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Reference


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Original Investigation

Smoking and Cloninger’s Temperament and Character Inventory

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Abstract

Introduction: Cloninger’s neuropsychopharmacological theory identifies four temperament traits and three character traits that are largely heritable and are associated with addictions.

Methods: We tested whether these personality traits were associated with smoking behavior and predicted smoking cessation and tobacco withdrawal symptoms. We conducted an Internet cohort study in 2005–2009. The Temperament and Character Inventory (TCI, 226 items, French version) was assessed in 2,993 people (1,593 current, 969 former, and 419 never-smokers). Subsets of participants indicated their smoking status after 30 days (n = 1,452, 48.5%) and answered the TCI again and reported tobacco withdrawal symptoms after 61 days (n = 644, 21.5%).

Results: Compared with never- and former smokers, daily smokers had higher scores of Harm Avoidance (HA) and lower scores of Persistence and Self-Directedness (SD). Daily smokers had higher scores of Novelty Seeking (NS) and lower scores of HA and higher scores of SD. Compared with never-smokers, daily smokers had higher scores of Novelty Seeking than never-smokers. In daily smokers, the level of tobacco dependence was associated with higher scores of HA and lower scores of SD. In the 60 daily smokers who had stopped smoking after 61 days, after adjustment for tobacco dependence level and baseline tobacco withdrawal ratings, SD predicted lower scores of depressed mood and anxiety at 61-day follow-up and HA predicted higher scores of depressed mood at 61-day follow-up. Personality ratings did not predict smoking cessation at follow-up in daily smokers or relapse in former smokers.

Discussion: A consistent association was found between smoking and high HA and low SD. Knowledge about these associations may be useful to clinicians to tailor counseling.

Introduction

Understanding associations between personality traits and smoking behavior may provide a useful approach for tailoring therapy to the needs of individual smokers and preventing smoking initiation in youth. Cloninger’s neuropsychological theory is of particular interest in this regard because it was derived from neurobiological studies of the brain networks regulating the behavior of rodents and from genetic studies in humans (Cloninger, Svrakic, & Przybeck, 1993). This model includes four dimensions of temperament: Novelty Seeking (NS), Harm Avoidance (HA), Reward Dependence (RD), and Persistence (P), which are largely inheritable (Ando et al., 2004; Gillespie, Cloninger, Heath, & Martin, 2003; Heath, Cloninger, & Martin, 1994). The model also describes three dimensions of character: Self-Directedness (SD), Cooperativeness (CO), and Self-Transcendence (ST) that account for aspects of personality that are independent of temperament and are also inheritable (Ando et al.; Gillespie et al., 2003). Contrary to the temperament dimensions, which appear early in life, the character dimensions mature during life and involve learning (Cloninger et al., 1993). These traits are measured with a self-administered questionnaire, the Temperament and Character Inventory (TCI; Cloninger et al.).

Cloninger’s theory was initially developed for the study of alcoholism, but it may also provide a useful framework to study the role of personality in smoking behavior. A specific prediction from Cloninger’s theory is that early onset of substance use is related to high NS and low HA (Heath, Madden, Slutske, & Martin, 1995; Howard, Kivlahan, & Walker, 1997; Wills, Vaccaro, & McNamara, 1994). Confirming this hypothesis, longitudinal data showed that high NS and low HA measured in young boys predicted use of cigarettes, alcohol, and drugs several years later (Masse & Tremblay, 1997). The most consistent association between the TCI and smoking has been found for NS (Downey, Pomerleau, & Pomerleau, 1996; Etter, Pelissolo, Pomerleau, & De Saint-Hilaire, 2003; Gurpegui et al., 2007; Heath et al., 1995; Leventhal et al., 2007; Masse & Tremblay; Pomerleau, Pomerleau, Flessland, & Basson, 1992; Ravaja & Keltikangas-Jarvinen, 2001; Tercyak & Audrain-McGovern, 2003; Van Ammers, Sellman, & Mulder, 1997; Wills et al., 1994; Wills, Windle, & Cleary, 1998), with associations reported for age at initiation, smoking status, dependence level, and in some (Leventhal et al.), but not all studies (Etter, Pelissolo, et al., 2003; Madden et al., 1997) the severity of tobacco withdrawal symptoms. Associations between smoking and HA have been less consistent: high HA ratings have been reported in smokers compared with non-smokers (Etter, Pelissolo, et al.; Pomerleau et al., 1992), and high HA has predicted negative affect following smoking abstinence (Leventhal et al.). However, low HA ratings...
have been found to predict smoking initiation (Heath et al.; Masse & Tremblay) and substance use in adolescents (Wills et al.). Inconsistent, weak, or no associations among smoking, RD, and P have been reported (Etter, Pelissolo, et al.; Heath et al.; Pomerleau et al.; Van Ammers et al., 1997; Wills et al., 1994, 1998).

