Nicotine & Tobacco Research Volume 6, Number 2 (April 2004) 327–348

Taylor&Francis
healthsciences

The Nicotine Dependence Syndrome Scale: A multidimensional measure of nicotine dependence

Saul Shiffman, Andrew J. Waters, Mary Hickcox

[Received 9 March 2001; accepted 13 May 2003]

We report the development of a new multidimensional questionnaire to measure nicotine dependence, based on Edwards's syndromal conceptualization of dependence. We present three studies. In study 1, we administered the Nicotine Dependence Syndrome Scale (NDSS) to 317 smokers in a smoking cessation study. Factor analysis of the NDSS revealed five factors: Drive (craving and withdrawal, and subjective compulsion to smoke), priority (preference for smoking over other reinforcers), tolerance (reduced sensitivity to the effects of smoking), continuity (regularity of smoking rate), and stereotypy (invariance of smoking). A single overall score based on the first principal component, NDSS-T, was retained as a single core measure of dependence. The NDSS showed promising psychometric properties: NDSS-T and factor scores showed strong associations with dependence-relevant measures, even when we controlled for scores on the Fagerström Tolerance Questionnaire (FTQ); and the NDSS predicted urges when smoking, withdrawal in acute abstinence, and outcome in cessation. The five factor scores showed differential patterns of correlations with external validators, supporting the multidimensionality of the measure. In study 2, we revised the NDSS to expand some subscales and administered it to 802 smokers in a cessation study. The same five factors were extracted, the internal reliability of some subscales was improved, and the factor scores again showed associations with dependence-relevant validators, which were largely maintained when we controlled for FTQ scores. In study 3, with 91 smokers in a cessation trial, we established that the test–retest reliability of the subscales was adequate. Thus, the NDSS presents a valid multidimensional assessment of nicotine dependence that may expand on current measures.

Introduction

Nicotine dependence has become the unifying construct of research on smoking behavior (U.S. Department of Health and Human Services [USDHHS], 1988). As a result, improved measures of nicotine dependence are needed. Such measures could facilitate tests of theories of dependence, help document how dependence develops, and help guide treatment.

Nicotine dependence has been measured by a variety of methods. It is commonly, and most conveniently, measured using self-report instruments. The most frequently used self-report measures of nicotine dependence in the literature, particularly the clinical literature, have been the Fagerström Tolerance Questionnaire (FTQ; Fagerström, 1978) and its revised version, the Fagerström Test for Nicotine Dependence (FTND; Haddock, Lando, Klesges, Talcott, & Renaud, 1999; Heatherton, Kozlowski, Frecker, & Fagerström, 1991). A two-item subset of the FTND, the Heaviness of Smoking Index (HSI), consisting of the time to the first cigarette of the day and number of cigarettes per day, has been proposed as a practical and economical substitute for the FTND (Heatherton, Kozlowski, Frecker, Rickert, & Robinson, 1989; Kozlowski, Porter, Orleans, Pope, & Heatherton, 1994).

The FTQ has several strengths. It is brief and easy to administer, has been widely used in research, and has adequate test–retest reliability (Pomerleau, Carton, Lutzke, & Flessland, 1994); it also has shown some utility in predicting success in smoking cessation (Haddock et al. 1999; Pinto, Abrams, Monti, & Jacobus, 1987) and has been shown to moderate the efficacy of nicotine medications (Fagerström & Schneider, 1989; Shiffman & Paton, 1999). However,

Saul Shiffman, Ph.D., Andrew J. Waters, Ph.D., and Mary Hickcox, Ph.D., University of Pittsburgh, Pennsylvania.

Correspondence: Saul Shiffman, Ph.D., Smoking Research Group, 130 N. Bellefield Avenue, Suite 510, Pittsburgh, PA 15260, USA. Tel: +1 (412)-383-2050; Fax: +1 (412)-383-2041; E-mail: shiffman@pinneyassociates.com

ISSN 1462-2203 print/ISSN 1469-994X online © 2004 Society for Research on Nicotine and Tobacco

DOI: 10.1080/1462220042000202481

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

psychometric and conceptual concerns have been raised about this scale. First, it has been reported to lack robust internal consistency (Heatherton et al., 1991; Lichtenstein & Mermelstein, 1986; Pomerleau, Pomerleau, Majchrzak, Kloska, & Malakuti, 1990). The use of dichotomous items and sometimes arbitrary scaling also has been criticized (Heatherton et al., 1991; Pomerleau, Majchrak, & Pomerleau, 1989; Tate & Schmitz, 1993). The FTND was developed to ameliorate some of these concerns (Heatherton et al., 1991), but many remain (Payne, Smith, McCracken, McSherry, & Anthony, 1994; Pomerleau et al., 1994). Second, although the FTQ is summarized in a single score, evidence indicates that it is multidimensional (Haddock et al., 1999; Heatherton et al., 1991; Lichtenstein & Mermelstein, 1986; Payne et al., 1994; Radzius, Moolchan, Henningfield, Heishman, & Gallo, 2001), which would weaken both its internal consistency and its interpretability, because it complicates placing smokers along a single continuum (Pomerleau et al., 1989). Third, although the FTQ and FTND predict smoking cessation, this relation is weak for smokers with moderate to high levels of dependence (Kozlowski et al., 1994), limiting the clinical utility of the scales. Relatedly, some studies have not found relationships between the FTQ and key dependence indices such as nicotine levels (McNabb, 1985), physiological tolerance (Lombardo, Hughes, & Fross, 1988), and withdrawal (Hughes & Hatsukami, 1986).

The Fagerström scales were intended as measures of physical tolerance per se (Fagerström, 1978) and thus were never meant to assess several important aspects of nicotine dependence, such as craving, subjective compulsion to smoke, nicotine withdrawal, behavioral saliency, or behavioral automaticity, which are often regarded as core constructs for dependence (Robinson & Berridge, 1993; Shadel, Shiffman, Niaura, Nichter, & Abrams, 2000; Tiffany, 1990).

Particularly in epidemiological research, nicotine dependence also has been assessed by diagnostic criteria, as implemented in the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*; American Psychiatric Association [APA], 1987, 1994; World Health Organization, 1992). The *DSM-IV* criteria, which are based indirectly on Edwards and Gross's (1976) construct of a dependence syndrome, encompass a wider set of dependence constructs, including persistence in the face of harm, saliency, and so on, and thus are conceptually rooted in a multidimensional construct. *DSM* diagnoses have been shown to be associated with heavier smoking and to predict persistence of smoking (Breslau, Johnson, Hiripi, & Kessler, 2001) as well as comorbidity with depression (Breslau, & Johnson, 2000). Studies comparing the Fagerström scales with *DSM* diagnoses have reported that *DSM-III-R*-defined nicotine dependence and the FTND show relatively little overlap and thus may measure different aspects of nicotine dependence (Breslau & Johnson; Moolchan et al., 2002), again suggesting that dependence may be multidimensional. FTND-defined dependence appears to be a better predictor of cessation than does *DSM-III-R*-defined dependence (Breslau & Johnson, 2000).

The *DSM-IV* classification system has the virtue that it covers all drug dependence disorders using parallel diagnostic criteria, allowing for comparisons (Kosten, Rounsville, Babor, Spitzer, & Williams, 1987). Also, *DSM* assessment of dependence conveniently classifies people as "dependent" or "not dependent," which is useful for case-finding and epidemiological studies (e.g., estimating the prevalence of dependence).

At the same time, the use of dichotomous diagnostic classification has been questioned on several grounds (Mirowsky, 1994; Persons, 1986; Robins & Helzer, 1986). It has been argued that dichotomizing compresses variability (Mirowsky, 1994). If dependence can vary in degree, as most theories suggest (Shadel et al., 2000), then a dichotomous classification will miss much variability. That nicotine dependence varies continuously, and not just dichotomously, is suggested by studies showing meaningful variation (e.g., in biochemical markers and in cessation outcomes) across the full range of the FTQ and FTND (e.g., Kozlowski et al., 1994) and across variation in the number of *DSM* symptoms (Nelson & Wittchen, 1998). Compressing variability into a dichotomous measure leads to a loss of statistical power and discrimination (Kraemer & Thiemann, 1987).

Dichotomous measures also may make it more difficult to study the progression of nicotine dependence, for example, during the initial development of dependence. Breslau et al. (2001), for example, have tracked increased prevalence over time, showing that more and more smokers become dependent over time or with increased smoking, but a dichotomous measure does not allow one to trace the continuous increase in dependence for particular individuals or to track growth curves (Rudiger & Rietz, 1988). Some researchers have used counts of *DSM* symptoms as a continuous measure (Nelson & Wittchen, 1998); however, this approach implicitly assumes the unidimensionality of the *DSM* criteria.

The dichotomous diagnostic decision also masks heterogeneity: The underlying concepts and criteria imply multidimensionality, but the diagnosis itself collapses these into a unidimensional yes–no decision. Because smokers can attain the diagnosis of dependence by meeting any of several criteria, the resulting diagnosis is conceptually heterogeneous. Factor analyses of the *DSM-III-R* criteria have suggested that they are multidimensional (Johnson, Breslau, & Anthony, 1996), and these analyses probably understate the multidimensionality, because only one or two items are used to assess each possible symptom dimension.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Thus, although it can be useful to have a single score or indicator for dependence, it may be important, at least for research purposes, to assess multiple dimensions. For example, different aspects of dependence may predict different outcomes (e.g., craving, withdrawal, relapse). Also, measuring diverse aspects of dependence could give insight into the development of dependence. For example, some aspects of dependence may develop earlier than others or even be necessary precursors (Shadel et al., 2000). Finally, a multidimensional scheme would suggest heterogeneity in how individuals express dependence and allow for different profiles of dependence, which might be useful for understanding individual differences (e.g., by gender) and for prediction and treatment.

Ideally, a measure of nicotine dependence would be grounded conceptually in constructs of dependence, would allow for the multidimensionality reflected in those constructs (Edwards & Gross, 1976; Shadel et al., 2000), and would yield reliable continuous scores. In this paper, we describe the development of a new self-report measure of nicotine dependence, the Nicotine Dependence Syndrome Scale (NDSS), based on these objectives. In constructing this instrument, we started with a theoretical foundation of Edwards's conceptualization of alcohol dependence as a syndrome (Edwards, 1986; Edwards & Gross, 1976). Because Edwards's syndromal concepts greatly influenced *DSM-III-R* and *DSM-IV* criteria for dependence (APA, 1987, 1994), these concepts resemble those in the *DSM* criteria. Edwards and Gross (1976) considered the essential elements of the syndrome to include (a) a narrowing in the repertoire of drug use behavior, (b) increased salience of drug-seeking behavior, (c) increased tolerance to the drug, (d) repeated withdrawal symptoms, (e) repeated relief or avoidance of withdrawal symptoms by further drug use, (f) subjective awareness of a compulsion to use the drug, and (g) rapid reinstatement of the syndrome after relapse. These constructs show little overlap with the content of the Fagerström scales (as *DSM-IV* diagnoses show surprisingly little concordance with FTQ; Breslau & Johnson, 2000; Kawakami, Takatsuka, Inaba, & Shimizu, 1999; Moolchan et al., 2002). Thus, we did not envision the NDSS as a complete substitute for the FTQ and FTND but as a complementary measure conceptually rooted in multidimensional concepts of dependence and thus expanding our measurement scope.

We used Edwards's concepts as a starting point to develop items to assess nicotine dependence. Our intention was not to test Edwards's model but to use it as a basis for an instrument that might have utility in assessing dependence. We report here on the three studies we used to assess the psychometric properties of this instrument. In study 1, we administered the initial NDSS to a sample of smokers participating in a smoking cessation study; and we report the concurrent, discriminant, and predictive validity of the instrument. On the basis of study 1, we revised the NDSS to improve on the psychometric properties of the original. In study 2, we administered the new version to a sample of smokers in a laboratory study, and we report the psychometric properties of the revised version. In study 3, we administered the new NDSS to smokers on two occasions, and we report the test–retest reliability of the subscales.

STUDY 1

Method

NDSS item development

The development of an initial pool of items took place prior to the data collection procedures of the study. These questionnaire items were generated based on the concepts in the Edwards and Gross (1976) model of the dependence syndrome, as applied to smoking. Focus groups of smokers (not part of the study sample) were asked to discuss their experience of dependence (leading to item generation) and to comment on draft items (item testing and refinement). The resulting item set and conceptual structure was next reviewed by a panel of eight addiction experts (see acknowledgments), who suggested item deletions, additions, and revisions. For example, other items to tap the salience of drug-seeking behavior were added because the airplane travel item might not have been relevant for all smokers. Also the item concerning waking up during the night was modified so that smokers did not have to make specific attributions for their nighttime smoking. Finally, items on not visiting nonsmoking friends and willingness to go outside to smoke, even in cold and rainy weather, were added. Focus groups of smokers who completed the draft subscales then responded to the items, and the items were reviewed for redundancy. The process resulted in 23 items assessing current dependence, which were administered to subjects in the present sample.

