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Associations between Cloninger's Temperament Dimensions and Acute Tobacco Withdrawal

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Abstract

This study examined associations between three temperament dimensions measured by the Temperament and Character Inventory-125 (Cloninger, 1992) and tobacco abstinence effects. Smokers ($N = 203$, ≥ 15 cig/day) attended two laboratory sessions, one following 12hr of abstinence and the other following ad libitum smoking (order counterbalanced). Participants completed measures of withdrawal symptoms, cigarette urges, and affect. Smokers high in Novelty Seeking reported greater abstinence-induced increases in several nicotine withdrawal symptoms, negative affect, and cigarette craving. Smokers high in Harm Avoidance reported greater abstinence-induced increases in negative affect and urges to smoke to relieve distress. Reward Dependence was not associated with abstinence effects. Novelty Seeking and Harm Avoidance showed independent predictive associations with negative affect and urges, and their associations with abstinence effects persisted when controlling for FTND scores. Smokers with different temperaments display different patterns of acute tobacco withdrawal, and may benefit from treatments matched to their particular abstinence profile.

Keywords

Temperament; Temperament and Character Inventory; Nicotine Withdrawal; Novelty Seeking; Harm Avoidance; Reward Dependence

1. Introduction

The intensity, duration, and pattern of nicotine abstinence effects can vary widely across individuals (Gilbert, 1995). Indeed, studies have identified several predictors of the severity and quality of abstinence effects (Pomerleau, 1997), including psychiatric conditions (Pomerleau, Marks, & Pomerleau, 2000), alcohol problems (Marks, Hill, Pomerleau, Mudd, & Blow, 1997), and gender (Leventhal et al., 2007). It is important to identify predictors of

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abstinence effects because interventions could be selected based upon a patient's characteristics. For example, Pomerleau et al. (2000) demonstrated that depressed smokers are at increased risk of experiencing depressed mood during nicotine abstinence and may therefore require mood management interventions to buffer these effects prior to a quit attempt (Hall, Muñoz, Reus, & Sees, 1996).

Personality is also a significant clinical characteristic that influences smoking patterns and may impact expressions of nicotine withdrawal (Gilbert & Gilbert, 1995). Several different theories and measures of personality have been used in the smoking literature, including Eysenck's personality scales (Eysenck & Eaves, 1980), Zuckerman's Sensation Seeking Scale (Zuckerman, Ball, & Black, 1990), Barratt's Impulsivity Scale (Doran et al., 2006), and Costa and McCrae's NEO-five factor inventory (Gilbert & Gilbert, 1995). These measures are designed to identify psychometrically-supported affective and behavioral patterns in humans. In contrast, Cloninger's psychobiological model of personality (Cloninger, Svrakic, & Przybeck, 1993) is unique because it is based on a synthesis of information from twin and family studies, investigations of longitudinal development, neuropharmacologic and neurobehavioral studies of learning in humans and other animals, and psychometric analyses of personality in individual and twin pairs (Cloninger, 1987). This model identifies personality dimensions that may be manifestations of genetically transmitted neuropharmacological processes (Ando et al., 2002; Ebstein, Novick, & Umansky, 1996; Ebstein et al., 1997). These personality dimensions can be assessed by the Temperament and Character Inventory (TCI; Cloninger, Przybeck, & Svrakic, 1994). The factorial structures of temperament dimensions of the TCI have been supported in several studies (Cloninger et al., 1993; Pèlissolo & Lèpine, 2000). The heritability of the TCI's temperament dimensions has been supported by a large twin study that reported heritability rates between 50% and 65% (Heath, Madden, Slutske, & Martin, 1995). Nevertheless, there remains some debate about the pharmacogenetic and psychometric specificity of these dimensions (Herbst, Zonderman, McCrae, & Costa, 2000).

The TCI has three major temperament dimensions: Novelty Seeking (NS), Harm Avoidance (HA), and Reward Dependence (RD). NS tends to be associated with low basal dopaminergic activity and is related to neural systems involved in behavioral activation and appetitive responses. NS is characterized by a tendency toward exploratory behavior in search of novel and rewarding stimuli, active avoidance and escape of aversive stimuli, impulsive responding, and extravagance in approach to cues of reward (Cloninger et al., 1993; Hansenne et al., 2002). High-NS individuals are characterized as quick tempered, curious, easily bored, impulsive, extravagant, and disorderly. HA tends to be associated with high serotonergic activity and is related to neural systems involved in behavioral inhibition and aversive responses (Cloninger et al., 1993; Peirson et al., 2000). HA involves a tendency to over-respond to aversive stimuli and signals of frustrative non-reward, worry about future problems, fear uncertainty, act shy around strangers, and fatigue rapidly. High-HA individuals are characterized as fearful, socially inhibited, shy, passive, easily tired, and pessimistic in circumstances that do not typically worry other individuals. RD tends to be associated with low noradrenergic activity and is related to neural systems involved in behavioral reinforcement (Cloninger et al., 1993; Garvey, Noyes, Cook, & Blum, 1996). RD is characterized by the tendency toward maintenance of ongoing behavior, sentimentality, social sensitivity, attachment, and dependence on approval by others. High-RD individuals are characterized as tender-hearted, sensitive, socially dependent, and sociable.