Most studies of TCI and smoking focused on the four temperament dimensions, and very few assessed associations with the three character dimensions (Gurpegui et al., 2007; Ravaja & Keltikangas-Jarvinen, 2001). Lower ratings of SD in heavy smokers than in non-smokers have been reported (Gurpegui et al.), but no association was reported with CO and ST. Thus, the aim of this study was to examine associations among the TCI, smoking behavior, and tobacco withdrawal symptoms in cross-sectional and longitudinal data.

Methods

Data collection
We posted the questionnaire between April 2005 and July 2009 on the smoking cessation Web site http://stop-tabac.ch/, which receives about 90,000 visitors every month (Etter, 2006; Wang & Etter, 2004). Visitors of this Web site can access a section with questionnaires on various topics (e.g., dependence level, Etter, 2005; withdrawal symptoms, Etter & Hughes, 2006; coping strategies, Etter, Bergman, & Perneger, 2000). The TCI was available in this section, and people answered if they were interested in obtaining a comparison of their personality scores with reference scores. Participants were informed that their answers would be used for statistical analyses on associations between personality and smoking behavior. Participants were given the option of declining to have their answers retained on file. Only people aged 18 or more were eligible. Participants who indicated an E-mail address were asked after 30 days: “Did you smoke any tobacco (even a puff) in the past 7 days?” (Yes/No), and they were asked after 61 days to answer the whole questionnaire again (retest). Non-respondents received up to four reminder E-mails. We recorded participants’ IP addresses to identify duplicate records. The study was carried out in accordance with the Declaration of Helsinki.

Assessment of smoking and withdrawal symptoms
We assessed tobacco smoking (daily, occasionally, former, and never), smoking even a puff of tobacco in the previous 7 days, age at first whole cigarette, and age at initiation of daily smoking. Smokers answered the five-item version of the Cigarette Dependence Scale (CDS-5; Etter, 2005; Etter, Le Houezex, & Perneger, 2003), and ex-smokers indicated the date when they had quit. Participants answered the Minnesota Withdrawal Form (MWF; Hughes, 1992), which covers eight tobacco withdrawal symptoms: craving, depressed mood/sad, irritable/angry, difficulty concentrating, increased appetite/weight gain, insomnia, anxious/nervous, and restless/impatient. These eight symptom scores are averaged to form a total score. Finally, participants indicated their age and sex.

We did not include non-daily smokers in analyses of associations between TCI and smoking, in particular because non-daily smokers are a heterogeneous group that includes stable non-daily smokers, former daily smokers, and initiators.

The Temperament and Character Inventory
We used the French language version of the TCI, a 226-item, self-administered questionnaire with true/false response options that measures four dimensions of temperament (NS, HA, RD, and P) and three dimensions of character (SD, CO, and ST; Cloninger et al., 1993; Pelissolo & Lepine, 1997, 2000).

Temperament scales
NS involves a tendency toward exploratory activity and enthusiasm in response to novelty and is related to brain systems involving behavioral activation (Cloninger et al., 1993; Howard et al., 1997). HA is a tendency to respond intensely to aversive stimuli and is related to brain systems involving behavioral inhibition (Cloninger et al.). RD is a tendency in the maintenance of ongoing behaviors and is manifest as sentimentality, social attachment, and dependence on approval of others (Cloninger et al.; Howard et al.). RD is related to systems activated by onset of reward and offset of punishment. Persistence was a subscale of RD in earlier conceptualizations but emerged subsequently as a distinct dimension.