Participants

Participants were 317 smokers who enrolled in a research smoking cessation clinic. Participants were recruited via advertisements for smoking cessation treatment and were paid US$50. To qualify, participants had to smoke at least 10 cigarettes per day, had to have been smoking for at least 2 years, and had to report high motivation and efficacy to quit (combined score of 150 on two 0–100 scales). This sample overlaps with that reported in several other papers on the relapse process (Shiffman et al., 1996a,b, 1997; Shiffman, Paty, Gnys, Kassel, & Hickcox, 1996c).

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Those publications were limited to individuals who achieved smoking cessation, whereas the present analysis was not. Some 57% of the participants were women, the participants averaged 44.2 years of age ($SD = 10.3$), and they had been smoking for an average of 23.0 years ($SD = 10.0$). They smoked an average of 26.4 cigarettes per day ($SD = 10.4$) at enrollment and smoked their first cigarette on average 16.8 min after awakening ($SD = 26.0$). Participants' mean FTQ score was 6.27 ($SD = 1.86$). Their mean baseline saliva cotinine concentration was 329 ng/ml ($SD = 150$) and mean expired-air carbon monoxide (CO) level was 34.2 ppm ($SD = 13.7$).

Procedure

Smokers were recruited for smoking cessation treatment. On enrollment in the program, participants completed the 23-item draft NDSS shown in Table 1, along with other measures described below. Using the methods described in Shiffman et al. (1996c) and Shiffman et al. (2002), participants separately used palmtop computers to monitor their smoking experience for 2 weeks prior to quitting and their quit experiences for up to 4 weeks after cessation. Participants also were given behavioral treatment. They were followed for 2 months after monitoring for outcome assessment.

Measures of smoking and nicotine dependence

Questionnaire measures. Subjects completed questions about basic smoking history, such as smoking rate and years of smoking. We also administered a modified form of the FTQ (Fagerström, 1978; Heatherton et al., 1991), in which items were given broader response options (e.g., instead of asking whether participants had trouble refraining from smoking in theaters, we asked them to rate, on a Likert scale, the degree of difficulty they had). We recoded responses (e.g., dichotomizing to correspond to dichotomous items on the FTQ) and scored them to derive total FTQ scores ($M = 6.27$, $SD = 1.86$). In study 2, in which participants completed both the standard FTQ questionnaire and the modified version, we validated the converted FTQ scores. The two correlated .85, comparing favorably with highest test–retest correlations for the FTQ presented in the literature (for two samples, .78 and .85; Pomerleau et al. 1994), indicating that the measures were equivalent.

Two other measures of addiction were obtained by direct self-assessment using the question "Do you think you are addicted to smoking?" (on a five-point scale from "definitely not" to "definitely") and by assessment of expected difficulty abstaining from smoking for various periods (a half day, a day, up to a month; on five-point scales and summarized as a composite score, Cronbach's $\alpha = .81$). Experience of past withdrawal symptoms was assessed by asking subjects to recall their experience when they had "quit smoking, cut down on smoking or gone without cigarettes for a while." This wording was chosen so that withdrawal history could be obtained from subjects who had not previously succeeded in quitting smoking. Withdrawal was assessed on scales of 0–4 applied to five individual symptoms (craving, irritability, nervousness, difficulty concentrating, and sleep disturbance), which were averaged to form a reliable composite ($\alpha = .85$). Salivary cotinine and expired-air CO levels also were measured at baseline.

We used selected scores from scales to assess smokers' patterns of occasions and reasons for smoking. Shiffman (1993) has argued that the higher-order factors of these scales function primarily as measures of dependence. We administered the Horn/Russell Reasons for Smoking Scale (Russell, Peto, & Patel, 1974), extracting the two higher-order factors of dependence (pharmacological smoking and non-pharmacological smoking) proposed by Russell et al. (1974) as indices of fundamental smoking motives. We also retained for analysis two scale scores relevant to dependence (addictive smoking and automatic smoking). From the McKennell Smoking Occasions Scale (McKennell, 1970), we extracted two higher-order factors (inner need and social smoking).

Finally, to establish whether the NDSS was biased by irrelevant response sets, participants completed the Social Desirability Scale (Crowne & Marlowe, 1960), which measures the tendency to make oneself look good on assessments. For further discriminant validity, we examined participants' scores on the Ways of Coping Inventory (Folkman & Lazarus, 1980), which asked participants how often they did certain actions in coping with difficulty. We thought it unlikely that scores on this last inventory would be related to dependence.

Measures from real-time monitoring. Assessments of mood and urges were collected through computerized self-monitoring, using Ecological Momentary Assessment (Shiffman & Stone, 1998). During both baseline monitoring and after quitting, participants carried a palmtop computer that functioned as an electronic diary. The electronic diary audibly prompted them at random times to complete assessments of mood and smoking urges approximately 4.5 times daily ($M = 4.46$, $SD = 1.86$; see Shiffman et al., 1996c, and Shiffman et al., 2002, for methods).

Baseline urge to smoke: During a 2-week baseline period of ad libitum smoking, participants were instructed to record each cigarette on the electronic diary as they started to smoke. The electronic diary

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Table 1. Study 1: Nicotine Dependence Syndrome Scale factor structure.

Questionnaire item	Mean (*SD*)	Factor					
		Drive	Priority	Tolerance	Continuity	Stereotypy	NDSS-T
1. After not smoking for a while, I need to smoke to relieve feelings of restlessness and irritability. (r)	3.92 (1.13)	**0.82**					**0.71**
2. Whenever I go without a smoke for a few hours, I experience craving. (w)	3.91 (1.11)	**0.78**					**0.70**
3. When I'm really craving a cigarette, it feels like I'm in the grip of some unknown force that I cannot control. (c)	3.62 (1.22)	**0.78**					**0.65**
4. After not smoking for a while, I need to smoke in order to keep myself from experiencing any discomfort. (r)	3.53 (1.31)	**0.73**					**0.69**
5. I tend to avoid restaurants that don't allow smoking, even if I would otherwise enjoy the food. (s)	2.23 (1.48)		**0.72**	0.28			**0.58**
6. Even if traveling a long distance, I'd rather not travel by airplane because I wouldn't be allowed to smoke. (s)	1.85 (1.21)		**0.71**				**0.50**
7. Sometimes I decline offers to visit with my non-smoking friends because I know I'll feel uncomfortable if I smoke. (s)	1.78 (1.12)		**0.71**				**0.51**
8. If you couldn't get ahold of any cigarettes for a whole day, how much would you be willing to pay by the next morning for just one cigarette.	468 (972)		**0.51**				0.30
9. Compared to when I first started smoking, I need to smoke a lot more now in order to really get what I want out of it. (t)	3.08 (1.47)	0.31		**0.79**			**0.64**
10. Compared to when I first started smoking, I can smoke much, much more now before I start to feel nauseated or ill. (t)	3.45 (1.52)	0.30		**0.74**			0.48
11. Since the time when became a regular smoker, the amount I smoke has either stayed the same or has decreased somewhat. (t)	2.18 (1.36)			**0.72**			0.36
12. My smoking pattern is very irregular throughout the day. It is not unusual for me to smoke many cigarettes in an hour, then not have another one until hours later. (n)	2.70 (1.32)				**0.88**		0.30
13. Sometimes, without realizing it, I go for several hours or more without smoking. (n)	2.38 (1.30)				**0.84**		0.40
14. I smoke just about the same number of cigarettes from day to day. (n)	3.69 (0.94)					**0.82**	0.31
15. My smoking is not much affected by other things. I smoke about the same amount whether I'm relaxing or working, happy or sad, alone or with others, etc. (n)	2.81 (1.34)		0.33			**0.72**	0.30
16. Not even a torrential rainstorm could stop me – if I were out of cigarettes, I would be immediately on my way to the store to get some more. (s)[a]	3.21 (1.41)						**0.68**
17. Where regulations require that I go outdoors to smoke, it's worth it to be able to smoke a cigarette, even in cold or rainy weather. (s)[a]	3.68 (1.21)						**0.65**
18. If I wake up during the night, I feel I need a cigarette. (w)[a,b]	2.58 (1.47)						
19. I can function much better in the morning after I've had a cigarette. (r)[a]	3.57 (1.32)						**0.63**
20. I feel a sense of control over my smoking. I can "take it or leave it" at any time. (c)[a]	1.36 (0.67)						0.41
21. Sometimes even when I'm telling myself I'm not going to have a cigarette, I find myself smoking anyway. (c)[a]	3.69 (1.16)						0.47
22. Whenever I quit or cut down on smoking, it is an unpleasant experience. (w)[a,b]	3.63 (1.19)						
23. The last time I quit (for 24 hours or more), when I went back to smoking it took a *long* time for me to build up to my old level of smoking. (re)[a,b]	1.59 (0.96)						
Cronbach's α		0.83	0.66	0.71	0.74	0.49	0.86

The questionnaire instructions were "Circle the number that indicates how well each of the following statements describes you: 1 = Not At All True, 2 = Somewhat True, 3 = Moderately True, 4 = Very True, 5 = Extremely True." For item 8, subjects wrote down in dollars a figure indicating how much they would be willing to pay for one cigarette after a day without cigarettes. For items 22 and 23, subjects also could endorse a response option "Does not apply" if, for example, they had never tried to quit or cut down smoking. Items 11–13 and 20 were reverse-scored prior to factor analysis. Means are means for unreversed scores. Edwards's dimensions are shown in parentheses after each item. Using the following codes: n = narrowing of the (smoking) repertoire, s = salience of (nicotine)-seeking behavior, t = increased tolerance to (nicotine), w = repeated withdrawal symptoms, r = repeated relief or avoidance of withdrawal symptoms by further (smoking), c = subjective awareness of compulsion (to smoke), and re = reinstatement of the syndrome after abstinence.
Factor loadings above 0.5 shown in bold. Factor loadings of 0.25 or less are not shown.
[a]The item was not included in the final five-factor solution.
[b]The item was not included in the one-factor solution.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

administered an assessment of urge to smoke (a single item on a 0–10 scale) for a random sample of about five cigarettes a day. Participants' urge also was assessed at random nonsmoking times during baseline days. Scores were averaged across day 4 to day 11 of baseline (Shiffman et al., 2002).

Urge and withdrawal in abstinence: For the purposes of this paper, cessation was defined as abstaining (i.e., no smoking) for at least 24 hr; cessation was achieved by 205 participants. (The figures for cessation, lapse, and relapse differ slightly from previous articles based on this sample because an early cohort of 11 participants did not complete the NDSS.) In this period, participants continued to be prompted and assessed at random intervals and administered a measure of urge, mood, and withdrawal symptoms. Factor analyses (Shiffman et al., 1996c) yielded three orthogonal factors: Negative affect ($\alpha = .87$), a bipolar valence factor including happy, irritable, miserable, tense, contented, frustrated-angry, sad, and overall feeling; arousal ($\alpha = .79$), including tired, energetic, and overall arousal level (not analyzed here because of no established relationship to nicotine withdrawal); and attention disturbance ($\alpha = .64$), including feeling "spacey" and difficulty concentrating. An item tapping restlessness also was retained. Averaged ratings from the first 2 days of quitting captured withdrawal experience.

Lapse and relapse. After quitting, participants were asked to record when they lapsed (Shiffman et al., 1996c). A lapse was defined as any smoking (i.e., even one puff). At a follow-up 2 months after the end of the electronic diary monitoring period, participants were asked to recall their daily smoking on calendars, using a timeline follow-back procedure. For survival analysis, we considered both the time to first lapse (i.e., the first episode of any smoking) and the time to relapse (i.e., smoking at least five cigarettes a day for three consecutive days) as outcome measures. Of the 205 smokers who quit, 160 lapsed and 103 relapsed during the study.

Data analysis

Participants' responses to NDSS items were subject to factor analysis. We first extracted principal components and then retained five factors for varimax rotation. In interpreting and refining the factor structure, we emphasized interpretability of the factors and simple loadings, eliminating items that loaded highly on two or more factors. Orthogonal factor scores were derived. We also examined oblique solutions, which allow factors to be correlated. The results were similar. We proceeded with orthogonal solutions, which have been used in analysis of dependence measures (Haddock et al., 1999) because they produce subscores that are not correlated with each other, thus simplifying analysis of the subscores without the need to account for complex intercorrelations. Because the principal components analysis indicated a strong first component, we also retained an estimate of the first component as an omnibus summary measure, the NDSS-T (for total). Subscore reliability was computed based on intercorrelations among the items loading highly on each factor.

We used factor scores to represent each factor. Unlike scores formed by averaging high-loading items, these scores retain the feature that the subscores are not correlated with each other (see appendix). To assess the validity of the NDSS scores, we correlated them with other measures relevant to dependence. This approach generated many coefficients. However, we regarded this analysis as an exploratory one in which broad patterns of correlations were more important than the statistical reliability of any particular coefficient. Nevertheless, we interpreted coefficients only if they met the conventional criteria of a p value less than .01. To test relation to relapse, we used survival analysis.