Cloninger's theory is especially relevant to smoking for several reasons. First, the behaviors assessed in TCI dimensions (e.g., impulsivity, intolerance of uncertainty) are conceptually relevant to the initiation and maintenance of nicotine dependence. For example, impulsive individuals high in NS may become more frustrated when restricted from nicotine reward and therefore may experience greater negative affect during tobacco abstinence. Second, the TCI

measures heritable traits that may mediate relations between genotypes and smoking behavior (Elovainio, Kivimäki, Viikari, Ekelund, & Keltikangas-Järvinen, 2005). For example, Elovainio et al. (2005) demonstrated that the effect of dopamine D4 receptor genotype on smoking behavior was mediated by NS. Third, systems involved in processing and responding to appetitive, aversive, and novel stimuli that are related to TCI temperament dimensions may also underlie smoking behavior (Chaudhri et al., 2006). Specifically, responding to aversive stimuli, such as the physical sensations of nicotine withdrawal, may be exaggerated in individuals with particular TCI profiles. Fourth, the pharmacological correlates of TCI dimensions may be related to the pathophysiology of nicotine addiction (Kenny & Markou, 2001). Indeed, dopaminergic and serotonergic systems, which are related to NS and HA, have been implicated in nicotine withdrawal (Kenny & Markou, 2001).

There has been a considerable degree of research on the association between TCI dimensions and smoking. Many studies have reported that NS is associated with various components of smoking behavior, including tobacco use initiation, smoking status, and nicotine dependence severity (Downey, Pomerleau, & Pomerleau, 1996; Elovainio et al., 2005; Etter, Pélissolo, Pomerleau, & de Saint-Hilaire, 2003; Heath et al., 1995; Laucht, Becker, El-Faddagh, Hohm, & Schmidt, 2005; Mâsse & Tremblay, 1997; Pomerleau, Pomerleau, Flessland, & Basson, 1992; Ravaja & Keltikangas-Järvinen, 2001; Van Ammers, Sellman, & Mulder, 1997). HA and RD have been reported to be modestly associated with smoking initiation and nicotine dependence severity in some studies (Etter et al., 2003; Heath et al., 1995; Pomerleau et al., 1992; Wills & Cleary, 1999; Wills, Vaccaro, & McNamara, 1994). However, in other studies, RD has been reported to be negatively associated with tobacco dependence (e.g., Etter et al., 2003). Given that there is a link between temperament scores on the TCI and various smoking characteristics, it is possible that smokers with different temperaments may display different patterns of acute tobacco withdrawal.

The current study examined associations between TCI dimensions and tobacco abstinence effects in a sample of smokers who participated in a laboratory study examining individual differences in acute tobacco withdrawal (Leventhal et al., 2007). Given that previous findings have linked NS to tobacco use (e.g., Etter et al., 2003), we hypothesized that NS would generally exhibit the strongest associations with abstinence effects. In light of research showing that NS is associated with positive reinforcement smoking (Pomerleau, Fagerström, Marks, Tate, & Pomerleau, 2003), we further hypothesized that NS would be associated with abstinence-induced reductions in positive affect and abstinence-induced increases in desire to smoke for pleasure. Given that previous findings have linked HA with negative reinforcement smoking (Pomerleau, Fagerström et al., 2003), we hypothesized that HA would be associated with abstinence-induced increases in negative affect and desire to smoke to relieve withdrawal distress. Finally, given the inconsistency of research findings on the association between RD and smoking, we had no specific hypotheses about the associations between RD and abstinence effects.