Character scales
SD is the ability to control and adapt one’s behavior to the situation. It includes responsibility for one’s choices, setting personal goals, confidence, resourcefulness, and self-acceptance. A low SD is a common characteristic of all personality disorders.

CO refers to the acceptance of and identification with others. Low CO is associated with all categories of personality disorders. ST reflects spirituality (Cloninger et al., 1993).

Hypotheses
In accordance with previous reports, we hypothesized that smoking would be positively associated with NS (Downey et al., 1996; Etter, Pelissolo, et al., 2003; Gurpegui et al., 2007; Heath et al., 1995; Leventhal et al., 2007; Masse & Tremblay, 1997; Pomerleau et al., 1992; Ravaja & Keltikangas-Jarvinen, 2001; Tercyak & Audrain-McGovern, 2003; Van Ammers et al., 1997; Wills et al., 1994, 1998). We also anticipated a positive association between HA and smoking based on previous reports (Etter, Pelissolo, et al.; Pomerleau et al.), and on similarities between HA and anxiety, in view of the documented association between anxiety and smoking (Johnson et al., 2000; West & Hajek, 1997). We made no specific hypothesis about the associations between smoking and RD and P, in view of the inconsistent associations reported in previous studies (Etter, Pelissolo et al.; Heath et al.; Pomerleau et al.; Van Ammers et al.; Wills et al., 1994, 1998).

Because refraining from smoking requires some of the characteristics covered by SD (e.g., goal setting, confidence, and resourcefulness), we hypothesized that SD would be negatively associated with smoking status and with cigarette consumption. We made no specific hypothesis about associations with CO and ST.

The variability in the intensity of tobacco withdrawal symptoms across individuals is still largely unexplained (Hughes, 2007a, 2007b). A plausible hypothesis is that personality traits...
could explain some of this variability. Based on previous findings (Leventhal et al., 2007), we hypothesized that NS would be associated with the intensity of tobacco withdrawal symptoms upon cessation, but we did not make any hypothesis about associations between withdrawal symptoms and the other TCI dimensions.

Statistical analyses
We used Cronbach’s alpha coefficients to assess the internal consistency of TCI scales. We used intraclass correlation coefficients to assess test–retest reliability (baseline vs. 61-day follow-up). We used linear regression models to assess associations between TCI and age and sex and in multivariate linear regression models. We used Z-scores (mean = 0, SD = 1) to facilitate comparisons between TCI scores (Table 4).

Because tobacco withdrawal is defined as change in symptom levels between smoking and abstinence (Hughes, 2007b), we analyzed associations between TCI and withdrawal symptoms only in longitudinal data. We tested whether baseline TCI scores predicted change in withdrawal ratings between baseline and 61-day follow-up in the 60 daily smokers who had quit smoking at follow-up ( criterion: no puff of tobacco in the previous 7 days). For this analysis, we used multivariate linear regression models in which TCI ratings (Z-scores) at baseline were the independent variables, MWF withdrawal ratings at follow-up were the dependent variables, and age, sex, and baseline MWF withdrawal ratings were covariates.

Results

Participation
The raw baseline file included 4,862 records. After deleting 890 empty records (no answers) and 979 duplicate records (identified by IP addresses and E-mail addresses), there remained 2,993 valid records (Table 1). There were 1,452 participants in the 30-day survey (48.5% of 2,993) and 644 participants in the 61-day retest survey (21.5% of 2,993). Most participants were women (63.8%), there were few never-smokers (14%), and most former smokers had quit smoking recently (median: 42 days since quit date; Table 1). Compared with those who did not answer the 30-day follow-up survey, participants who took part in this survey had higher baseline scores of NS (.14 SD units, p < .001), RD (.18 SD units, p < .001), P (.20 SD units, p < .001), SD (.09 SD units, p = .02), CO (.23 SD unit, p < .001), and ST (.13 SD unit, p < .001).