To assess the incremental utility of the NDSS subscales beyond the FTQ, we computed partial correlations in which the FTQ was partialled out; we similarly computed correlations in which smoking rate was partialled out. To assess the incremental utility of multiple scales and their ability to make unique contributions as predictors of dependence, we entered the extracted NDSS scores into a simultaneous regression analysis with external indicators of nicotine dependence. Finally, to assess the degree to which scoring the multiple subscales improved prediction over using a single summary score (the NDSS-T), we estimated the percentage of variance in measures of dependence accounted for by each (the five subscales and the summary score). The R^2 values were adjusted to account for the different numbers of predictors associated with each equation. We also attempted to test the incremental utility of the multiple subscales by entering them into simultaneous regression equations with the NDSS-T, but the collinearity between the NDSS-T and the subscales precluded stable estimates of parameters.

Results

Factor analyses of NDSS

Table 1 shows the mean and standard deviation for NDSS items. Items 22 and 23, which required prior quit efforts, and item 18, with missing data, were excluded from factor analysis. A principal components analysis revealed a first principal component that accounted for 28.5% of the total item variance; this component was scored and retained for analysis

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

as the NDSS-T. The NDSS-T also correlated highly ($r = .94$) with a higher-order factor extracted from analysis of the obliquely rotated factors. Cronbach's alpha for the NDSS-T was .86, indicating good internal reliability. The loadings for the items are shown in Table 1.

We then used principal components analysis with varimax rotation to explore multifactor solutions. A five-factor solution produced interpretable factors with eigenvalues greater than 1 and was consistent with the scree plot. To purify the factors, we deleted items that either failed to load highly (>.40) on any factor or that split between two factors (<.20 difference between highest loadings). Item loadings for the 15 items are shown in Table 1. The five-factor solution accounted for 65.4% of the item variance.

We labeled the five factors smoking drive, behavioral priority, tolerance, continuity, and stereotypy. We used factor scores (standard variates with $M = 0$ and $SD = 1$) for subsequent analyses. As can be seen from Table 1, smoking drive reflects urges to smoke, in part motivated by relief of uncomfortable withdrawal symptoms. This factor seems to capture the experience of withdrawal symptoms and the need to smoke to relieve these symptoms, as well as subjective compulsion to smoke. Behavioral priority reflects the extent to which smoking is valued over other competing reinforcers. A tolerance factor emerged comprising self-reports of nicotine tolerance. Finally, Edwards's concept of narrowed repertoire of use was captured by two factors. Continuity refers to the tendency to smoke continuously with little interruption; and stereotypy reflects a consistent, fixed pattern of smoking, largely uninfluenced by other stimuli.

As shown in Table 1, most subscales had adequate reliability. However, stereotypy (a two-item factor) had poor reliability ($\alpha = .49$). Continuity, although reliable, comprised only two items. An aim of the revision undertaken in study 2 was to enhance these two subscales.

Discriminant validity

Correlations between NDSS scores and social desirability scores were not significant. The average absolute correlation was .06. Similar null coefficients ($M = .07$) were observed for correlations with Ways of Coping scores for problem-focused coping, seeking support, avoidance, wishful thinking, and blaming self.

Concurrent and incremental validity

Table 2 shows the correlations of the NDSS-T and the NDSS factors with other measures of nicotine dependence. As expected, the NDSS-T and four of the five NDSS factors correlated significantly with FTQ scores. All except stereotypy also correlated with smoking rate. NDSS-T and drive had the broadest

Table 2. Study 1-Correlations with nicotine dependence indicators.

	Nicotine dependence indicator						
	FTQ	Smoking rate (CPD)	Years of smoking	Difficulty abstaining	Past severity of withdrawal	Self-rated addiction	Baseline cotinine
NDSS-T	**0.54*****	**0.48*****		**0.44*****	**0.36*****	**0.30*****	**0.27*****
FTQ	–	0.24***		0.42***	0.26***	0.21***	0.12*
CPD		–		0.40***	0.29***	0.25***	0.11
Drive	**0.31*****	**0.16****	**−0.11**	**0.31*****	**0.39*****	**0.25*****	**0.20*****
FTQ	–	−0.02	−0.20***	0.27***	0.33***	0.17***	0.12*
CPD		–	−0.16**	0.29***	0.35***	0.24***	0.16**
Priority	**0.28*****	**0.34*****	**0.16****	**0.16*****			
FTQ	–	0.22***	0.10	0.12*			
CPD		–	0.07	0.10			
Tolerance	**0.26****	**0.31*****					
FTQ	–	0.20***					
CPD		–					
Continuity	**0.24*****	**0.29*****		**0.29*****		**0.16*****	**0.26*****
FTQ	–	0.20***		0.25***		0.13*	0.18***
CPD		–		0.24***		0.12*	0.16**
Stereotypy			**0.23*****				
FTQ	–		0.23***				
CPD		–	0.21***				
FTQ	–	**0.55*****	**0.22*****	**0.20*****	**0.23*****	**0.19*****	**0.35*****
NDSS	–	0.36***	0.20***	−0.06	0.05	0.05	0.24***
CPD	–	–	0.15*	0.08	0.13*	0.10	0.19***

CPD, cigarettes per day; FTQ, Fagerström Tolerance Questionnaire; NDSS, Nicotine Dependence Syndrome Scale.
Dashes indicate correlations that were not computed. The boldfaced coefficients represent zero-order correlations. The nonbold coefficients for NDSS-related variables represent partial correlation coefficients after controlling for FTQ (upper line) and after controlling for smoking rate (lower line). The nonbold coefficients for the FTQ represent partial correlation coefficients after controlling for drive, priority, tolerance, continuity, and stereotypy (upper line) and after controlling for smoking rate (lower line). The *n* values for correlations range from 276 to 301. Higher values on each NDSS scale score represent higher scores on those dimensions. Zero-order correlations <.15 (and associated partial correlations) only shown if partial correlations >.15.
*p<.05, **p<.01, ***p<.005.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

array of correlations, correlating with difficulty abstaining, baseline cotinine, self-rated addiction, and past withdrawal. Continuity also correlated significantly with all but the last. Only priority and stereotypy correlated with years of smoking. All NDSS scores except tolerance and stereotypy correlated with self-rated difficulty abstaining, even when FTQ scores were partialled out.

Table 3 shows the correlations of the NDSS-T and the five NDSS factors with dependence-relevant scores from the Reasons for Smoking Scale (Russell et al., 1974) and the McKennell Smoking Occasions Scale (McKennell, 1970). All NDSS subscales except continuity correlated significantly with Russell's pharmacological smoking and drive; priority and tolerance correlated with McKennell and Thomas's inner need smoking. Continuity did not correlate with any measures in this group. Russell's addictive smoking scale correlated with NDSS-T, drive, and priority, whereas automatic smoking correlated primarily with tolerance and stereotypy. Only tolerance correlated with nonpharmacological smoking and social smoking. Russell's automatic smoking also showed expected correlations with NDSS subscale scores, notably stereotypy.

Predicting subsequent real-world experience

Table 4 shows the correlation between NDSS scores and data subsequently obtained through real-time self-monitoring. NDSS-T and drive were correlated with urge to smoke during ad libitum smoking at baseline, whether assessed just prior to smoking or when not smoking. Priority correlated only with urge when not smoking. No other correlations with baseline urges were found.

We also examined correlations with withdrawal experience, investigating subsequent urge, negative affect, restlessness, and attention disturbance reported in real time during early abstinence. NDSS-T, drive, and priority were correlated with urge intensity during the first 2 days of abstinence. Mood-related withdrawal symptoms were not reliably associated with NDSS subscales or the FTQ. Restlessness and attention disturbance were correlated with NDSS-T and drive, the two NDSS subscales that touch on withdrawal experience. None of these measures correlated with FTQ at a p value less than .01, and in all cases the NDSS correlations were higher than those observed for the FTQ.

Table 3. Study 1: Correlations with smoking typology measures.

	Smoking typology measure					
	Reasons for smoking				Smoking occasions	
	Pharmacological	Nonpharmacological	Addictive	Automatic	Inner need	Social smoking
NDSS-T	**0.44*** **		**0.34*** **	**0.33*** **	**0.52*** **	**0.14***
FTQ	0.38***		0.35***	0.23***	0.43***	0.14*
CPD	0.35***		0.31***	0.22***	0.43***	0.19***
Drive	**0.20*** **		**0.21*** **		**0.28*** **	
FTQ	0.14*		0.21***		0.19***	
CPD	0.16**		0.21***		0.24***	
Priority	**0.24*** **		**0.17*** **	**0.15***	**0.27*** **	
FTQ	0.16**		0.13*	0.07	0.19***	
CPD	0.16**		0.14*	0.05	0.18***	
Tolerance	**0.24*** **	**0.19*** **		**0.19*** **	**0.27*** **	**0.16***
FTQ	0.20***	0.20***		0.15*	0.21***	0.15*
CPD	0.18***	0.19***		0.13*	0.19***	0.17***
Continuity						
FTQ						
CPD						
Stereotypy	**0.16***			**0.24*** **		
FTQ	0.14*			0.21***		
CPD	0.10			0.20***		
FTQ	**0.31***		**0.16***	**0.28*** **	**0.29*** **	
NDSS	0.11		−0.02	0.16*	0.04	
CPD	0.17***		0.09	0.15*	0.17***	

CPD, cigarettes per day; FTQ, Fagerström Tolerance Questionnaire; NDSS, Nicotine Dependence Syndrome Scale. The boldfaced coefficients represent zero-order correlations. The nonbold coefficients for NDSS-related variables represent partial correlation coefficients after controlling for FTQ (upper line) and after controlling for smoking rate (lower line). The nonbold coefficients for the FTQ represent partial correlation coefficients after controlling for drive, priority, tolerance, continuity, and stereotypy (upper line) and after controlling for smoking rate (lower line). The n values for correlations range from 257 to 301. Higher values on each NDSS scale score represent higher scores on those dimensions. The pharmacological and nonpharmacological scales are higher-order factors derived from Russell et al. (1974); addictive and automatic are two dependence-relevant scales. Inner need and social smoking are two higher-order factors derived from the McKennell Smoking Occasions Scale. Zero-order correlations $<.15$ (and associated partial correlations) only shown if partial correlations $>.15$.
*$p<.05$, **$p<.01$, ***$p<.005$.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Table 4. Study 1: Correlations with monitoring variables.

	Monitoring variables: Baseline and abstinence					
	Baseline smoking		Withdrawal in abstinence			
	Urge before smoking	Urge random nonsmoking	Urge	Negative affect	Restlessness	Attention disturbance
NDSS-T	**0.26*** **	**0.29*** **	**0.28*** **		**0.21*** **	**0.22*** **
FTQ	0.20***	0.18**	0.23***		0.15*	0.22***
CPD	0.28***	0.26**	0.30***		0.19**	0.23***
Drive	**0.24*** **	**0.24*** **	**0.22*** **		**0.20*** **	**0.26*** **
FTQ	0.21***	0.17**	0.18*		0.17*	0.25***
CPD	0.25***	0.22**	0.21***		0.18*	0.25***
Priority		**0.19*** **	**0.27*** **			
FTQ		0.13	0.23***			
CPD		0.15	0.27***			
Tolerance						
FTQ						
CPD						
Continuity			**0.17***	**0.13**		
FTQ			0.12	0.14*		
CPD			0.18*	0.17*		
Stereotypy				**−0.17***		
FTQ				−0.18*		
CPD				−0.17*		
FTQ	**0.19*** **	**0.26*** **	**0.16***		**0.16***	
NDSS	0.09	0.12	−0.01		0.05	
CPD	0.23***	0.25***	0.16*		0.10	

CPD, cigarettes per day; FTQ, Fagerström Tolerance Questionnaire; NDSS, Nicotine Dependence Syndrome Scale. The boldfaced coefficients represent zero-order correlations. The nonbold coefficients for NDSS-related variables represent partial correlation coefficients after controlling for FTQ (upper line) and after controlling for smoking rate (lower line). The nonbold coefficients for the FTQ represent partial correlation coefficients after controlling for drive, priority, tolerance, continuity, and stereotypy (upper line) and after controlling for smoking rate (lower line). The *n* values for correlations range from 191 to 251. Higher values on each NDSS scale score represent higher scores on those dimensions. Measures of urge to smoke, negative affect, restlessness, and attention disturbance in withdrawal were taken from the first 2 days of a quit attempt. Subjects with adequate data on both of the first 2 days of abstinence were included, even if they had lapsed during that period. Zero-order correlations $<.15$ (and associated partial correlations) only shown if partial correlations $>.15$.
*$p<.05$, **$p<.01$, ***$p<.005$.

Predicting time to first lapse and relapse

Using Cox survival analyses, we found that NDSS-T scores predicted time to first lapse ($OR=1.19$, 95% $CI=1.02$–1.38, $p<.05$) and time to relapse ($OR=1.33$, 95% $CI=1.09$–1.62, $p<.005$). None of the five factor scores individually predicted time to first lapse (all p values $>.1$); only tolerance marginally predicted time to relapse ($OR=1.22$, 95% $CI=1.00$–1.49, $p<.1$).