2. Methods

2.1 Participants

Participants were 203 smokers recruited from the Baltimore metropolitan area via newspaper and radio advertisements in between 2001 and 2004. The sample was recruited to be balanced on gender (49.8% men, 50.2% women) and race (51.7% black, 48.3% white) and had an average age of 36.7 ($SD = 10.1$). On average, participants smoked 22.2 cigarettes/day ($SD = 6.61$), scored 6.47 ($SD = 1.70$) on the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991), and had smoked for 19.7 years ($SD = 10.3$). Participants had to meet the following inclusion criteria: (a) age of 18 years or older; (b) report being a current smoker of at least 15 cigarettes per day; (c) report having smoked for at

least 2 years; (d) smoke a brand of cigarettes that delivers at least 11.0 mg tar and 0.7 mg nicotine as rated by the Federal Trade Commission method; and (e) have a score on the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) of three or more. Participants were excluded based on the following: (a) if they reported a recent history of certain diseases, including myocardial infarction, heart failure, angina, stroke, diabetes, and hypertension; (b) if they were treated with nicotine replacement products in the past six months, or with antidepressants in the past year; (c) if they reported using any smoking cessation treatments in past 6 months; or (d) if their estimated IQ on the Shipley Institute on Living Scale was less than 78 (Shipley, 1940). Females who were pregnant or nursing were also excluded. The study was approved by the Institutional Review Board of the National Institute on Drug Abuse—Intramural Research Program (NIDA-IRP).

2.2 Procedure

A preliminary telephone screening that surveyed tobacco use and health characteristics was conducted. Eligible participants were invited to attend a screening session conducted at NIDA-IRP [details on the screening procedure can be found in Leventhal et al. (2007)]. Eligible participants attended a 90-minute orientation session and then attended two counterbalanced experimental sessions (one while abstinent and one while non-abstinent), lasting 60-minutes each. The three sessions occurred on different days. Participants were instructed to smoke normally before the orientation session. During the orientation session, participants completed a demographics questionnaire, the TCI, and several questionnaires assessing tobacco use and dependence, including the FTND. Experimental sessions were scheduled to occur in the afternoons. In each session, participants completed questionnaire measures, cognitive performance measures (not reported here), and physiological measures (not reported here). In the current study, we report data from questionnaire measures which we hypothesized were associated with temperament (associations between TCI scores and physiological/cognitive performance measures are available upon request). Questionnaires were administered before the cognitive performance tests during both experimental sessions. A full description of the cognitive and physiological assessments is reported in Leventhal et al. (2007).

For the non-abstinent session, participants were asked to smoke a cigarette within 20 minutes of the beginning of the session. For the abstinent session, participants were asked to refrain from smoking for at least 12 hours before the session. The order of completion of the abstinent and non-abstinent sessions was counterbalanced. At the abstinent session, participants were considered non-abstinent if they reported having smoked on that day or had high breath carbon monoxide (CO) levels (> 11 ppm). Under these conditions, the abstinent session was re-scheduled. At the non-abstinent session, participants with low CO levels (< 10 ppm) were excluded from analyses ($n = 6$), as there was considerable doubt as to whether: (1) they were 15+ cigarettes/day smokers, or (2) they had complied with the instructions to smoke normally before the non-abstinent session. The final sample ($n = 203$) had mean CO levels of 30.0 ppm at the non-abstinent session ($SD = 12.1$) and mean CO levels of 6.9 ppm at the abstinent session ($SD = 2.5$).

2.3 Measures

2.3.1 TCI—The standard TCI measures four dimensions of temperament (novelty seeking, harm avoidance, reward dependence, persistence) and three dimensions of character (self-directedness, cooperativeness, self-transcendence) and has 226 items (Cloninger et al., 1993). To reduce response burden we used a subset of items from the TCI-125 (Cloninger, 1992), which is an abbreviated version that employs a true-false format with 125 items. Because we were interested in three out of the four temperament dimensions and none of the character dimensions, we administered only 55 items from the TCI-125 (i.e., items that comprised the NS, HA, and RD scales).¹ The TCI-125 has been used in numerous previous studies (Akiskal

et al., 2005; Picardi, Toni, & Caroppo, 2005; Smith, Duffy, Stewart, Muir, & Blackwood, 2005). This scale correlates with other related measures of temperament (Akiskal et al., 2005), has acceptable internal consistencies (Chakroun-Vinciguerra, Faytout, Pèlissolo, & Swendsen, 2005), has the same factor structure as the standard TCI (Chakroun-Vinciguerra et al., 2005), and demonstrates associations with demographic characteristics that are similar to the original questionnaire (Chakroun-Vinciguerra et al., 2005). In the current study, each scale demonstrated adequate internal consistency (Cronbach α): NS = .67, HA = .82, RD = .72. Consistent with previous studies (e.g., Cloninger et al., 1993), there were small, non-significant, correlations between NS, HA, and RD scores (r s = -.09 to .02). Each of these dimensions has three or four 5-item subscales that assess specific subconstructs within a broader dimension (see names of the subscales in Table 1). See the TCI-125 publication manual (Cloninger, 1992) for further detail on the subdimensions.