Internal consistency and test–retest reliability
Except for P (alpha = .66), Cronbach’s alpha coefficients were above the recommended threshold of .7 for all the general scales (Nunnally & Bernstein, 1994). However, several subscales, in particular NS4, RD1, RD4, CO2, CO3, and CO5, had low alpha coefficients (Table 2). Test–retest correlation coefficients were high for HA (r = .89) and ST (r = .86) and acceptable for the other scales. However, the CO5 subscale (“Pure Hearted”) had a low test–retest correlation (r = .50; Table 2).

Associations with age and sex
Age was inversely associated with NS and positively with P, SD, CO, and ST (Table 2). There was no difference between men and women for NS, but women had higher scores than men for all the other dimensions (Table 2). Thus, all subsequent analyses were adjusted for age and sex.

Associations between the TCI and smoking
Compared with never-smokers and after adjustment for age and sex, daily smokers had higher ratings of NS and HA and lower ratings of SD (Table 3). Daily smokers also had lower Persistence and SD scores than former smokers (Table 3). In ever-smokers, after adjusting for age and sex, we found no association between TCI scores and age at the first whole cigarette and age at initiation of daily smoking (Table 4). In daily smokers, after adjusting for age and sex, cigarette dependence (CDS-5 scale) was positively associated with HA and negatively with SD (Table 4). These associations were maintained after further adjustment for cigarettes/day (HA: beta = .46, p < .001; SD: beta = -.33, p < .001). Recent quitters (who had quit for 0–60 days) had higher NS scores and lower CO scores than former smokers who had quit for ≥6 months (Table 3). In former smokers, the age at smoking cessation was not associated with TCI scores (data not shown).

Prediction of smoking cessation and relapse
Of the 674 daily smokers who took part in the 30-day survey, 98 (14.5%) had stopped smoking at follow-up (criterion: no puff in previous 7 days). Of the 410 former smokers who had not smoked during the 7 days prior to baseline and who answered the 30-day survey, 58 (14.1%) had relapsed at follow-up (criterion: smoked 1+ puff in the 7 days prior to follow-up). None of
the TCI scores predicted smoking cessation in daily smokers or relapse in former smokers (data not shown).

**Associations with withdrawal symptoms**

In longitudinal data, in the 60 baseline daily smokers who had stopped smoking at the 61-day survey (criterion: no puff of tobacco in the previous 7 days), each SD unit in baseline HA was associated with .31 units higher MWF “Depressed” ratings at 61 days ($t = 3.36, p = .002$) after adjustment for age, sex, and baseline MWF Depressed ratings. This association was maintained after further adjustment for CDS-5 dependence ratings: +.33 units in MWF Depressed at follow-up (data not shown). These associations were maintained after further adjustment for baseline CDS-5 dependence ratings: −.41 units in MWF Depressed ($t = 5.11, p < .001$) and −.32 units in MWF Anxious at follow-up ($t = 2.72, p = .009$) per SD unit of baseline SD. Baseline TCI scores did not predict any of the other MWF scores at follow-up (data not shown).

**Discussion**

We found a consistent association between smoking and SD, which was not previously reported in such detail: SD was lower in current smokers than in never-smokers and in former smokers and it was negatively associated with tobacco dependence and with post-cessation depression and anxiety in recent quitters (but not with the other tobacco withdrawal symptoms).
Table 3. Mean TCI scores in daily, never-, and former smokers and in recent quitters