Incremental utility of multiple scales

Because the NDSS measures dependence using five scores, it seemed important to establish whether there were particular and unique contributions of the five subscales. We examined this question by putting the five subscales into simultaneous regression equations predicting other indices of dependence. Table 5 shows the beta coefficients from these regressions. For every dependent variable, at least two NDSS subscales contributed independently and incrementally to prediction. For most dependence indicators (smoking rate, difficulty abstaining, pharmacological smoking, and inner need), at least four of the five NDSS subscales added incremental variance to the models. Thus, we concluded there was value in retaining all five subscales for further development.

To assess the relative capability of the single NDSS-T score and the five NDSS factor scores, we first estimated the percentage of variance accounted for in each of the above equations. These percentages were then compared to the percentage of variance accounted for by the NDSS-T summary score. Both estimates were adjusted for the number of independent variables. The results were mixed. For several variables (pharmacological smoking, inner need, and difficulty abstaining), the single NDSS-T score seemed to capture as much variance as the five separate subscales. For other variables (smoking rate, cotinine, and past withdrawal severity), the five-factor model appeared to capture incremental variance in dependence-relevant variables.

Incremental validity of NDSS beyond the FTQ and smoking rate

If it is to have incremental utility and validity, a measure of nicotine dependence should account for variance not accounted for by other current measures

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Table 5. Study 1: Incremental utility of multiple scales.

	Validator					
	Smoking rate	Baseline cotinine	Past severity of withdrawal	Difficulty abstaining	Russell's pharmacological smoking	McKennell's inner need
Drive	0.16 (0.05)***	0.20 (0.06)***	0.41 (0.06)***	0.31 (0.05)***	0.19 (0.06)***	0.27 (0.050)***
Priority	0.35 (0.05)***	0.11 (0.06)	0.16 (0.06)**	0.17 (0.05)***	0.24 (0.06)***	0.28 (0.050)***
Tolerance	0.33 (0.05)***	0.03 (0.06)	0.08 (0.06)	0.06 (0.05)	0.25 (0.06)***	0.27 (0.050)***
Continuity	0.31 (0.05)***	0.26 (0.06)***	0.06 (0.06)	0.29 (0.05)***	0.02 (0.06)	0.13 (0.050)*
Stereotypy	0.09 (0.05)*	0.08 (0.06)	−0.10 (0.06)	0.12 (0.05)*	0.16 (0.06)***	0.12 (0.050)*
Five-factor adjusted R^2 (%)	33.3	11.1	18.3	21.4	16.8	24.7
NDSS-T adjusted R^2 (%)	23.0	7.1	12.6	19.3	19.2	26.6

For Nicotine Dependence Syndrome Scale (NDSS) subscales (drive, priority, tolerance, continuity, stereotypy), the parameter estimates are standardized parameter estimates in regressions in which all five scales are entered together. The rows marked "adjusted R^2" display the percentage of variance accounted for by regression equations, adjusted for the number of parameters in the model. The first R^2 represents the regression using the five NDSS factors (represented in the column above). The second R^2 represents the regression for the NDSS-T alone. The n values for regressions range from 276 to 301.
*$p<.05$, **$p<.01$, ***$p<.005$.

of dependence such as the FTQ or smoking rate. We therefore examined the correlations between NDSS scores and other variables after partialling out FTQ scores or smoking rate (Tables 2, 3 and 4). Some of the variance in NDSS scores also was captured by FTQ scores (e.g., the association between drive and smoking rate). However, in most cases in which significant zero-order NDSS correlations were observed, they were generally maintained (though sometimes reduced) after we controlled for FTQ scores. Among the significant correlations (Tables 2, 3 and 4) between NDSS subscales and external indicators, only 10% were reduced in magnitude 50% or more when FTQ was covaried. For example, controlling for FTQ scores did not dramatically affect the correlations between NDSS scores and difficulty abstaining, self-rated addiction, addictive or inner need smoking, or any of the abstinence state measures. In other words, NDSS scores captured dependence-relevant variance not captured by the FTQ. This was particularly true for predictive validity of associations with real-time monitoring measures (Table 4). The converse was often untrue: The FTQ did not predict any baseline or withdrawal monitoring variables when NDSS subscales were partialled out. Also, when NDSS subscales were partialled out, FTQ no longer correlated with self-rated addiction, difficulty abstaining, pharmacological smoking, inner need, or addictive smoking. Overall, just over 70% of significant correlations between FTQ and other variables were reduced 50% or more when NDSS subscales were covaried.

Similar results were observed when smoking rate was partialled out of the correlations between NDSS subscales and criterion measures. Smoking rate could not account for many of the observed correlations between NDSS subscales and external standards: Only 8% of the significant correlations were reduced substantially ($\geq$50%) when smoking rate was partialled out.

We also examined the NDSS in survival analyses in which FTQ and smoking rate were partialled out. In univariate analysis, the FTQ did not predict time to first lapse ($OR=1.08$, 95% $CI=.99$–1.18, $p<.1$) but did predict time to relapse ($OR=1.16$, 95% $CI=1.04$–1.31 $p<.01$). In equations including both FTQ and NDSS-T, neither significantly predicted lapse (NDSS: $OR=1.15$, 95% $CI=.96$–1.38, $p>.1$; FTQ: $OR=1.04$, 95% $CI=.94$–1.15, $p>.1$), though the NDSS-T continued to marginally predict relapse ($OR=1.22$, 95% $CI=.97$–1.54, $p=.08$).

In equations including both smoking rate and NDSS-T, neither significantly predicted lapse (NDSS: $OR=1.12$, 95% $CI=.94$–1.34, $p>.1$; smoking rate: $OR=1.01$, 95% $CI=.99$–1.03, $p>.1$), though smoking rate predicted relapse ($OR=1.04$, 95% $CI=1.01$–1.06, $p<.005$), whereas the NDSS did not ($OR=1.14$, 95% $CI=.91$–1.42, $p>.1$).

Discussion

We have described the initial development and validation of the NDSS, a new self-report measure of nicotine dependence. Psychometric analyses support the multidimensionality of nicotine dependence and the validity of the NDSS subscales. NDSS scores correlated with other markers of nicotine dependence, including measures of past and subsequent craving and withdrawal. These analyses also demonstrated that the subscales of the NDSS had independent and incremental associations with key constructs such as cotinine levels and difficulty abstaining from smoking. Moreover, the ability of the NDSS to modestly predict such outcomes persisted even when FTQ scores or smoking rate were partialled out, demonstrating that the NDSS captured additional variance not captured by the FTQ and smoking rate. The NDSS demonstrated discriminant validity and freedom from social desirability bias.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

The NDSS was conceptually derived from Edwards and Gross's (1976) multidimensional conceptual framework for the dependence syndrome. We performed exploratory rather than confirmatory factor analysis, because our goal was to derive and score a practical measure of nicotine dependence rather than to test the dimensions posited by Edwards against our questionnaire. The factors extracted empirically by exploratory factor analysis reflected only loosely the structure posited by Edwards. The drive factor seemed to capture Edwards's dimensions of the experience of repeated withdrawal symptoms and the need to smoke to relieve these symptoms, as well as felt compulsion to smoke. This factor captured what many researchers view as the subjective essence of dependence – the sense of suffering when abstinent and the felt need for the drug. Accordingly, it was the highest correlate of self-assessed addiction and difficulty abstaining. It also correlated with urge to smoke, both during ad libitum smoking and in abstinence, and with restlessness and difficulty concentrating during abstinence.

The priority factor reflected the behavior-economic dimension of dependence (Vuchinich & Tucker, 1997), that is, addicts' willingness to forego other reinforcers in favor of their target drug (saliency). It was among the strongest correlates of typology-based dependence measures. It also was a good correlate of urge intensity when not smoking (either between cigarettes during ad libitum smoking or in abstinence after quitting), perhaps reflecting the saliency of smoking during deprivation.

The tolerance factor represented a self-reported perspective on the pharmacological tolerance that Edwards and others (Jaffe, 1989) considered as an important component or precursor to dependence. As expected, it correlated with smoking rate. It also correlated with nonpharmacological motives for smoking. However, it was not associated with most markers of dependence such as craving or withdrawal. Because our sample consisted of long-time heavy smokers, the tolerance factor may have been hampered by limited range. It may be more important earlier in the development of smoking.

The continuity and stereotypy factors reflected a consistent pattern of smoking, in which smoking is not much influenced by other stimuli. Together, they seemed to capture Edwards's dimension of reduced flexibility and the narrowing of the drug-taking repertoire. These data suggest that the narrowing of the repertoire may have two components: A narrowing related to the development of a continuous rhythm of smoking (i.e., smoking all the time, or continuity) and a narrowing related to the independence of smoking from internal or external stimuli (i.e., always smoking in the same way whatever else is happening, or stereotypy). Although the two concepts seem similar, they were distinctly defined in the factor analysis. (Indeed, reducing the number of factors did not result in the merger of these two factors, and the factors were not correlated in oblique rotations.) Their distinction was further reinforced by their differential pattern of correlations with external variables: Continuity correlated with smoking rate and with difficulty abstaining, as might be expected. Stereotypy correlated most strongly with a scale measuring automatic smoking, as might be expected. As with tolerance, the stereotypy factor may suffer from limited range in this heavy smoking sample and could emerge as more important earlier in the natural history of smoking. It also may have been constrained by limited reliability.

The single-factor NDSS-T score provided a useful single summary score for nicotine dependence. It consistently showed the strongest correlations with external validators, probably because of its greater reliability as well as its broader coverage of dependence. The NDSS-T correlated most strongly with the drive subscale ($r = .68$), which reflects withdrawal, craving, and subjective compulsion; the summary score did not reflect the other facets of dependence nearly as well (r averaging .33). However, in analyses predicting some external indices relevant to dependence, the single NDSS-T score accounted for as much variance as the five factors did. Moreover, it prospectively predicted time to first lapse, whereas the individual scores did not. Thus, the NDSS-T performed reasonably well as a single summary index of nicotine dependence, suitable for use when a single index is desired.

Despite the good performance of the NDSS-T as a single dependence index, we believe an argument exists for using the five NDSS subscales to represent a multidimensional concept of dependence. On some measures, use of the subscales increased the percentage of variance that could be accounted for. Further, the subscales correlated differentially with different external correlates, often in ways that were consistent with the constructs (e.g., drive showed an association with difficulty abstaining, continuity showed an association with smoking rate and cotinine levels, and stereotypy showed an association with Russell's automatic smoking). Furthermore, multiple regression analyses showed that the subscales made independent and incremental contributions to prediction of important external variables. For example, drive, priority, and continuity all were independently associated with reports of difficulty abstaining for various periods of time; continuity and drive were independently associated with baseline cotinine levels; and drive and priority were associated with past withdrawal severity. Taken together, these findings suggest that nicotine dependence can be profitably characterized in several dimensions.

Indeed, in the sample studied here, the utility of a multidimensional assessment may have been underestimated. In this sample of mature heavy smokers, in

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

whom dependence is highly developed, the different dimensions may converge, and the distinctions among the components of dependence may be blurred. However, we speculate that, when dependence is less advanced, the subscales may be more discriminating. The separate subscales may be particularly important for studying the development of dependence, in that they may help discriminate the onset of different aspects of dependence, and for their unique contributions to the progression toward fully developed nicotine dependence (Shadel et al., 2000). For example, we would expect that tolerance may develop first, followed by drive, with stereotypy and continuity emerging last. Testing such conjectures requires a multidimensional measure of dependence.

Although many of the differential associations observed between NDSS subscales and external validators were conceptually meaningful, some findings were theoretically unexpected and puzzling. For example, how long a smoker had been smoking seemed to have little bearing on most measures of dependence, though the current smoking rate was associated with dependence on almost every measure. This finding suggests a good deal of heterogeneity may exist in terms of how quickly nicotine dependence develops or when it plateaus. Priority, which taps the incentive salience and importance of smoking, was associated with urge to smoke when subjects were not smoking, suggesting that need for reinforcement (and not just need for withdrawal-relief) drives urges and smoking. Some unexpected negative findings were made. For example, even though drive predicted postquit restlessness and attention disturbance, it did not predict postcessation negative affect, despite its association with past withdrawal experience. Perhaps mood is subject to so many other influences that it is hard to isolate withdrawal effects. The implications of these findings are unclear and require further research.