2.3.2 Questionnaires assessing tobacco abstinence effects—During the two experimental sessions, participants completed the following questionnaires: *Hughes Hatsukami Withdrawal Questionnaire* (HHWQ; Hughes & Hatsukami, 1986), a widely-used measure that assesses 11 symptoms and signs of tobacco withdrawal; *Wisconsin Smoking Withdrawal Scale* (WSWS; Welsch et al., 1999), which contains 23 items that load onto an overall severity scale and six subscales of tobacco withdrawal (anxiety, anger, hunger, concentration problems, craving, sadness) and²; *Brief Questionnaire of Smoking Urges* (QSU; Cox, Tiffany, & Christen, 2001), which assesses desire for the positive reinforcing effects of smoking (Factor 1; 5 items), and desire for relief of negative affect and an urgent need to smoke (Factor 2; 5 items); and *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988), which assesses Positive Affect (PA; 10 items, e.g., enthusiastic, strong) and Negative Affect (NA; 10 items, e.g., distressed, upset). These scales have been shown to represent orthogonal dimensions of affect (Watson et al., 1988) and be sensitive to the effects of nicotine abstinence in the current sample (Leventhal et al., 2007). With the exception of the QSU (which can only be used to assess craving “right now”), participants were required to report on experiences “so far today” in order to capture the totality of experience during the course of the abstinent and non-abstinent day.³

2.4 Statistical Analyses

Our primary aim was to examine associations between TCI dimensions and abstinence effects. This was accomplished through multiple regression models in which abstinence effects, expressed as difference scores (i.e., score while abstinent - score while non-abstinent), served as the dependent variable, and TCI dimensions served as the independent variable. Because we had specific hypotheses about how each TCI dimension would be associated with abstinence effects (e.g., associations between NS and PANAS-positive affect/QSU-Factor 1), we conducted separate analyses using each abstinence effect as a dependent variable, rather than using a multivariate approach that tested the entire set of dependent variables in a single model. For each abstinence effect, we conducted separate multiple regression models for each TCI dimension and each TCI subdimension. Given that previous studies have reported that TCI dimensions are associated with age, gender, and ethnicity (Etter et al., 2003; Heath et al., 1995), which have been shown to be associated with nicotine dependence (Hughes, Helzer, &

¹The TCI's fourth dimension (Persistence), which was not assessed in this study, was originally a subscale of RD but was subsequently identified as a dimension in its own right (Cloninger et al., 1993). Prior studies have reported that Persistence is not associated with smoking characteristics in daily smokers (Etter et al., 2003). We therefore focused on NS, HA, and RD.

²We excluded WSWS items that assess sleep disturbance because participants would not have been abstinent for a long period before going to sleep.

³The HHWQ, PANAS, QSU also were administered a second time (T2) after participants completed the cognitive performance tasks. Results from the T2 QSU were very similar to those reported here; those from the T2 HHWQ and PANAS were generally directionally consistent, though weaker in magnitude in some instances.

Lindberg, 2006), we also conducted additional multiple linear regression models in which we adjusted for age, gender, and ethnicity. For comparison purposes, we computed associations between FTND scores and abstinence effects, using multiple regression models (controlling for age, gender, and ethnicity). In follow-up analyses, we evaluated the independent effects of TCI dimensions by simultaneously including all TCI dimensions (NS, HA, RD) as predictors in individual regression models for each abstinence effect. We also examined the incremental predictive utility of each TCI dimension when adjusting for FTND scores and demographics. For dependent variables in which the previous incremental analyses demonstrated significant effects for at least two TCI dimensions, we examined the incremental predictive utility of the set of three TCI dimensions over and above demographic characteristics and FTND scores using hierarchical regression. In these analyses demographics were entered on step 1, FTND was entered on step 2, and the TCI dimensions were entered on step 3 with R^2 statistics reported at step 1 and $R^2 \Delta$ statistics reported at steps 2 and 3. Analyses were performed using SAS (SAS Institute Inc., 2003). For all comparisons, statistical significance was set at $p < .05$, and all tests were 2-tailed.

3. Results

3.1 Associations between TCI Dimensions and Demographic and Baseline Smoking Characteristics

Black and older participants had higher NS scores ($r_s \geq .19, p < .01$). Women had higher HA scores and RD1-Sentimentality scores ($r_s \geq .17, p < .05$). These findings are consistent with the previous literature (e.g., Etter et al., 2003). After controlling for age, gender, and ethnicity, FTND and cigarettes smoked per day were generally not associated with TCI dimensions or subscales, with the exception of a positive association between FTND and NS4-Disorderliness ($\beta = .17, p < .05$), and a negative association between FTND and RD4-Dependence ($\beta = -.22, p < .01$).