<table>
<thead>
<tr>
<th></th>
<th>Daily smokers</th>
<th>Never-smokers</th>
<th>Former smokers</th>
<th>Recent quitters (quit ≤ 60 days)</th>
<th>Long-term quitters (quit &gt; 182 days)</th>
<th>Daily vs. never</th>
<th>Daily vs. former</th>
<th>Recent vs. long-term</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1,414</td>
<td>419</td>
<td>969</td>
<td>257</td>
<td>222</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Novelty Seeking</td>
<td>21.4</td>
<td>18.8</td>
<td>21.1</td>
<td>22.0</td>
<td>20.1</td>
<td>8.1 (.001)</td>
<td>.1 (.91)</td>
<td>3.1 (.002)</td>
</tr>
<tr>
<td>Harm Avoidance</td>
<td>17.8</td>
<td>16.5</td>
<td>17.8</td>
<td>17.1</td>
<td>16.1</td>
<td>2.6 (.009)</td>
<td>2.0 (.044)</td>
<td>.7 (.50)</td>
</tr>
<tr>
<td>Reward Dependence</td>
<td>15.0</td>
<td>14.6</td>
<td>15.2</td>
<td>15.4</td>
<td>14.9</td>
<td>.6 (.56)</td>
<td>1.1 (.28)</td>
<td>.8 (.41)</td>
</tr>
<tr>
<td>Persistence</td>
<td>4.6</td>
<td>4.6</td>
<td>4.9</td>
<td>4.8</td>
<td>5.1</td>
<td>2.2 (.03)</td>
<td>2.5 (.012)</td>
<td>1.8 (.07)</td>
</tr>
<tr>
<td>Self-Directedness</td>
<td>25.4</td>
<td>27.3</td>
<td>28.6</td>
<td>28.7</td>
<td>30.1</td>
<td>5.7 (.001)</td>
<td>7.5 (.001)</td>
<td>1.1 (.27)</td>
</tr>
<tr>
<td>Cooperativeness</td>
<td>30.8</td>
<td>30.5</td>
<td>31.7</td>
<td>31.0</td>
<td>32.6</td>
<td>1.4 (.17)</td>
<td>1.9 (.06)</td>
<td>2.4 (.017)</td>
</tr>
<tr>
<td>Self-Transcendence</td>
<td>14.7</td>
<td>14.2</td>
<td>14.4</td>
<td>14.0</td>
<td>14.5</td>
<td>.3 (.76)</td>
<td>1.8 (.07)</td>
<td>.8 (.40)</td>
</tr>
</tbody>
</table>

Note. Statistical tests were done with adjustment for age and sex in multivariate linear regression models. CO = Cooperativeness; RD = Reward Dependence; NS = Novelty Seeking; HA = Harm Avoidance; SD = Self-Directedness; ST = Self-Transcendence.

We also found a consistent association between smoking and HA (HA was higher in current smokers than in never-smokers and was positively associated with dependence and with post-cessation Depressed ratings).

There are few previous studies of associations between the TCI and tobacco withdrawal symptoms (Etter, Pelissolo, et al., 2003; Leventhal et al., 2007; Madden et al., 1997). We replicated previous results showing that smokers high in HA reported greater abstinence-induced increases in negative affect (Leventhal et al.), but we did not replicate the result that smokers high in NS had more withdrawal symptoms (Leventhal et al.). In contrast, we found an association not previously reported between SD and post-cessation depression and anxiety in recent quitters. In longitudinal data, the associations between depressed mood and SD and HA remained significant after adjustment for dependence level and therefore did not simply reflect the associations between HA and SD and tobacco dependence.

Harm Avoidance

The positive association between HA and smoking behavior and nicotine dependence is congruent with some (Etter, Pelissolo et al., 2003; Pomerleau et al., 1992) but not all previous reports (Downey et al., 1996; Heath et al., 1995; Howard et al., 1997; Masse & Tremblay, 1997; Wills et al., 1994). HA theoretically derives from the behavioral inhibition system. Thus, individuals low on HA, having lower sensitivity to cues of threat, should be more likely to engage in dangerous activities, including substance use. However, HA also reflects worry, fear of uncertainty, and shyness, concepts that have similarities with anxiety, and the association between smoking and anxiety is well documented (Johnson et al., 2000; West & Hajek, 1997). High HA could predict smoking in people who seek the anxiolytic or antidepressant effects of smoking (Kassel & Schiffman, 1997), or alternatively, smoking could be a risk factor for anxiety (Johnson et al.).