While highlighting correlations between the NDSS and other dependence-relevant measures, we also noted that the magnitude of the correlations was relatively modest. Relatively few correlation coefficients exceeded .30, though a few were as high as .50. This finding was not a limitation unique to the NDSS: The correlation coefficients with FTQ were similarly limited. Several factors may have limited the observed correlations. For example, the treatment-seeking sample was relatively dependent, with limited range limiting the potential observed correlations. The criterion measures themselves had limited reliability. This issue is not unique to the present study: Past studies using nicotine dependence measures to predict outcomes such as craving, withdrawal, and cessation also have demonstrated limited associations. For example, in some studies, *DSM* diagnoses have sometimes predicted smoking cessation only weakly (Breslau & Johnson, 2000), and Fagerström measures have had modest associations with cotinine levels (e.g., Pomerleau et al., 1990), withdrawal (Hughes & Hatsukami, 1986), and outcome (Kozlowski et al., 1994). These modest associations suggest we have not completely captured the essence of nicotine dependence or learned how to measure it completely.

Given that the FTQ is an established standard for assessing nicotine dependence, it seemed important to show that the NDSS was correlated with the FTQ – which it was – but also that it could capture additional variance. The data demonstrated this incremental validity. For example, the relationship of the NDSS to self-reported difficulty abstaining was hardly changed by partialling out FTQ variance (even though the FTQ contains relevant content). The association of the NDSS subscales with typology-based indicators of dependence (the second-order pharmacological smoking and inner need smoking factors) was largely incremental to FTQ variance. In general, partialling out variance related to the FTQ did not dramatically decrease NDSS-criterion correlations. The incremental contribution of NDSS subscales was particularly evident for prospective prediction of urges to smoke and affective symptoms, during ad libitum smoking and during abstinence. Thus, the NDSS added to the FTQ's assessment of dependence. Conversely, though, partialling NDSS subscales accounted for much of the variance initially explained by the FTQ: 10 of 14 significant correlations between the FTQ and other variables were reduced at least 50% when NDSS subscales were partialled out. However, there may still be utility in using the FTQ even when nicotine dependence is being assessed with the NDSS. Because we were aiming for a concept-based instrument that would make an incremental contribution to our battery of assessments, we did not systematically incorporate the FTQ's content into the NDSS. Thus, the NDSS does not include useful constructs such as time to the first cigarette in the morning. Further, the FTQ retained some predictive utility even when NDSS subscales were partialled out.

The NDSS also showed substantial incremental validity in relation to smoking rate. Although NDSS subscales correlated with smoking rate, smoking rate did not account for much of the correlation between NDSS and criterion variables: Most correlations between NDSS subscales and other variables were maintained when smoking rate was partialled out.

Study 1 had several limitations. The sample was composed of relatively heavy smokers seeking intensive treatment, which likely limited the range of observed nicotine dependence, perhaps restricting the sensitivity of the psychometric analysis. We computed many correlation coefficients, with concomitant potential for type I error. However, our intention was not to pick out particular correlation coefficients to designate as significant – in either sense of the term – but to display an overall pattern of associations that would place the NDSS within a broad net of

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

other constructs. In any case, particular associations reported here should be considered tentative pending replication in more focused tests. An important limitation is that we did not assess *DSM-IV* dependence and thus cannot address the relationship between the NDSS and this important diagnostic criterion.

In sum, the overall performance of the NDSS was promising in this initial study. However, the stereotypy and continuity factors appeared less robust than the other factors, suggesting the need for an expansion of the subscales to strengthen those factors. We also wanted to replicate the factor structure in a different sample, perhaps one with a broader range of smoking rates. These objectives were pursued in study 2.

STUDY 2

Although the NDSS showed promising psychometric properties in study 1, it also demonstrated some areas of psychometric weakness. Most prominently, two subscales – stereotypy and continuity – were defined by only two items, and stereotypy demonstrated poor reliability. Accordingly, new items were written based on the underlying concepts of the subscales, to try to capture the extent to which smoking becomes more stereotyped (always smoking in the same way whatever else is happening) and continuous (smoking all the time). The seven new items are included in Table 6.

Study 2 had four main purposes: (a) To expand and improve the stereotypy and continuity factors, (b) to replicate the five factors in study 1, using a different sample, (c) to replicate the concurrent validity of the subscales, using a subset of validators like those in study 1, and (d) to illustrate the use of a multiscale measure to contrast group profiles of dependence, using differences between Whites and African Americans as an illustrative contrast.

Method

Participants

Participants were 802 smokers who volunteered to take part in a laboratory experiment testing acute effects of smoking cessation medications. Participants were recruited at one of four cities via advertisements for a smoking cessation study. To qualify, participants had to smoke 11–40 cigarettes per day. They were recruited to satisfy quotas for smokers of 11–24 ($n = 440$) and 25–40 ($n = 362$) cigarettes per day (based on the indications for 2-mg and 4-mg nicotine gum and for 21-mg nicotine patches, which were tested in the laboratory study). On average, participants smoked 24.0 cigarettes per day ($SD = 8.3$) and had been smoking for 23.9 years ($SD = 10.7$). On average, they smoked their first cigarette 25.1 min after awakening ($SD = 43.0$) and scored 7.3 ($SD = 2.1$) on the FTQ. Baseline CO averaged 26 ppm ($SD = 11.5$). Some 57% of the participants were women, 66% were White, 31% were Black, and 3% were Asian or "other." Participants averaged 39.2 years of age ($SD = 10.6$).

Procedure

Participants were enrolled in a study to examine the effects of several nicotine replacement products on relief of acute, cue-provoked craving assessed in a laboratory session. The findings from that study are reported elsewhere (Shiffman et al., 1998, 2003). Because the data reported here (the 30-item NDSS and several dependence-relevant measures) were collected at baseline, prior to randomization and treatment, the treatment conditions are not relevant. The dependence-relevant measures included FTQ score and several assessments identical to those in study 1: A measure of self-rated addiction, items assessing difficulty abstaining for various periods, and items assessing severity of withdrawal in a past quit attempt.

As in study 1, we factor analyzed the NDSS data using orthogonal factor rotation and related the resulting factor scores to dependence-relevant variables. We also performed analyses to develop scoring algorithms for estimating the orthogonal (uncorrelated) scale scores from the items; these algorithms are described in the appendix.

To illustrate the use of a multidimensional assessment, we analyzed ethnic differences in NDSS, contrasting White ($n = 537$) and African American ($n = 255$) smokers (26 participants with "other" ethnicity were excluded from these analyses). The analyses (ANOVA for univariate effects, MANOVA for simultaneous analysis of multiple NDSS subscales) controlled for research site, because sites differed in ethnic distribution.

Results

Factor analysis of revised NDSS

Using principal components analysis with varimax (orthogonal) rotation, we extracted a five-factor solution that accounted for 57.2% of the total item variance. We applied the same factor purification approach as in study 1. The item loadings for the retained items are shown in Table 6, along with reliability coefficients (α). As can be seen, the revision increased the reliability of the stereotypy subscale (.70 vs. .49 in study 1). We used factor scores (standard variates with $M = 0$ and $SD = 1$) for subsequent analyses.

The five factors extracted corresponded closely to the factors extracted in study 1. In particular, the composition of drive, priority, and tolerance subscales was similar to the composition of those subscales in

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Table 6. Study 2: Nicotine Dependence Syndrome Scale factor structure.

Questionnaire item	Mean (*SD*)	Factor					
		Drive	Priority	Tolerance	Continuity	Stereotypy	NDSS-T
1. After not smoking for a while, I need to smoke to relieve feelings of restlessness and irritability.	3.40 (1.11)	**0.75**					**0.67**
2. Whenever I go without a smoke for a few hours, I experience craving.	3.66 (1.08)	**0.72**				0.27	**0.68**
3. After not smoking for a while, I need to smoke in order to keep myself from experiencing any discomfort.	3.05 (1.22)	**0.68**					**0.66**
4. When I'm really craving a cigarette, it feels like I'm in the grip of some unknown force that I cannot control.	3.03 (1.26)	**0.65**					**0.58**
5. I feel a sense of control over my smoking. I can "take it or leave it" at any time.	1.43 (0.79)	**0.52**			0.36	−0.26	
6. I tend to avoid restaurants that don't allow smoking, even if I would otherwise enjoy the food.	1.98 (1.29)		**0.82**				0.47
7. Sometimes, I decline offers to visit with my non-smoking friends because I know I'll feel uncomfortable if I smoke.	1.67 (1.04)		**0.81**				0.39
8. Even if traveling a long distance, I'd rather not travel by airplane because I wouldn't be allowed to smoke.	2.16 (1.33)		**0.63**			0.31	**0.56**
9. Since the time when I became a regular smoker, the amount I smoke has either stayed the same or has decreased somewhat.	2.11 (1.22)			**0.77**			
10. Compared to when I first started smoking, I need to smoke a lot more now in order to get what I really want out of it.	3.07 (1.33)	0.29		**0.70**			**0.56**
11. Compared to when I first started smoking, I can smoke much, much more now before I start to feel nauseated or ill.	3.38 (1.37)	0.31		**0.57**			0.44
12. It's hard to estimate how many cigarettes I smoke per day because the number often changes.	2.47 (1.27)				**0.72**		0.27
13. My smoking pattern is very irregular throughout the day. It is not unusual for me to smoke many cigarettes in an hour, then not have another one until hours later.	2.44 (1.24)				**0.68**		**0.53**
14. The number of cigarettes I smoke per day is often influenced by other factors – how I'm feeling, what I'm doing, etc.	3.30 (1.15)	−0.36			**0.60**		**0.64**
15. I smoke at different rates in different situations.	3.41 (1.09)	−0.33			**0.59**		0.49
16. My smoking is not much affected by other things. I smoke about the same amount whether I'm relaxed or working, happy or sad, alone or with others, etc.	2.49 (1.19)					**0.74**	
17. My cigarette smoking is fairly regular throughout the day.	3.12 (1.13)	0.31				**0.66**	
18. I smoke consistently and regularly throughout the day.	3.07 (1.32)	0.28				**0.65**	
19. I smoke about the same amount on weekends as on weekdays.	2.98 (1.31)					**0.63**	
20. I smoke just about the same number of cigarettes from day to day.[a]	3.23 (1.13)						0.36
21. Not even a torrential rainstorm could stop me – if I were out of cigarettes, I would be immediately on my way to the store to get some more.[a]	3.14 (1.33)						**0.70**
22. Sometimes, without realizing it, I go for several hours or more without smoking.[a]	2.30 (1.17)						0.38
23. Where regulations require that I go outdoors to smoke, it's worth it to be able to smoke a cigarette, even in cold or rainy weather.[a]	3.66 (1.09)						**0.66**
24. I rarely go for very long without smoking.[a]	3.36 (1.15)						**0.72**
25. If I wake up during the night, I feel I need a cigarette.[a]	2.49 (1.36)						**0.60**
26. I can function much better in the morning after I've had a cigarette.[a]	3.22 (1.30)						**0.71**
27. Sometimes even when I'm telling myself I'm not going to have a cigarette, I find myself smoking anyway.[a]	3.42 (1.13)						**0.53**
28. Whenever I quit or cut down on smoking, it is an unpleasant experience.[a,b]	3.03 (0.96)						
29. The last time I quit (for 24 hours or more), when I went back to smoking it took a *LONG* time for me to build up to my old level of smoking.[a,b]	1.59 (0.89)						
30. If you couldn't get a hold of any cigarettes for a whole day, how much would you be willing to pay by the next morning for just one cigarette?[a,b]	577 (7084)						
Coefficient α		**0.76**	**0.69**	**0.55**	**0.63**	**0.70**	**0.84**

Factor loadings above 0.5 are shown in bold. Factor loadings of 0.25 or less are not shown. Items 5, 9, 12–15, and 22 were reverse-scored prior to factor analysis; mean scores are means for unreversed scores. For items 28 and 29, there were four response options (rather than five), ranging from "not at all" to "extremely." Subjects could endorse an option "does not apply" for these items; 8.9% endorsed this option for item 28 and 11.7% for item 29. For item 30, subjects wrote down in dollars a figure indicating how much they would be willing to pay for one cigarette after a day without cigarettes.

[a]The item was not included in the final five-factor solution.

[b]The item was not included in the one-factor solution.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

study 1. The new items generally loaded on the stereotypy and continuity factors, as intended. As in study 1, we retained the first principal component as a summary score, the NDSS-T.

Concurrent validity

Table 7 shows the associations of the NDSS-T and the five factor scores with dependence-relevant variables. The NDSS-T score showed several associations with dependence-relevant measures. All subscales correlated with difficulty abstaining, and all except continuity correlated with smoking rate. As in study 1, drive was the major correlate of self-rated addiction. In general, the correlations were similar to those seen in study 1. As in study 1, most NDSS correlations persisted, with reduced magnitude, when FTQ variance was partialled out; correlations between FTQ and criterion variables were in the same range as those with the NDSS.

Incremental utility of multiple scales

Table 8 shows the results of regression analyses in which we predicted select external validators from all five subscales entered simultaneously as independent variables. For smoking rate and difficulty abstaining, all five subscales showed independent predictive utility. For past severity of withdrawal, all subscales except continuity showed independent utility. The subscales collectively accounted for 15%–29% of the variance in these measures. The single NDSS-T score accounted for as much variance in smoking rate and difficulty abstaining as did the five subscale scores; however, the subscales accounted for more variance in past withdrawal severity.

