension considered to have a predominantly innate neurobiological and genetic basis.

**Links with previous knowledge**

Compared to other prisoners without a substance-related disorder, NS is the main factor influencing the development of either AAD or DAD. This is consistent with the literature that identifies NS as a central factor in addiction (Examples: for type II alcoholism (Cloninger, 2000; Howard et al., 1997), for opiates (Fassino et al., 2004; Vukov et al., 1995), for pathological gamblers (Martinotti et al., 2006), for cocaine (Ball et al., 2006)). However, we did not find any difference between alcoholics and drug addicts regarding NS (and NS scores were even slightly higher in alcoholics unlike the findings of the Lebon et al. study). This lack of difference may be due to the fact that most of the drug addicts in this cohort were cannabis-dependent while in other studies they were predominantly opiate addicts. Furthermore, NS has been related to a wide range of drugs, and seems associated more with severity of dependence and the number of drugs used than to the drug of choice (Conway et al., 2004). However, we did not find any difference between alcoholics and drug addicts regarding NS (and NS scores were even slightly higher in alcoholics unlike the findings of the Lebon et al. study). This lack of difference may be due to the fact that most of the drug addicts in this cohort were cannabis-dependent while in other studies they were predominantly opiate addicts. Furthermore, NS has been related to a wide range of drugs, and seems associated more with severity of dependence and the number of drugs used than to the drug of choice (Conway et al., 2004) and also to the most illicit and deviant substances (Chakroun et al., 2004). It has also been related to early onset alcoholism, considered to be more severe (Howard et al., 1997; Le Bon et al., 2004b).

A direct influence of childhood adversity was associated with drug addiction but not with alcoholism, as well as a stronger influence of character (both CA and characters being theoretically more environmentally driven). Poor family supervision and involvement and lack of school “connectedness” has been related to subsequent substance use (Wang et al., 2005). Moreover, most alcoholics in prison are likely to have type II alcoholism, not thought to be markedly environmentally influenced, explaining the lack of environmental influence in this cohort.

Thus, when we compare the relative weight of our three sets of variables (childhood adversity, character, and temperament variables), we can observe differences between AAD and DAD. Alcoholism seems to be predominantly influenced by temperament (theoretically more neurobiologically and genetically determined) while drug addiction is influenced to a similar degree by our set of three variables.

While some of our results support the general validity of Cloninger’s model, the significant link between childhood adversity and novelty-seeking seems in contradiction with the hypothesized neurobiological background of this variable. This is an unexpected but interesting result (it is stable in both of our models) and only novelty-seeking among the three temperaments is concerned. It suggests that childhood adversity is linked to a more marked tendency to look for novel stimuli. Interestingly, a study has shown that high NS scores and negative parental emotional warmth ratings were associated in adolescent delinquents (Richter et al., 2002). Thus, temperament may also be determined by environment, at least for NS. However, it should be noted that the internal structure of the TCI has been recently criticized and may explain this particular finding (Herbst et al., 2000; Gana and Trouillet, 2003). Conversely, we accepted the assumption that character has low heritability but some recent studies have shown that all character scales had substantial genetic contribution (Ando et al., 2004). It is also widely accepted that the gene–environment interaction is a major factor in the development of addiction (Caspi et al., 2005). Our structural equation model only partially took into account this possible interaction through simple correlations between temperaments, character, and environment and thus our model may have underestimated the effect of such interaction. We are now investigating if this result is reproducible for other diagnoses.

**Limitations of the study**

In the first place, it should be noted that our aim was not to this study is not a genetic epidemiology study, but a classic epidemiological study of risk factors. Some of these factors are supposed to be more genetically loaded, some are more environmentally loaded. However, although there are some bases for an innate/environmental structure in the TCI, this dichotomy has been disputed (for example, Ando et al., 2004) and the use of temperament as a direct proxy for genetic influence and character for environmental influence may be unwarranted. However, we think it is still interesting to artificially separate these factors into two groups (innate and environmental) for heuristic purposes.