Novelty Seeking

Our results confirm previous reports showing that NS is higher in current smokers than in never- and former smokers (Downey et al., 1996; Etter, Pelissolo, et al.; Gurpegui et al., 2007; Heath et al., 1995; Leventhal et al., 2007; Masse & Tremblay, 1997; Pomerleau et al., 1992; Ravaja & Keltikangas-Jarvinen, 2001; Tercyak & Audrain-McGovern, 2003; Van Ammers et al., 1997; Wills et al., 1994, 1998). However, contrary to previous reports,

Table 4. Associations between TCI scores and smoking in ever-smokers and daily smokers

<table>
<thead>
<tr>
<th></th>
<th>Ever-smokers</th>
<th>Daily smokers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age at first whole cigarette</td>
<td>Cigarettes/day</td>
</tr>
<tr>
<td>N</td>
<td>2,562</td>
<td>1,414</td>
</tr>
<tr>
<td>Novelty Seeking</td>
<td>−.08 ns</td>
<td>.24 ns</td>
</tr>
<tr>
<td>Harm Avoidance</td>
<td>−.02 ns</td>
<td>.70**</td>
</tr>
<tr>
<td>Reward Dependence</td>
<td>.05 ns</td>
<td>−.96 ***</td>
</tr>
<tr>
<td>Persistence (RD2)</td>
<td>−.02 ns</td>
<td>−.27 ns</td>
</tr>
<tr>
<td>Self-Directedness</td>
<td>.08 ns</td>
<td>−1.03***</td>
</tr>
<tr>
<td>Cooperativeness</td>
<td>.07 ns</td>
<td>−1.08***</td>
</tr>
<tr>
<td>Self-Transcendence</td>
<td>.03 ns</td>
<td>−.07 ns</td>
</tr>
</tbody>
</table>

Note. Coefficients from multivariate linear regression models indicate change in dependent variables for an increase of one SD in TCI scores after adjustment for age and sex. For instance, each additional SD unit of HA was associated with smoking .70 more cigarettes/day. RD = Reward Dependence; NS = Novelty Seeking; HA = Harm Avoidance; SD = Self-Directedness; ST = Self-Transcendence.

Statistical significance: *p ≤ .05; **p ≤ .01; ***p ≤ .001; ns = not significant.
we found no association between NS and age at smoking initiation (Heath et al.; Masse & Tremblay). It is possible that retrospective reports of age at initiation were imprecise, which blurred any association. Overall, the association between NS and smoking seems to be sound, as it was established in various studies and population groups. Novelty Seekers may find smoking more rewarding, and they may be more responsive to effects of nicotine such as improved mood and arousal. Alternatively, Novelty Seekers may be more likely than people lower in stimulus-seeking behavior to encounter tobacco in their environment, or NS may create a tendency to gravitate into groups of substance users (Wills et al., 1994).

Reward Dependence
We replicated the finding of a negative association between RD and cigarette consumption (Heath et al., 1995) but found no association between RD and cigarette dependence. Otherwise, this study confirms previous reports of an absence of association between RD and smoking (Downey et al., 1996; Heath et al.; Howard et al., 1997; Leventhal et al., 2007; Masse & Tremblay, 1997; Pomerleau et al., 1992; Wills et al., 1994).

Persistence
Contrary to previous findings (Etter, Pelissolo, et al., 2003; Pomerleau et al., 1992), we observed lower Persistence scores in daily smokers than in former smokers, but as in previous reports, we found no association between Persistence and the other variables under scrutiny (Downey et al., 1996; Heath et al., 1995; Howard et al., 1997). Thus, the association between smoking and Persistence is inconsistent across studies, and little can be concluded about it.

Self-Directedness
We found a consistent association between SD and smoking: SD was substantially lower in daily smokers than in never- and former smokers, confirming a previous report (Gurpegui et al.). However, our analysis was more comprehensive than previous ones, as it also showed that in daily smokers, SD was associated with a lower dependence level and lower cigarette consumption and that in recent quitters, SD was inversely associated with post-cessation anxiety and depression, although not with any other tobacco withdrawal symptom. An association between SD and smoking is perhaps not surprising, as refraining from smoking involves some of the characteristics included in SD, such as goal setting, taking responsibility for one’s choices, an ability to control one’s behavior, resourcefulness, and confidence. It is also possible that people with high SD scores, having more resourcefulness and self-acceptance, are better equipped to face mood changes following smoking cessation, which may explain the negative association between SD and post-abstinence anxiety and depression. Our finding of a consistent association between SD and smoking may be useful to clinicians, as individuals with low SD may need specific support to quit smoking and to manage withdrawal symptoms.

