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Validation of the nicotine dependence syndrome scale (NDSS): a criterion-group design contrasting chippers and regular smokers

Saul Shiffman[a,*], Michael A. Sayette[b,**]

[a] *Smoking Research Group, University of Pittsburgh, 130 N. Bellefield Avenue (510), Pittsburgh, PA 15260, USA*
[b] *Department of Psychology, University of Pittsburgh, 210 Bouquet Street, 3137 Sennot Square, Pittsburgh, PA 15260, USA*

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Abstract

The nicotine dependence syndrome scale (NDSS) is a new multi-dimensional measure of nicotine dependence, yielding five scores for different aspects of dependence as well as a total score. In this study, we tested the NDSS in a young adult sample (mean age = 24), using an extreme-groups comparison between non-dependent smokers (chippers, $n = 123$) and regular smokers ($n = 130$). Scores on each NDSS subscale strongly discriminated between the groups, with the NDSS-total discriminating them almost perfectly. The subscales were generally independent discriminators, demonstrating the discriminant validity of the subscales. NDSS scales also discriminated levels of intake and dependence within the chippers group, suggesting that the scales were sensitive to individual differences even at the very low end of the dependence continuum.

Keywords: Smoking; Nicotine dependence; Chippers; Assessment

1. Introduction

Nicotine dependence is the driving force behind cigarette smoking (U.S. Department of Health and Human Services, 1988). Estimates suggest that the majority of adult smokers meet diagnostic criteria for dependence (Shiffman and Paton, 1999), and recent research suggests that dependence may develop rapidly in young smokers (Colby et al., 2000; DiFranza et al., 2000). Nevertheless, individual smokers vary considerably in their degree of dependence (Shiffman and Paton, 1999; Shiffman, 1989). Thus, measures capable of assessing degrees of nicotine dependence are important tools for research and treatment.

Shiffman et al. (2004) have recently developed and tested a new instrument – the nicotine dependence syndrome scale (NDSS) – to assess dependence. Conceptually rooted in Edwards' (1986) concept of a dependence syndrome, the NDSS is multi-dimensional, following the notion that dependence is multi-faceted (Shadel et al., 2000). In addition to a single summary score reflecting the first principal component, the NDSS estimates five factor-analytically derived dimensions of dependence. *Drive* captures the craving, withdrawal-avoidance, and subjective compulsion that is often regarded as the core of addiction. *Priority* measures the degree to which smoking comes to be valued over other reinforcers, a concept most prominently articulated by the discipline of behavioral economics (Vuchinich, 1997). *Tolerance* refers to decreased sensitivity to nicotine and/or escalation of dose to overcome such decreases, and was long considered essential for dependence (Jaffe, 1989). *Stereotypy* refers to the development of rigid patterns of tobacco use, which indicates the behavior's increasing resistance to change (see

* Corresponding author. Tel.: +1 412 687 5677.
** Co-corresponding author. Tel.: +1 412 624 8799.
E-mail addresses: shiffman@pitt.edu (S. Shiffman), sayette@pitt.edu (M.A. Sayette).

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Edwards, 1986). *Continuity* refers to the behavioral momentum of smoking, as reflected in its constancy.

The NDSS is thought to have some advantages over the widely used measures developed by Fagerstrom: the Fagerstrom tolerance questionnaire (FTQ; Fagerstrom, 1978; Fagerstrom and Schneider, 1989) and the revised Fagerstrom test of nicotine dependence (Heatherton et al., 1991; Haddock et al., 1999). The Fagerstrom scales cover a narrow range of dependence-related content: smoking rate, smoking in the morning (following overnight nicotine depletion), and difficulty refraining from smoking when it is not appropriate. The NDSS includes content considered theoretically and conceptually central to dependence, such as craving, withdrawal, and tolerance (which, despite the scale's name, is not covered in the FTQ). The multi-dimensional structure may also better reflect modern concepts of dependence, which regard dependence as multi-faceted (Edwards and Gross, 1976; American Psychiatric Association, 1994; Shadel et al., 2000). This may also be a psychometric advance: the FTQ and FTND are scored unidimensionally, even though some analyses have suggested a multi-dimensional structure (Lichtenstein and Mermelstein, 1986). In a demonstration of the value of a multi-dimensional measure, analysis of ethnic differences in NDSS scores showed that African–American smokers scored higher than Caucasians on some dimensions, but lower on others (Shiffman et al., 2004). Thus, the NDSS may be a conceptual and psychometric advance over prior measures of dependence.