3.2 Associations between TCI Dimensions and Abstinence Effects

As shown in Table 1, NS and its subscales—NS2-Impulsivity and NS3-Extravagance—were significantly associated with abstinence-induced increases on the HHWQ, the WSWs, several of the WSWs subscales, PANAS-NA, and QSU-Factor 2 (with and without adjusting for demographic characteristics). HA, and some of its subscales, were significantly associated with abstinence-induced increases on PANAS-NA and QSU-Factor 2. RD and its subscales were not significantly associated with abstinence effects for any measure. The significant associations between TCI dimensions and abstinence effects were comparable in size to (and in some cases larger than) the significant associations between FTND scores and abstinence effects (see Table 1).

3.3 Independent Predictive Effects of Each TCI Dimension on Abstinence Effects

NS predicted abstinence-induced increases in HHWQ total, WSWs total, WSWs-anger, WSWs-anxiety, WSWs-craving, PANAS-NA, and QSU-Factor 2 ($\beta_s \geq .14, p_s \leq .05$) over and above the effects of HA, RD, age, sex, and ethnicity. HA predicted abstinence-induced increases in PANAS-NA, and QSU-Factor 2 ($\beta_s \geq .16, p_s \leq .05$), over and above the effects of HS, RD, age, sex, and ethnicity.⁴ RD showed no independent associations with abstinence effects.

⁴Because there was evidence that HA and NS showed independent effects on PANAS-NA and QSU-Factor 2 scales, we examined the exploratory hypothesis that HA and NS may interact to predict those two abstinence effects. Results from those exploratory analyses showed no significant interactions ($p_s > .30$).

Given that both NS and HA showed independent effects on PANAS-NA and QSU-Factor 2, we ran two additional multiple regression models in which NS and HA were simultaneous predictors in order to examine the total variance accounted for by these dimensions together. The model predicting abstinence-induced changes in PANAS-NA was significant, $F(2, 199) = 8.41, p = .0003$, and showed that NS and HA together accounted for 8% of the variance. The model predicting abstinence-induced changes in QSU-Factor 2 accounted for 7% of the variance, $F(2, 199) = 7.19, p = .001$.

3.4 Incremental Predictive Effects of TCI Dimensions on Abstinence Effects

Figure 1 illustrates the results of multiple regressions in which abstinence effects were regressed on TCI dimensions (tested individually), while controlling for FTND scores, age, sex, and ethnicity. In most cases, the effects of HA and NS persisted when controlling for FTND and demographic characteristics.

In the previous incremental analyses, PANAS-NA and QSU-Factor 2 were significantly predicted by at least two TCI dimensions and were therefore used for hierarchical regression modeling. In step 1 of the hierarchical regression of PANAS-NA, the model containing only age, gender, and ethnicity was significant, $F(3, 199) = 5.97, p = .0006, R^2 = .08$. In step 2, the addition of FTND did not lead to a significant increase in proportion of variance, $F(1, 198) = 1.21, p = .27, R^2 \Delta = .01$. In step 3, the addition of NS, HA, and RD led to a significant increase in proportion of variance, $F(3, 196) = 4.37, p = .005, R^2 \Delta = .05$. In the hierarchical regression of QSU-Factor 2, step 1 showed a significant effect of the demographic variables, $F(3, 198) = 6.10, p = .0005, R^2 = .08$. Step 2 showed a significant effect for the addition of FTND, $F(1, 197) = 3.79, p = .05, R^2 \Delta = .02$. Step 3 showed a significant effect for the addition of the three TCI scales, $F(3, 195) = 3.02, p = .03, R^2 \Delta = .02$.

4. Discussion

The current study examined associations between temperament dimensions assessed by Cloninger's TCI and tobacco abstinence effects. The main finding was that, of the three TCI temperaments, NS demonstrated modest associations with tobacco abstinence effects across a number of domains. This was true even after adjusting for demographic characteristics and nicotine dependence severity (Figure 1).