NDSS profiles of White and African American smokers

We examined differences in dependence measures between White and African American smokers (Table 9). The two groups did not differ in smoking rate. Univariate analyses showed no significant differences in NDSS-T ($p > .2$) but did show significant differences in FTQ, with African American smokers scoring slightly higher than White smokers, $F(1, 756) = 4.7$, $p < .03$. A multivariate repeated-measures MANOVA on the five NDSS subscales (Figure 1) revealed a highly significant scale × group interaction, $F(4, 768) = 10.9$, $p < .0001$, indicating that ethnic group differences differed significantly by subscale. African American smokers scored significantly lower on drive and continuity but significantly higher on stereotypy. (Controlling for FTQ did not substantially alter the results.) This finding illustrates subscale differences – in different directions – even in the presence of no differences in the NDSS-T summary score.

Table 7. Study 2: Nicotine dependence indicators.

	External variable					
	FTQ	Smoking rate (CPD)	Years of smoking	Difficulty abstaining	Past severity of withdrawal	Self-rated addiction
NDSS-T	**0.59*** **	**0.37*** **		**0.52*** **	**0.50*** **	**0.31*** **
FTQ	–	0.12***		0.33***	0.41***	0.23***
CPD	–	–		0.47***	0.48***	0.28***
Drive	**0.26*** **	**0.16*** **		**0.42*** **	**0.49*** **	**0.36*** **
FTQ	–	0.04		0.34***	0.45***	0.32***
CPD	–	–		0.40***	0.48***	0.34***
Priority	**0.30*** **	**0.17*** **		**0.16*** **	**0.18*** **	
FTQ	–	0.04		0.02	0.09**	
CPD	–	–		0.13***	0.15***	
Tolerance	**0.23*** **	**0.24*** **	**−0.12*** **	**0.16*** **		
FTQ	–	0.14***	−0.16***	0.05		
CPD	–	–	−0.19***	0.10**		
Continuity						
FTQ	–					
CPD	–	–				
Stereotypy	**0.32*** **	**0.20*** **	**0.15*** **	**0.16*** **		
FTQ	–	0.05	0.13***	0.01		
CPD	–	–	0.12***	0.11***		
FTQ	–	**0.50*** **		**0.51*** **	**0.34*** **	**0.22*** **
NDSS	–	0.37***		0.36***	0.15***	0.10**
CPD	–			0.46***	0.27***	0.18***

CPD, cigarettes per day; FTQ, Fagerström Tolerance Questionnaire; NDSS, Nicotine Dependence Syndrome Scale. Dashes indicate correlations that were not computed. The boldfaced coefficients represent zero-order correlations. The nonbold coefficients for NDSS-related variables represent partial correlation coefficients after controlling for FTQ (upper line) and after controlling for smoking rate (lower line). The nonbold coefficients for FTQ represent partial correlation coefficients after controlling for drive, priority, tolerance, continuity, and stereotypy (upper line) and after controlling for smoking rate (lower line). Higher values on each NDSS subscale score represent higher scores on those dimensions. The *n* values for correlations range from 770 to 802. Zero-order correlations <.15 (and associated partial correlations) only shown if partial correlations >.15.
*$p < .05$, **$p < .01$, ***$p < .005$.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Table 8. Study 2: Incremental utility of multiple scales.

	Validator		
	Smoking rate	Difficulty abstaining	Past severity of withdrawal
Drive	0.16 (0.03)***	0.42 (0.03)***	0.49 (0.03)***
Priority	0.18 (0.03)***	0.17 (0.03)***	0.19 (0.03)***
Tolerance	0.24 (0.03)***	0.17 (0.03)***	0.10 (0.03)***
Continuity	0.07 (0.03)*	0.13 (0.03)***	−0.06 (0.03)
Stereotypy	0.20 (0.03)***	0.16 (0.03)***	0.10 (0.03)***
Five-factor adjusted R^2 (%)	15.3	26.7	29.2
NDSS-T adjusted R^2 (%)	14.0	27.4	25.1

For NDSS (NDSS, Nicotine Dependence Syndrome Scale) subscales (Drive, Priority, Tolerance, Continuity, Stereotypy), the parameter estimates are standardized parameter estimates in regressions in which all five scales are entered together. The rows marked "adjusted R^2" display the percentage of variance accounted for by regression equations, adjusted for the number of parameters in the model. The first R^2 represents the regression using the five NDSS factors (represented in the column above). The second R^2 represents the regression for the NDSS-T alone. The *n* values for the regressions range from 788 to 794.
*$p<.05$, **$p<.01$, ***$p<.005$.

Table 9. NDSS and FTQ scores by race.

	Whites *(n=534)*		African-Americans *(n=238)*	
Dependence measure	Mean	SD	Mean	SD
NDSS-T	−0.04	0.93	0.11	1.14
Drive*	0.18	0.90	−0.41	1.09
Priority	−0.11	0.96	0.28	1.04
Tolerance	−0.04	1.03	0.06	0.94
Continuity*	0.17	0.95	−0.35	1.03
Stereotypy*	−0.16	0.95	0.36	1.02
FTQ*	7.04	1.91	7.96	2.20

FTQ, Fagerström Tolerance Questionnaire; NDSS, Nicotine Dependence Syndrome Scale.
*$p<.05$.

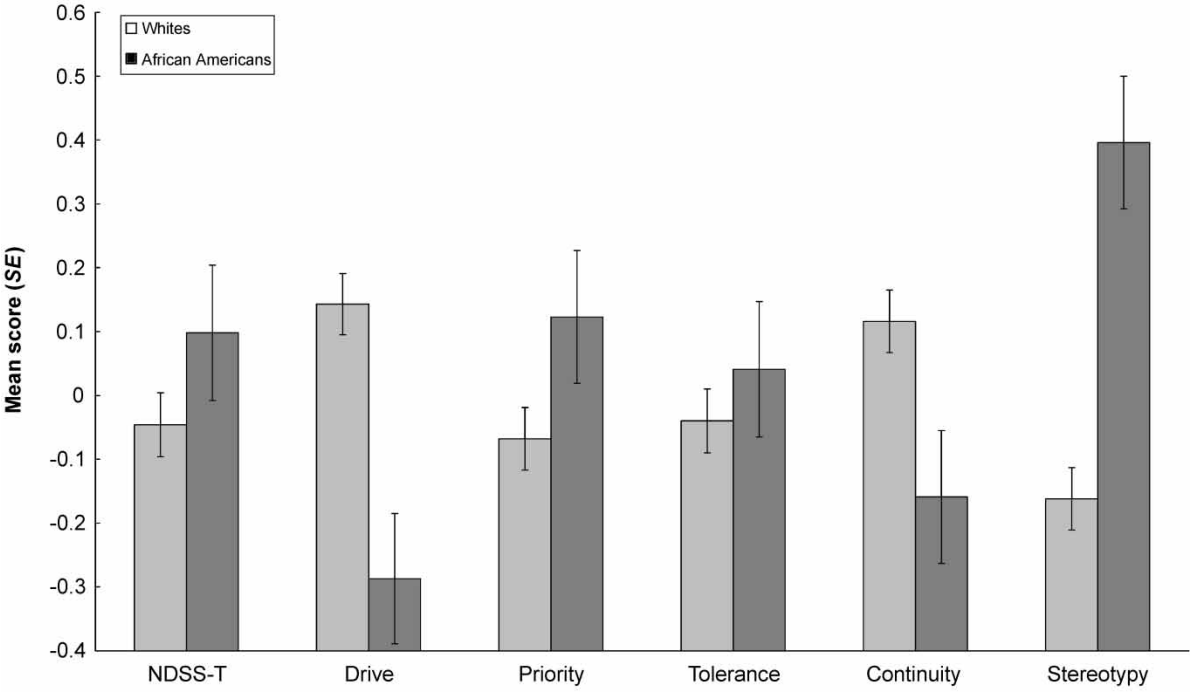

Figure 1. Mean ($\pm SE$) NDSS-T and subscale scores for White ($n=534$) and African American ($n=238$) smokers.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Discussion

Study 2 confirmed the five-factor structure extracted in study 1. By adding the new items, we were able to increase the number of items loading onto continuity and stereotypy, thereby increasing the reliability of stereotypy. The reconfigured continuity and stereotypy factors again contain apparently overlapping content regarding the changeability of smoking rate, which might argue for merger of these factors. However, the factor analysis itself again did not support this approach: Extracting four, rather than five, factors did not cause continuity and stereotypy to merge (and oblique rotations again did not yield high correlation between these factors). Also, the two factors differed in their correlations with external measures: Stereotypy correlated with FTQ score and with smoking rate; continuity did not. Further, the two subscales showed significant and opposite differences between White and African American smokers. Although the conceptual distinction between the factors is not entirely clear, we retained both factors pending further exploration of their conceptual differences.

As in study 1, NDSS scores showed significant but modest associations with dependence-relevant variables, even after we controlled for the FTQ; these associations were consistent with those observed in study 1, suggesting that the results are reliable. Further, the different NDSS factors again showed different patterns of correlations with external variables. In particular, smokers who had longer smoking history reported higher scores on stereotypy, which may indicate increased automatization over time (Tiffany, 1990). Longer-term smokers did not, however, report higher scores on drive, which may suggest that withdrawal-related phenomena do not greatly increase over time in mature adult smokers, at least within the range of smoking history observed here. Smoking experience may be more closely associated with increases in drive much earlier in the smoking career. As in study 1, the sample consisted of relatively heavy longtime smokers, which may not lend itself to sensitive evaluation of these hypotheses. Data on a representative population, or on a sample that included adolescent and young adult smokers, would be useful to confirm the factor structure and correlates of the NDSS. The drive, continuity, and tolerance factors showed lower reliability in study 2 than in study 1, but the differences may be related to random sampling variation or differences in the samples.

Like the sample in study 1, this was a treatment-seeking sample and, despite a deliberately broad range of smoking rate, tended toward heavier and more dependent smokers. Analyses in such samples likely restricted the range of both the NDSS and other variables, likely limiting the range of correlations that could be observed. This situation could partially account for why we saw relatively modest correlations between measures of dependence – either FTQ or NDSS – and other measures thought to be relevant to dependence. Validation of the NDSS in unrestricted and representative samples would be worthwhile.

The analysis of differences in dependence between Whites and African Americans illustrates the potential utility of the NDSS's multidimensional assessment. Although no differences were observed between White and Black smokers on the overall NDSS-T, analysis by subscales revealed sharp differences in the profile of dependence by subscale. African American smokers scored notably higher on stereotypy but scored significantly lower on drive and continuity. That is, African American smokers experienced less craving and withdrawal and were less continuous in their smoking, but their smoking patterns were reported to be much more rigid and inflexible, changing little with environmental circumstances (cf. Edwards's narrowing of the behavioral repertoire). This finding suggests that smoking in African Americans may be more ritualistic or driven by behavioral factors. Further study is needed to understand the meaning and implications of these differences, but the findings illustrate how using a multidimensional assessment tool allows us to go beyond broad ethnic differences in overall level of dependence to describe different profiles of dependence.

Taken as a whole, the data confirmed the findings of study 1: NDSS scores contained dependence-relevant information not represented in current dependence measures, and the subscales tapped different components of dependence, differentially tapping group differences.

STUDY 3

The previous two studies addressed the internal consistency, reliability, and validity of the NDSS but did not establish its test–retest reliability. To obtain test–retest correlation measures, we examined a third dataset in which smokers completed the 30-item NDSS on two occasions, to examine whether NDSS scores remained stable over repeated measurements.

Method

Participants

Participants were 91 chronic, heavy cigarette smokers who completed a study on the effect of bupropion on craving and withdrawal (Shiffman et al., 2000). Participants were selected to be highly dependent. To qualify, participants had to be aged 20–55 years; have smoked an average of more than 25 cigarettes per day for the past 5 years; have baseline serum cotinine concentrations greater than 200 ng/ml, expired-air CO levels greater than 10 ppm, and FTQ

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

scores greater than 7; and report having had difficulty abstaining from smoking in the past (>2 on a relevant question). They also had to pass an extensive medical screening. The sample and study are described in detail in Shiffman et al. (2000).

Most of the participants were male (59%) and White (81%). Average age was 34.5 years ($SD = 9.02$), and they had been smoking for an average of 19.2 years ($SD = 8.67$). At enrollment, these participants reported smoking an average of 35.5 cigarettes per day ($SD = 9.32$) and scored an average of 9.3 ($SD = 1.17$) on the FTQ.

Procedure

Data were collected in a study examining the effects of bupropion on nicotine withdrawal symptoms (Shiffman et al., 2000). Participants were randomized to receive 0, 150, or 300 mg/day of bupropion during a 14-day loading period that allowed for ad libitum smoking, followed by 3 days of abstinence. The 30-item NDSS was administered at entry into the trial and again on day 14, the day prior to testing under conditions of abstinence. Bupropion treatment had no effect on the NDSS. We applied the scoring algorithms reported in the appendix to score the NDSS. We assessed test–retest correlations and differences between scores on the two administrations.