Cooperativeness and Self-Transcendence
CO was somewhat higher in former smokers than in recent quitters, which may reflect the usefulness of social support for the success of quit attempts. As expected, ST was not associated with smoking.

Comparison with studies using Eysenck’s model and the Five-Factor model
A meta-analysis of associations between smoking and Eysenck’s personality model concluded that smoking was associated with Extraversion and Neuroticism (Munafo, Zetteler, & Clark, 2007). However, the models of Eysenck and Cloninger do not assess the same aspects of personality (Heath et al., 1994; Jensen, Lillebaek, Mortensen, & Jensen, 1999), and it is therefore difficult to compare our results with the results of this meta-analysis. A meta-analysis of associations between smoking and the Five-Factor model of personality concluded that compared with non-smokers, smokers have lower Conscientiousness, low Agreeableness, and high Neuroticism (Malouff, Thorsteinssson, & Schutte, 2006). There is overlap between Cloninger’s model and the Five-Factor model (De Fruyt, Van De Wiele, & Van Heeringen, 2000). In particular, HA is positively correlated with Neuroticism and negatively with Conscientiousness, and SD is negatively correlated with Neuroticism and positively with Conscientiousness (De Fruyt et al.). These correlations suggest that our results may be congruent with previously reported associations between the Five-Factor model and smoking (Malouff et al., 2006).

Data reliability
For the main dimensions, Cronbach’s alpha coefficients were comparable to U.S. data (alpha = .76–.87) and French data (alpha = .49–.87), and test–retest coefficients were comparable to French data (r = .69–.90; Cloninger et al., 1993; Pelissolo & Lepine, 2000). This suggests that the Internet and traditional data collection methods produce data of comparable quality. However, alpha coefficients were low for several subscales, in particular NS4, RD1, RD4, CO2, CO3, and CO5. In addition, CO5 (Pure Hearted) also had a low test–retest reliability, which sheds some doubts about the validity of this subscale, at least in a French-speaking population.

Strengths and limitations
This was one of the largest samples in which associations between the TCI and smoking were ever studied, one of few longitudinal studies on this topic, and one of very few that assessed associations with the character dimensions of TCI. On the other hand, this study was conducted in a self-selected sample of visitors of a smoking cessation Web site. Compared with population-based samples, this sample included fewer never-smokers and higher proportions of recent quitters and of smokers motivated to quit (Etter & Perneger, 2001). Furthermore, scores of NS were higher and scores of SD were lower in this sample than in normative data (Pelissolo & Lepine, 2000), probably because participants were relatively young and consisted largely of smokers (as the two latter variables are associated with NS and SD). The response rate at 30-day follow-up (48.5%) was relatively low but higher than the average response rate of 39.6% observed in a meta-analysis of Internet surveys (Cook, Heath, & Thompson, 2000). However, the response rate at 61-day retest (21.5%) was lower than that threshold. The relatively low participation rates at follow-up and the fact that participants who took part in the follow-up surveys had higher TCI scores at baseline may limit the generalizability of our longitudinal analyses (since these analyses were conducted in selected samples),...
but this problem does not affect the internal validity of these analyses. Finally, TCI ratings did not predict smoking cessation or relapse longitudinally. Our longitudinal sample was probably too small (98 quitters and 58 relapsers) to detect small effects. Alternatively, quitting and relapsing may depend upon many other determinants that were not measured in this study.

Conclusions
An original contribution of this study is its finding of a consistent association between SD and smoking observed in several analyses across various subgroups of participants. This finding may be useful to clinicians to design improved interventions for people with low SD. Furthermore, our results confirmed previously reported associations between NS and smoking and provide new information on associations with HA. Knowledge of associations between these scores and smoking could be helpful for the development of new treatments of tobacco dependence and for the individual tailoring of therapy.

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Declaration of Interests
None declared.

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Vincent Bauyard, from the Health on the Net Foundation (www.hon.ch), developed the software for data collection. The author takes responsibility for the integrity of the data and the accuracy of the data analysis, and he had full access to all the data in the study.

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