Smokers high in NS (and its subscales) reported significantly greater abstinence-induced increases in various withdrawal symptoms (anxiety, anger, concentration difficulties), negative affect, and craving. These findings are in concordance with our hypotheses and results from a previous study showing that smokers with attention deficit hyperactivity disorder (which is generally associated with impulsivity and other aspects of NS; Downey et al., 1996) are more likely to report irritability, anxiety, difficulty concentrating, and restlessness during tobacco withdrawal (Pomerleau, Downey et al., 2003). Because NS has been previously linked with positive reinforcement smoking (Pomerleau, Fagerström et al., 2003), we hypothesized that NS would be associated with abstinence-induced reductions in positive affect and abstinence-induced increases in desire to smoke for pleasure. However, abstinence effects in high-NS smokers were not significantly exaggerated in these domains. It is possible that psychological characteristics that are more representative of the hedonic capacity construct, such as anhedonia, may be more closely associated with abstinence-induced changes in positive affect and desire to smoke for pleasure (Cook, Spring, McChargue, & Hedeker, 2004).

Associations with abstinence effects differed somewhat across NS subscales (Table 1). NS2-Impulsiveness and NS3-Extravagance subscales were most strongly associated with abstinence effects and may have been driving the effects shown by the NS total scale. Interestingly, a previous study reported that, of all the TCI subscales, NS-3 demonstrated the most robust

associations with tobacco dependence (Etter et al., 2003). Accordingly, the NS2 and NS3 subscales may be useful for identifying smokers who would likely experience excessive unpleasant withdrawal symptoms when trying to abstain.

HA was not associated with abstinence-induced increases in withdrawal assessed by the HHWQ and the WSWS. However, HA was modestly associated with abstinence-induced increases in generalized negative affect (assessed by the PANAS) and desire to smoke to relieve distress, even after adjusting for demographics and nicotine dependence severity (Figure 1). The current results parallel data demonstrating that smokers with depression and anxiety, which are generally associated with high HA (Peirson & Heuchert, 2001; Pomerleau et al., 1992), experience greater abstinence-induced increases in depressed mood, irritability, anxiety, and restlessness (Pomerleau et al., 2000). Furthermore, these findings also correspond with previous reports that smokers with high HA scores are more likely to smoke for negative reinforcement purposes (Pomerleau, Fagerström et al., 2003). At the subscale level, HA1-Anticipatory Worry and HA4-Fatigability and Asthenia exhibited the pattern demonstrated by the HA scale (i.e., associations with abstinence-induced increases in PANAS-NA and QSU-Factor 2), which suggests that these two subscales might have accounted for associations produced by the HA total scale.

In contrast with HA and NS, RD was not associated with abstinence effects. This is not surprising given that evidence regarding the relation between RD and smoking behavior is mixed (Etter et al., 2003; Heath et al., 1995; Pomerleau et al., 1992; Van Ammers et al., 1997; Wills & Cleary, 1999; Wills et al., 1994), with some studies actually showing a negative association between RD and nicotine dependence (e.g., Etter et al., 2003).

There are several possible explanations of the pattern of associations between the temperament dimensions and abstinence effects. One account of the current findings is that they are reflective of response biases, such that smokers high in NS or HA are more likely to report distress irrespective of actual withdrawal effects. However, the use of a non-abstinent session and abstinence-induced change scores counteracts the influence of any baseline reporting biases. In addition, if response biases systematically impacted abstinence-associated changes, temperament-withdrawal associations would be expected on all measures of distress. Results showed that this was not the case, as associations between NS and HA and abstinence effects were stronger for particular subscales (e.g., QSU-factor 2; PANAS-negative affect) and weaker for others (e.g., WSWS-Hunger, PANAS-Positive Affect). Thus, it is likely that the effects are real and are driven by altered biopsychological processes that influence withdrawal responses in high-NS and high-HA smokers rather than response biases.

There are several potential mechanisms that could explain the pattern of findings. One is that high NS and HA smokers may be vulnerable to particular nicotine-induced neuroadaptations and may therefore experience greater psychological changes during abstinence (withdrawal effect). Alternatively, high NS and HA smokers may have pre-existing psychological symptoms that are masked while smoking but become manifest again during abstinence (offset effect) (Pomerleau, 1997). Finally, smokers with particular temperaments may exhibit exaggerated responses to stressful circumstances or situations involving the restriction of reward (Ravaja, Keltikangas-Järvinen, & Kettunen, 2006), which could lead to greater distress and frustration during abstinence. Given that effects were most pronounced for measures related to distress and desire to smoke to relieve distress, this explanation may be the most plausible account of the present findings.