Results

Table 10 shows the means and standard deviations for the NDSS scores for the two administrations. The means and standard deviations were fairly stable over the two administrations. None of the scores showed significant differences between the two administrations (all p values > .05 using within-subjects ANOVA). Table 10 also shows the test–retest correlations of the NDSS scores. These correlations ranged from .71 to .83.

Discussion

Study 3 assessed the stability of the NDSS over a 2-week interval. No systematic changes were found in any of the NDSS scores over this interval. Moreover, all of the scores showed adequate test–retest reliability, with coefficients ranging from .71 to .83, which places them in the moderate-to-good range for reliability.

The sample used here to assess test–retest reliability was selected to have substantial nicotine dependence. This restriction of range would tend to suppress test–retest correlations. Thus, the observed coefficients likely underestimated the test–retest reliability. Conversely, dependence may be more stable in these highly dependent smokers. Some test–retest coefficients exceeded the estimated internal reliability coefficients reported in study 2 (e.g., tolerance: .71 vs. .55; continuity: .77 vs. .63), which suggests that the reliability of the subscales may have been underestimated by the procedures in study 2.

This study demonstrated adequate test–retest reliability of NDSS scores and no evidence of mean drift over a 2-week interval.

General discussion

Nicotine dependence has become the most important explanatory concept in the study of smoking (USDHHS, 1988). As a result, valid and sophisticated instruments are needed to assess dependence. The NDSS presents a theoretically based, empirically shaped multidimensional assessment of nicotine dependence, which extends the scope of current assessments.

The NDSS shows evidence of being a valid measure of dependence. It correlates with a spectrum of other measures and markers of dependence, including the FTQ, which is the measure of nicotine dependence most widely used in research today. Analysis showed that the NDSS complements and extends the scope of the FTQ, capturing some variance not captured in FTQ scores, as demonstrated by its associations with important measures, such as craving, withdrawal, and smoking motives, even when FTQ scores or smoking rate were partialled out. The NDSS was developed to expand the scope of assessment of nicotine dependence and did not incorporate much of the content of the FTQ. Because the FTQ has such a substantial history in the smoking literature, and because it appears to capture some variance that the

Table 10. Repeated administrations of NDSS.

	Dependence measure					
	NDSS-T	Drive	Priority	Tolerance	Continuity	Stereotypy
Mean (*SD*): 1	0.63 (0.80)	0.22 (0.96)	0.67 (1.11)	0.31 (0.93)	0.52 (0.98)	0.47 (0.96)
Mean (*SD*): 2	0.59 (0.84)	0.19 (0.88)	0.83 (1.12)	0.19 (0.89)	0.63 (0.97)	0.47 (0.92)
Correlation	0.81	0.83	0.73	0.71	0.77	0.73

NDSS, Nicotine Dependence Syndrome Scale. The n values for the dependence measures are as follows: NDSS-T ($n = 89$), drive ($n = 89$), priority ($n = 91$), tolerance ($n = 90$), continuity ($n = 93$), and stereotypy ($n = 93$), calculated using the scoring algorithm shown in the Appendix for the two administrations.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

NDSS does not, we do not advocate abandoning the FTQ (or its successor, the FTND). At the same time, the analyses demonstrated that the FTQ fails to capture important components of dependence tapped by the NDSS. The NDSS samples the multidimensional components of dependence and represents the broad conceptual framework of nicotine dependence (Shadel et al., 2000). We advocate that the NDSS be used and tested in clinical and other studies.

Room exists for further enhancement of the NDSS. Scale revisions may improve the reliability of some subscales and clarify the factor structure. The distinction between stereotypy and continuity needs conceptual and empirical exploration. It may be possible to incorporate FTQ and FTND content into the NDSS, for example, incorporating constructs such as morning smoking. The scale also could be expanded to assess craving as a separate construct or to assess functionally enhancing effects of nicotine, such as the effects of nicotine on attention. It may be useful to revise the scale instructions or item stems to better specify a timeframe. It may be possible to use the instrument to assess current dependence (the intention of the current scale) or lifetime dependence (with a revised instructions set). Validity of the scale should further be evaluated in several ways: For example, by testing its ability to distinguish chippers (Shiffman, Paty, Kassel, Gnys, & Zettler-Segal, 1994) from dependent smokers or its ability to predict response to nicotine replacement therapy (Shiffman & Paton, 1999). Also, it seems important to determine the relationship between the NDSS and *DSM*-based measures of dependence. Given the importance of studying the development of nicotine dependence, the validation of a dependence measure suitable for use with young smokers seems a top priority. We have developed an adolescent version of the NDSS (Nichter, Nichter, Thompson, Shiffman, & Moscicki, 2002).

The NDSS can be used and scored in two ways (scoring instructions are found in the appendix). For researchers and clinicians interested in a single score to capture overall severity of dependence, the NDSS-T summary score is likely to be a useful measure. The NDSS-T demonstrated correlations to a variety of constructs, including self-rated addiction, past withdrawal severity, difficulty abstaining, prospectively predicted urge and withdrawal intensity when abstinent, and actual relapse risk. This score should be useful in studying individual differences in dependence, the development of dependence, and differential treatment effects.

For the researcher or clinician interested in a more complex and differentiated assessment of nicotine dependence, we recommend scoring all five subscales of the NDSS (using the algorithms in the appendix). The NDSS was rooted in a multidimensional view of nicotine dependence, which posits that nicotine dependence reflects the operation of several processes, such as tolerance, withdrawal, automaticity, and incentive salience, corresponding to important conceptual components of dependence (Shadel et al., 2000). The data were consistent with a multidimensional model, demonstrating that different facets or factors of dependence, as assessed in the NDSS, (a) could be factor-analytically distinguished, (b) correlated differentially with indices of dependence, (c) made unique, nonoverlapping contributions to predicting such indices, and (d) were differentially associated with ethnic differences. Thus, the data validated the multidimensional conception and assessment of dependence. For scoring the NDSS without introducing artifactual correlation among the factors, we recommend using the scoring algorithms shown in the appendix. These regression-derived algorithms for estimating the factors from some of the constituent items yield normalized scores (z scores normed to the sample in study 2) with minimal between-factor correlations. Further research, perhaps with more representative samples, could use confirmatory factor techniques to explore the fit of various models, including the relative merits of correlated and uncorrelated factors.

This multidimensional conception of dependence suggests several hypotheses and provides an instrument for addressing them empirically. If dependence consists of several dimensions, it follows that different smokers may have different types or profiles of dependence. That is, two smokers with similar ''total levels of dependence'' might demonstrate substantially different profiles of withdrawal, incentive salience, stereotypy, and the like. Indeed, we observed ethnic differences in subscales even though overall dependence was similar. Such profile differences may have important implications for smoker behavior and for treatment of smoking. Cluster-analytic studies could potentially define subtypes of nicotine dependence, which may differ in etiology, presentation, and treatment needs. The different dimensions of dependence also could serve as potential phenotypes to be explored in genetic research. Evidence suggests that vulnerability to nicotine dependence is partially heritable (True et al., 1999). One can speculate that some aspects of the syndrome are more heritable or that different aspects are inherited separately.

A multidimensional concept of dependence also can provide a more differentiated model of the development of dependence over the course of a smoker's career. For example, some aspects of dependence (e.g., tolerance) may appear before others (e.g., priority). DiFranza and colleagues (2000) have suggested that felt need to smoke may appear early in the smoking career of some teenagers. If this suggestion were confirmed, it would be important to know whether this aspect of dependence (related to drive) emerges before others, such as behavioral priority or even

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

nicotine tolerance. Alternatively, the emergence of each facet may depend on particular smoking behavior milestones, such as daily smoking or learning to use smoking for affect management. Breslau et al. (2001) have demonstrated a progressive increase in incidence of *DSM-IV* diagnoses of nicotine dependence over years of daily smoking. This progression in the summary diagnosis could reflect sequential staging of different aspects of dependence over time. These hypotheses are, at this stage, highly speculative. To assess them empirically, we need a multidimensional measure of nicotine dependence such as the NDSS. The NDSS may enhance our ability to measure and thus to understand and, ultimately, to prevent and treat nicotine dependence. We believe that tobacco research can profit from a multidimensional concept of nicotine dependence (Shadel et al., 2000) and psychometric measures to match.

Acknowledgments

Andrew J. Waters is now at MD Anderson Cancer Center. Study 1 was supported by grant DA06084 from the National Institute on Drug Abuse (NIDA). Data collection in study 2 was supported by GlaxoSmithKline Consumer Healthcare; the analysis was supported by NIDA grant DA06084. Data collection in study 3 was supported by GlaxoSmithKline; the analysis was supported by NIDA grant DA06084. Dr. Shiffman has provided consultation and conducted research for GlaxoSmithKline. The authors thank the many colleagues who helped conduct the studies reported here: Jean Paty, Maryann Gnys, Jon Kassel, Celeste Elash, Moise Khayrallah, Chad Gwaltney, Andy Johnston, Raymond Niaura, William Shadel, Doug Jorenby, and others. The Tobacco Etiology Research Network, funded by the Robert Wood Johnson Foundation and under the leadership of Dick Clayton, was a valuable source of support and academic stimulation. Stephanie Paton provided able editorial assistance. The authors also appreciate the critique of an earlier draft by Suzanne Colby, Dorothy Hatsukami, and Jon Kassel. Finally, they are grateful to Griffith Edwards, Ellen Gritz, Alan Marlatt, Raymond Niaura, Damaris Rosenhow, Maxine Stitzer, Gay Sutherland, and Robert West for commenting on the initial item pool for the study 1 NDSS questionnaire.

References

American Psychiatric Association. (1987). *Diagnostic and statistical manual of mental disorders* (3rd ed., revised). Washington, DC: Author.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.). Washington, DC: Author.

Breslau, N., & Johnson, E. O. (2000). Predicting smoking cessation and major depression in nicotine-dependent smokers. *American Journal of Public Health*, *90,* 1122–1127.

Breslau, N., Johnson, E. O., Hiripi, E., & Kessler, R. (2001). Nicotine dependence in the United States – Prevalence, trends, and smoking persistence. *Archives of General Psychiatry*, *58,* 810–816.

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology*, *24,* 349–354.

DiFranza, J. R., Rigotti, N. A., McNeill, A. D., Ockene, J. K., Savageau, J. A., St Cyr, D., & Coleman, M. (2000). Initial symptoms of nicotine dependence in adolescents. *Tobacco Control*, *9,* 313–319.

Edwards, G. (1986). The Alcohol Dependence Syndrome: A concept as stimulus to enquiry. *British Journal of Addiction*, *81,* 171–183.

Edwards, G., & Gross, M. M. (1976). Alcohol dependence: Provisional description of a clinical syndrome. *British Medical Journal*, *1,* 1058–1061.

Fagerström, K.-O. (1978). Measuring degree of physical dependence to tobacco smoking with reference to individualization of treatment. *Addictive Behaviors*, *3,* 235–241.

Fagerström, K.-O., & Schneider, N. G. (1989). Measuring nicotine dependence: A review of the Fagerström Tolerance Questionnaire. *Journal of Behavioral Medicine*, *12,* 159–182.

Folkman, S., & Lazarus, R. S. (1980). An analysis of coping in a middle-aged community sample. *Journal of Health and Social Behavior*, *21,* 219–239.

Haddock, C. K., Lando, H., Klesges, R. C., Talcott, G. W., & Renaud, E. A. (1999). A study of the psychometric and predictive properties of the Fagerström Test for Nicotine Dependence in a population of young smokers. *Nicotine & Tobacco Research*, *1,* 59–66.

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., & Fagerström, K.-O. (1991). The Fagerström Test for Nicotine Dependence: A revision of the Fagerström Tolerance Questionnaire. *British Journal of Addiction*, *86,* 1119–1127.

Heatherton, T. F., Kozlowski, L. T., Frecker, R. C., Rickert, W. S., & Robinson, J. (1989). Measuring the heaviness of smoking using self-reported time to the first cigarette of the day and number of cigarettes smoked per day. *British Journal of Addiction*, *84,* 791–800.

Hughes, J. R., & Hatsukami, D. (1986). Signs and symptoms of tobacco withdrawal. *Archives of General Psychiatry*, *43,* 289–294.

Jaffe, J. H. (1989). Addictions: What does biology have to tell? *International Review of Psychiatry*, *1,* 51–61.

Johnson, E. O., Breslau, N., & Anthony, J. C. (1996). The latent dimensionality of DIS/*DSM-III-R* nicotine dependence: Exploratory analyses. *Addiction*, *91,* 583–588.

Kawakami, N., Takatsuka, N., Inaba, S., & Shimizu, H. (1999). Development of a screening questionnaire for tobacco/nicotine dependence according to *ICD*-10, *DSM-III-R*, and *DSM-IV*. *Addictive Behaviors*, *24,* 155–166.