No objective measures of substance use were carried out and the substance-related disorder diagnoses were based only on a clinical assessment. This is a general problem encountered in substance-related disorder studies, where underreporting is the rule among patients. In prison, the setting can aggravate this general tendency. Indeed, prisoners may fear that they could face disciplinary measures or have reduced access to their supplies if they report substance abuse. However, in our study, we tried to limit the effect of the setting by 1) ensuring a strict anonymity of the interview 2) using a diagnosis procedure that increases inter-rater reliability, sensitivity, and specificity.

Another limitation is that our data are not prospective. We opted for a primary personality disorder model, which requires longitudinal data, while we have only transversal data based on introspect. This may have some consequences on the interpretation of our results: Indeed, we cannot ignore the fact that some personality traits were in fact subsequent to substance abuse (the so-called primary substance abuse model) or reshaped by chronic substance abuse (for example, it is well known that ideas of reference or distorted perception, secondary to intoxication, can durably modify cognitive and behavior habits, leading to social avoidance and a more suspicious character (Verheul and Van den brink, 2005). Similarly, environment may reshape character (and our data suggest that, at least for NS, temperament may also be influenced by environment): for example, life in prison may lead prisoners to resort more frequently to manipulative behaviors to avoid being exploited by their peers or to adjust to antisocial behaviors that are the group norm in prisons (Bernstein et al., 1998). However, we can assume that some changes may occur in personality and that these changes are rarely drastic.

Another point is the limited number of variables used in our models and thus we cannot rule out potential confounding factors, also implied in substance abuse, particularly the high prevalence of antisocial personality and mood disorders in this sample. Other potential factors could be included in this analysis such as the type of crime committed. Furthermore, as described by Reulbach et al., there may be a relationship between high harm-avoidance levels and Lesch type II alcoholism. A
study on this subject is currently underway. However, structural equations models have to be clear and accessible in their construction in order to facilitate interpretation. Moreover, we did not aim to test a general model of addiction but a limited hypothesis, the relative weight of character, temperaments, and childhood adversity in the development of substance use disorder.

Finally, our population of comparison is not made up of control subjects but of prisoners without a substance-related disorder. This population has a higher prevalence of psychiatric disorders (especially antisocial personality) and childhood adversity than a normal population and some differences may have been blunted (especially for harm avoidance) or exaggerated (for novelty seeking). For example, average NS scores may be higher in our population when compared to a normal population. Indeed, prisoners may be more sensitive to new stimuli that break prison monotony, and thus score globally higher on NS than nonjailed substance abusers. Furthermore, a study has shown that NS segregated type I and type II alcoholism (Howard et al., 1997) and we can also assume that most of the alcoholics in prison are type II, which displays usually more violent behavior.

Model fit

Finally, our models for AAD and DAD yielded a very good fit. The RMSEA estimates were 0.0247 (90% CI: 0.0000–0.0548) for AAD and 0.0258 (90% CI: 0.0000–0.0591) for DAD, Bentler and Bonett’s NFI are 0.9969 and 0.9976, respectively; chi-square tests are not rejected with $\chi^2 = 8.0497$, df = 5, $P = 0.1535$ and $\chi^2 = 6.6655$, df = 4, $P = 0.1547$, respectively. Akaike information criterion (AIC) was −1.95 for the AAD model and −1.33 for the DAD model. These results show an excellent match between the models and the data. Moreover, sex may have been the source of a confounding effect, especially concerning the correlation with temperament and character. However, we tested alternative models for men separately, and the results were closely related to our main model, justifying a common analysis.

CONCLUSION

Structural equation models are an interesting and neat way to explore the developmental aspects of addiction, especially when the task is to understand the relative influence of risk factors. In this study, it appears that temperament is the main risk factor underlying alcoholism while both environmental and temperament risk factors interact in drug addiction. For both disorders, novelty-seeking is of crucial importance. Finally, while in theory novelty-seeking is thought to be mainly an innate factor, our data favor a more complex origin, also involving some environmental components.

LIST OF ABBREVIATIONS

AAD, alcohol abuse and/or dependence; DAD, drug abuse and/or dependence; NS, novelty seeking; HA, harm avoidance; RD, reward dependence; CHAR, character.

FUNDING

This study was entirely funded by the French ministry of health and the department of justice. We have no financial disclosures to make. Michael Lukasiewicz benefited from a scholarship from Lilly Neuroscience Institute for this work.

Acknowledgements — We thank Florianne Crine for her editorial assistance.

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