The present findings should be considered in the context of the study's limitations. First, the investigation used an abridged version of the TCI. Although previous studies have shown that this format is psychometrically comparable to the standard version (Chakroun-Vinciguerra et

al., 2005; Cloninger, 1992), different results might be found using the original TCI questionnaire. Second, the associations between TCI dimensions and abstinence effects were of modest magnitude, though comparable to those observed between the FTND and abstinence effects and generally consistent across multiple measures. Given that associations were of small (but significant) effect size, subjective effects of overnight abstinence may only partially be determined by temperament. Other factors such as gender, ethnicity, age, level of dependence, experience with prior periods of abstinence, and expectations of nicotine withdrawal are important factors that may also play a role in the overall tobacco abstinence response. Third, we do not know whether the associations between TCI dimensions and abstinence effects reflect withdrawal effects, offset effects, effects of frustrative non-reward, or effects of general stressful circumstances. It is therefore only possible to speculate on the mechanisms that underlie the associations between TCI dimensions and abstinence effects. Longitudinal studies, or experimental studies of responses to non-drug related stressors, would shed further light on these mechanisms. Fourth, we only used a single measure of personality. Given that other studies have shown associations between personality traits and abstinence effects using other measures of personality [e.g., Gilbert et al. (1998) used the NEO-five factor inventory], it would be useful to compare findings with the TCI to other personality inventories. Finally, the study was limited to individuals who abstained for 12 hours, and who were not attempting to quit. Therefore, it is unclear whether these findings will generalize to smokers abstaining for longer periods, or smokers attempting to quit.

To the best of our knowledge, the current study is the first to document associations between TCI temperament dimensions and tobacco abstinence effects. We showed that, of the three temperament dimensions, NS was associated with acute withdrawal across a number of domains, even after controlling for other TCI dimensions and nicotine dependence. Because the effects of NS and HA were independent of each other, smokers who score high in both NS and HA may be at particular risk for experiencing negative affect and urges to smoke in abstinence. Thus, high-NS, high-HA smokers may particularly benefit from nicotine replacement therapy (Shiffman, Ferguson, Gwaltney, Balabanis, & Shadel, 2006) or mood management interventions (Hall et al., 1996) to counteract the unpleasant effect of tobacco withdrawal.

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Figure 1. Associations between TCI dimensions and abstinence effects, adjusted by age, ethnicity, gender, and FTND scores

Note. Data are standardized regression coefficients (beta values) from multiple regression analyses. TCI scores were the independent variable (tested individually in separate models), and abstinence-induced change scores (score while abstinent – score while non-abstinent) were the dependent variables. For each TCI score, each abstinence effect was tested in a separate model (adjusting for age, ethnicity, gender, and FTND score). TCI = Temperament and Character Inventory; NS = Novelty Seeking; HA = Harm Avoidance; RD = Reward Dependence; FTND = Fagerström Test of Nicotine Dependence; HHWQ = Hughes Hatsukami Withdrawal Questionnaire; WSWS = Wisconsin Smoking Withdrawal Scale; Ang = anger; Anx = anxiety; Sad = sadness; Conc = concentration difficulty; Crav = craving; Hung = hunger; Pos Aff = PANAS-Positive Affect Score; Neg Aff = PANAS-Negative Affect Score; QSU = Brief Questionnaire of Smoking Urges; F1 = factor 1; F2 = factor 2. Associations above the broken horizontal line are statistically significant, β s > .1390, p s < .05.

Table 1
Descriptive statistics of TCI dimensions and associations between TCI dimensions and acute tobacco abstinence effects