Kosten, T. R., Rounsville, B. J., Babor, T. F., Spitzer, R. L., & Williams, J. B. W. (1987). Substance-use disorders in *DSM-III-R* – Evidence for the dependence syndrome across different psychoactive substances. *British Journal of Psychiatry*, *151,* 834–843.

Kozlowski, L. T., Porter, C. Q., Orleans, C. T., Pope, M. A., & Heatherton, T. (1994). Predicting smoking cessation with self-reported measures of nicotine dependence: FTQ, FTND, and HSI. *Drug and Alcohol Dependence*, *34,* 211–216.

Kraemer, H. C., & Thiemann, S. (1987). *How many subjects? Statistical power analysis in research*. Newbury Park, CA: Sage.

Lichtenstein, E., & Mermelstein, R. J. (1986). Some methodological cautions in the use of the Tolerance Questionnaire. *Addictive Behaviors*, *11,* 439–442.

Lombardo, T. W., Hughes, J. R., & Fross, J. D. (1988). Failure to support the validity of the Fagerström Tolerance Questionnaire as a measure of physiological tolerance to nicotine. *Addictive Behaviors*, *13,* 87–90.

McKennell, A. C. (1970). Smoking motivation factors. *British Journal of Social and Clinical Psychology*, *9,* 8–22.

McNabb, M. E. (1985). Nicotine Tolerance Questionnaire scores and plasma nicotine: No correlation. *Addictive Behaviors*, *10,* 329–332.

Mirowsky, J. (1994). The advantages of indexes over diagnoses in scientific assessment. In W. R. Avison & I. H. Gotlib (Eds.), *Stress and mental health: Contemporary issues and prospects for the future* (pp. 261–290). New York: Plenum.

Moolchan, E. T., Radzius, A., Epstein, D. H., Uhl, G., Gorelick, D. A., Cadet, J. L., & Henningfield, J. E. (2002). The Fagerström Test for Nicotine Dependence and the Diagnostic Interview Schedule – Do they diagnose the same smokers? *Addictive Behaviors*, *27,* 101–113.

Nelson, C. B., & Wittchen, H. U. (1998). Smoking and nicotine dependence – Results from a sample of 14- to 24-year-olds in Germany. *European Addiction Research*, *4,* 42–49.

Nichter, M., Nichter, M., Thompson, P. J., Shiffman, S., & Moscicki, A. (2002). Using qualitative research to inform survey development on nicotine dependence among adolescents. *Drug and Alcohol Dependence*, *68S,* 41–50.

Payne, T. J., Smith, P. O., McCracken, L. M., McSherry, W. C., & Anthony, M. M. (1994). Assessing nicotine dependence: A comparison of the Fagerström Tolerance Questionnaire (FTQ) with the Fagerström Test for Nicotine Dependence (FTND) in a clinical sample. *Addictive Behaviors*, *19,* 307–317.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Persons, J. B. (1986). The advantages of studying psychological phenomena rather than psychiatric diagnoses. *American Psychologist*, *41,* 1252–1260.

Pinto, R. P., Abrams, D. B., Monti, P. M., & Jacobus, S. I. (1987). Nicotine dependence and likelihood of quitting smoking. *Addictive Behaviors*, *12,* 371–374.

Pomerleau, C. S., Carton, S. M., Lutzke, M. L., & Flessland, K. A. (1994). Reliability of the Fagerström Tolerance Questionnaire and the Fagerström Test for Nicotine Dependence. *Addictive Behaviors*, *19,* 33–39.

Pomerleau, C. S., Majchrzak, M. J., & Pomerleau, O. F. (1989). Nicotine dependence and the Fagerström Tolerance Questionnaire: A brief review. *Journal of Substance Abuse*, *1,* 471–477.

Pomerleau, C. S., Pomerleau, O. F., Majchrzak, M. J., Kloska, D. D., & Malakuti, R. (1990). Relationship between nicotine tolerance questionnaire scores and plasma cotinine. *Addictive Behaviors*, *15,* 73–80.

Radzius, A., Moolchan, E. T., Henningfield, J. E., Heishman, S. J., & Gallo, J. J. (2001). A factor analysis of the Fagerström Tolerance Questionnaire. *Addictive Behaviors*, *26,* 303–310.

Robins, L. N., & Helzer, J. E. (1986). Diagnosis and clinical assessment – The current state of psychiatric diagnosis. *Annual Review of Psychology*, *37,* 409–432.

Robinson, T. E., & Berridge, K. C. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Research Reviews*, *18,* 247–291.

Rudiger, G. M., & Rietz, C. (1988). The neglected time dimension? Introducing a real longitudinal model: Testing latent growth curves, stability, and reliability as time-bound processes. *Methods of Psychological Research*, *3,* 109–130.

Russell, M. A. H., Peto, J., & Patel, U. A. (1974). The classification of smoking by factorial structure of motives. *Journal of the Royal Statistical Society*, *137,* 313–346.

Shadel, W. G., Shiffman, S., Niaura, R., Nichter, M., & Abrams, D. (2000). Current models of nicotine dependence: What is known and what is needed to advance understanding of tobacco etiology among youth. *Drug and Alcohol Dependence*, *59S,* 9–21.

Shiffman, S. (1993). Assessing smoking patterns and motives. *Journal of Consulting and Clinical Psychology*, *61,* 732–742.

Shiffman, S., Gnys, M., Paty, J. A., Hickcox, M., Richards, T., & Kassel, J. D. (1996a). Temptations to smoke after quitting: A comparison of lapsers and maintainers. *Health Psychology*, *15,* 455–461.

Shiffman, S., Gwaltney, C. J., Balabanis, M. H., Liu, K. S., Paty, J. A., Kassel, J. D., Hickcox, M., & Gnys, M. (2002). Immediate antecedents of cigarette smoking: An analysis from ecological momentary assessment. *Journal of Abnormal Psychology*, *111,* 531–545.

Shiffman, S., Hickcox, M., Paty, J. A., Gnys, M., Kassel, J. D., & Richards, T. (1996b). Progression from a smoking lapse to relapse: Prediction from abstinence violation effects, nicotine dependence, and lapse characteristics. *Journal of Consulting and Clinical Psychology*, *64,* 993–1002.

Shiffman, S., Hickcox, M., Paty, J. A., Gnys, M., Kassel, J. D., & Richards, T. (1997). The abstinence violation effect following smoking lapses and temptations. *Cognitive Therapy and Research*, *21,* 497–523.

Shiffman, S., Johnston, J. A., Khayrallah, M., Elash, C. A., Gwaltney, C. J., Paty, J. A., Gnys, M., Evoniuk, G., & DeVeaugh-Geiss, J. (2000). The effect of bupropion on nicotine craving and withdrawal. *Psychopharmacology*, *148,* 33–40.

Shiffman, S., Khayrallah, M., Niaura, R., Shadel, W. G., Jorenby, D. E., Ryan, C., & Ferguson, C. L. (1998, March). *Efficacy of acute administration of Nicorette gum against cue-provoked craving*. Poster session presented at the annual meeting of the Society for Research on Nicotine and Tobacco, New Orleans, LA.

Shiffman, S., & Paton, S. M. (1999). Individual differences in smoking: Gender and nicotine addiction. *Nicotine & Tobacco Research*, *1,* S153–S157.

Shiffman, S., Paty, J. A., Gnys, M., Kassel, J. D., & Hickcox, M. (1996c). First lapses to smoking: Within subjects analysis of real time reports. *Journal of Consulting and Clinical Psychology*, *64,* 366–379.

Shiffman, S., Paty, J. A., Kassel, J. D., Gnys, M., & Zettler-Segal, M. (1994). Smoking behavior and smoking history of tobacco chippers. *Experimental and Clinical Psychopharmacology*, *2,* 126–142.

Shiffman, S., Shadel, W. G., Niaura, R., Khayrallah, M. A., Jorenby, D. E., Ryan, C. F., & Ferguson, C. L. (2003). Efficacy of acute administration of nicotine gum in relief of cue-provoked cigarette craving. *Psychopharmacology*, *166,* 343–350.

Shiffman, S., & Stone, A. A. (1998). Ecological momentary assessment: A new tool for behavioral medicine research. In D. Krantz and A. Baum (Eds.), *Technology and methods in behavioral medicine* (pp. 117–131). Mahwah, NJ: Lawrence Erlbaum Associates.

Tate, J. C., & Schmitz, J. M. (1993). A proposed revision of the Fagerström Tolerance Questionnaire. *Addictive Behaviors*, *18,* 135–143.

Tiffany, S. T. (1990). A cognitive model of drug urges and drug use behavior: Role of automatic and non-automatic processes. *Psychological Review*, *97,* 147–168.

True, W. R., Xian, H., Scherrer, J. F., Madden, P. A. F., Bucholz, K. K., Heath, A. C., Eisen, S. A., Lyons, M. J., Goldberg, J., & Tsuang, M. (1999). Common genetic vulnerability for nicotine and alcohol dependence in men. *Archives of General Psychiatry*, *56,* 655–661.

U.S. Department of Health and Human Services. (1988). *The health consequences of smoking: Nicotine addiction. A report of the surgeon general.* Washington, DC: U.S. Government Printing Office.

Vuchinich, R. E., & Tucker, J. A. (1997). Choice, behavioral economics, and addictive behavior patterns. In W. R. Miller & N. Heather (Eds.), *Treating addictive behaviors* (pp. 93–104). New York: Plenum.

World Health Organization. (1992). The ICD-10: Classification of mental and behavioral disorders: Clinical descriptions and diagnostic guidelines. Geneva, Switzerland: Author.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016

Appendix: Instructions for scoring the Nicotine Dependence Syndrome Scale.

			Scores on subscales				
		Overall score	Drive	Priority	Tolerance	Continuity	Stereotypy
(1)	After not smoking for a while, I need to smoke to relieve feelings of restlessness and irritability	0.116	0.255		−0.105		
(2)	Whenever I go without a smoke for a few hours, I experience craving	0.149	0.246	−0.081			
(3)	After not smoking for a while, I need to smoke in order to keep myself from experiencing any discomfort	0.120	0.184				
(4)	When I'm really craving a cigarette, it feels like I'm in the grip of some unknown force that I cannot control	0.106	0.189		−0.087		
(5)	I feel a sense of control over my smoking. I can "take it or leave it" at any time	−0.092	−0.392			−0.286	0.259
(6)	I tend to avoid restaurants that don't allow smoking, even if I would otherwise enjoy the food	0.101		0.397		0.097	−0.132
(7)	Sometimes I decline offers to visit with my non-smoking friends because I know I'll feel uncomfortable if I smoke			0.478	−0.098		
(8)	Even if traveling a long distance, I'd rather not travel by airplane because I wouldn't be allowed to smoke	0.133		0.232		−0.055	
(9)	Since the time when I became a regular smoker, the amount I smoke has either stayed the same or has decreased somewhat		0.147		−0.494	−0.072	
(10)	Compared to when I first started smoking, I need to smoke a lot more now in order to get what I really want out of it	0.086			0.331		
(11)	Compared to when I first started smoking, I can smoke much, much more now before I start to feel nauseated or ill	0.067		−0.065	0.260		
(12)	It's hard to estimate how many cigarettes I smoke per day because the number often changes	0.049				−0.312	0.088
(13)	My smoking pattern is very irregular throughout the day. It is not unusual for me to smoke many cigarettes in an hour, then not have another one until hours later					−0.312	
(14)	The number of cigarettes I smoke per day is often influenced by other factors - how I'm feeling, what I'm doing, etc.		0.112		−0.076	−0.241	−0.110
(15)	I smoke at different rates in different situations	0.045		−0.062		−0.244	
(16)	My smoking is not much affected by other things. I smoke about the same amount whether I'm relaxed or working, happy or sad, alone or with others, etc.		−0.151				0.346
(17)	My cigarette smoking is fairly regular throughout the day	0.119		−0.104			0.270
(18)	I smoke consistently and regularly throughout the day	0.145			0.067		0.213
(19)	I smoke about the same amount on weekends as on weekdays	0.095		−0.052			0.231
Intercept		−3.854	−2.649	−0.877	−0.022	3.645	−3.014

Scoring instructions: The numbers represent parameter estimates and intercepts for computing factor-type scores from item scores (all nonreversed). Six scores can be computed (overall score and five scale scores). Overall score: This can be computed using the values above as follows: Overall score = (0.116 × [1]) + (0.149 × [2]) + (0.120 × [3]) + (0.106 × [4]) − (0.092 × [5]) + (0.101 × [6]) + (0.133 × [8]) + (0.086 × [10]) + (0.067 × [11]) + (0.049 × [12]) + (0.045 × [15]) + (0.119 × [17]) + (0.145 × [18]) + (0.095 × [19])–3.854. Factor scores: These are computed in the same way using the eight parameter estimates and intercept in regressions. Raw data should be used for the regressions, not standardized data. No items should be reverse-scored before using the algorithms.

Downloaded from http://ntr.oxfordjournals.org/ at Pennsylvania State University on May 17, 2016