	M	SD	HHWQ		WSWS				PANAS		QSU			
			Total		Total	Ang	Anx	Sad	Conc	Crav	Hung	Pos	Neg	Total
Novelty Seeking (NS)	10.8	3.5	.17 (.14)**	.23 (.15)***	.21 (.16)***	.10 (.07)	.15 (.08)*	.20 (.15)***	.09 (.05)	.04 (.07)	.21 (.18)***	.19 (.15)**	.15 (.10)*	.19 (.16)***
NS1: Exploratory Excitability vs. Rigidity	2.9	1.1	.10 (.06)	.14 (.07)	.18 (.14)***	.05 (.03)	-.01 (.06)	.13 (.09)	.00 (.03)	.08 (.00)	.15 (.12)*	.00 (.04)	.04 (.01)	.09 (.07)
NS2: Impulsiveness vs. Reflection	2.5	1.5	.21 (.18)**	.23 (.16)***	.22 (.17)***	.06 (.02)	.22 (.16)***	.19 (.14)***	.14 (.09)	.00 (.04)	.20 (.14)***	.19 (.13)**	.15 (.09)*	.19 (.14)***
NS3: Extravagance vs. Reserve	3.2	1.3	.20 (.20)***	.25 (.22)***	.17 (.16)**	.14 (.14)*	.18 (.16)**	.06 (.03)	.07 (.05)	.04 (.01)	.22 (.21)***	.16 (.14)*	.11 (.07)	.18 (.19)***
NS4: Disorderliness vs. Regimentation	2.2	1.4	-.05 (-.07)	.00 (-.05)	-.02 (-.04)	.01 (.01)	-.02 (-.06)	.14 (.11)*	.01 (.00)	.03 (.00)	.00 (.00)	.07 (.06)	.09 (.08)	.04 (.02)
Harm Avoidance (HA)	7.0	4.3	.12 (.09)	.03 (.00)	.07 (.03)	.01 (-.01)	.05 (.02)	.10 (.09)	.05 (.03)	.02 (.02)	.19 (.15)***	.11 (.14)	.03 (.06)	.18 (.20)***
HA1: Anticipatory worry vs. Optimism	1.5	1.4	.09 (.07)	.02 (.00)	.04 (.04)	.00 (-.02)	.05 (.03)	.09 (.08)	.08 (.07)	.02 (.02)	.19 (.16)***	.02 (.03)	.07 (.06)	.13 (.14)
HA2: Fear of uncertainty vs. Confidence	2.0	1.4	.07 (.07)	-.04 (-.02)	.03 (.04)	.03 (-.03)	.03 (.04)	-.04 (-.01)	.05 (.05)	.00 (-.01)	.08 (.06)	.03 (.08)	.04 (.01)	.10 (.14)
HA3: Shyness vs. Gregariousness	1.8	1.6	.10 (.07)	.07 (.03)	.06 (.03)	.03 (.01)	.03 (.00)	.18 (.15)***	.02 (-.04)	.00 (-.01)	.08 (.06)	.20 (.18)*	.17 (.16)**	.18 (.15)*
HA4: Fatigability and asthenia vs. Vigor	1.6	1.4	.09 (.06)	(.03) -.01	.04 (.00)	.04 (.00)	.05 (.00)	.05 (.03)	.05 (.02)	.03 (.03)	.23 (.18)***	.08 (.10)	.02 (.04)	.13 (.14)
Reward Dependence (RD)	8.6	3.2	-.01 (-.03)	-.06 (-.07)	-.08 (-.10)	.03 (-.05)	-.05 (.07)	-.06 (.07)	.05 (-.08)	.05 (-.05)	-.06 (-.10)	.05 (-.02)	.07 (-.02)	-.02 (.00)
RD1: Sentimentality vs Insensitivity	3.3	1.4	.00 (-.03)	-.06 (-.06)	-.05 (-.10)	.01 (-.03)	-.06 (.07)	-.10 (.11)	.09 (-.12)	.00 (-.02)	.03 (-.02)	.00 (.04)	.07 (-.01)	.09 (.10)
RD3: Attachment vs. Detachment	2.6	1.8	-.03 (-.05)	-.09 (-.11)	-.09 (-.11)	.04 (-.05)	-.03 (-.06)	-.06 (.08)	.03 (.01)	.07 (-.06)	-.08 (-.11)	.08 (-.06)	.05 (-.03)	-.09 (-.08)
RD4: Dependence vs. Independence	2.7	1.3	.02 (.03)	.04 (.04)	-.01 (-.01)	.02 (-.02)	-.01 (.00)	.05 (.05)	.08 (-.09)	.02 (-.03)	-.07 (-.07)	.02 (-.01)	.02 (-.01)	.02 (.00)
FTND	6.5	1.7	.16 (.14)**	.12 (.09)	.15 (.12)*	.15 (.13)	.12 (.11)	.09 (.07)	.12 (.10)	.02 (.01)	.11 (.08)	.08 (.12)	.01 (.03)	.16 (.20)***

Note: Sample size varies across analyses, $N = 202 - 203$. RD2-Persistence, which later became its own dimension, was not assessed in the current study. Withdrawal data are standardized regression coefficients (beta values) from multiple regression analyses. TCI scores were the independent variable (tested individually in separate models), and abstinence effects (score while abstinent - score while non-abstinent) were the dependent variables. For each TCI score, each abstinence effect was tested in a separate model. Results from unadjusted models are not in parentheses. Results from models adjusting for age, ethnicity, and gender are in parentheses. TCI = Temperament and Character Inventory; FTND = Fagerström Test of Nicotine Dependence; HHWQ = Hughes Houtman Withdrawal Questionnaire; WSWS = Wisconsin Smoking Withdrawal Scale; PANAS = Positive and Negative Affect Schedule; QSU = Brief Questionnaire of Smoking Urges. Ang = anger; Anx = anxiety; Sad = sadness; Conc = concentration difficulty; Crav = craving; Hung = hunger; Neg = negative affect; Pos = positive affect; Fac = factor.

100' > *p*

10' > *p*
**
50' > *p*
*

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