In analyses of two large samples, Shiffman et al. (2004) demonstrated the concurrent and predictive validity of the NDSS. NDSS scales correlated with other psychometric measures of dependence (including the FTQ) and with measures of self-perceived addiction, difficulty abstaining, and past experience of withdrawal. NDSS scales also predicted experience of craving and withdrawal symptoms upon quitting, and were related to subsequent relapse risk. Many of these relationships held even when scores on the FTQ were statistically controlled, demonstrating that the NDSS extends the assessment of dependence beyond the scope of the FTQ. The incremental utility of multiple scales within the NDSS was demonstrated by analyses showing that multiple scales made independent and incremental contributions to predicting relevant outcomes. For example, all of the subscales were independently correlated with smoking rate, difficulty abstaining, and smoking-typology-based dependence measures. Thus, the NDSS appears to be a promising measure of nicotine dependence.

A limitation of Shiffman et al.'s (2004) analyses was the use of samples of relatively older, heavy, and dependent long-time smokers who were seeking treatment for smoking cessation. This limits generalizability and also presumably limits the range of variability in nicotine dependence that could be observed and analyzed. More recently, Clark et al. (in press) evaluated the psychometric characteristics of the NDSS in a teen sample largely drawn from teens at risk for substance abuse disorders, and report that the NDSS was correlated with concurrent measures of dependence and also predicted later increases in smoking rate.

The prior validation studies relied primarily on variance in other psychometric assessments within a single sample to validate the NDSS. An alternative approach to validation is the extreme-groups or criterion-group design, in which subject groups that are known to represent extremes on the relevant dimension are contrasted on the measure under consideration (Manterola et al., 2002; Messick, 1995). In other words, the validity of the NDSS can also be assessed by determining whether it robustly distinguishes nicotine-dependent and non-dependent smokers.

Despite the high penetration of nicotine dependence among smokers, it has been demonstrated that some people – labeled "tobacco chippers" – maintain regular smoking for years and even decades without developing dependence (Shiffman et al., 1994). Chippers have typically been defined as those who smoke no more than five cigarettes/day (Shiffman et al., 1994), on the premise that such low levels of nicotine intake are insufficient to induce or support dependence. It has been demonstrated that chippers derive normal amounts of nicotine from cigarettes (Shiffman et al., 1990), but do not suffer withdrawal when deprived of smoking (Shiffman et al., 1995), and do not report any other signs of dependence (Shiffman et al., 1994). Chippers also differ from regular smokers in their family history of smoking (Shiffman, 1989), suggesting that genetic factors may protect them from dependence. Thus, chippers appear to be relatively free of nicotine dependence, and measures of nicotine dependence can be validated by their ability to robustly distinguish chippers from regular smokers.

1.1. Study aims

In this study, we assess the ability of the NDSS and its subscales to discriminate chippers and regular smokers, and the ability of the scales to make independent and incremental contributions to such discrimination. The NDSS was previously validated through correlations with other variables in a group that varied continuously in dependence (Shiffman et al., 2004). The "defined groups" or "extreme groups" comparisons in this study complement that approach by using pre-defined group membership as a criterion variable to establish the validity of the measures (Manterola et al., 2002; Messick, 1995), even though the scale would typically be administered to samples representing the full range of dependence. Finally, we also assessed the concurrent validity of NDSS scales *within* the chippers group, where restriction of range should make such discriminations challenging. Previous analyses in Shiffman et al. (2004) demonstrated that the NDSS could capture dependence-related variance in groups of relatively heavy smokers. However, the ability of the NDSS to assess variations in dependence at the low range of dependence has not been tested. Being able to assess differences in dependence at the low end of the dependence continuum would be important for characterizing the full spectrum of

smokers, which may be useful for assessing dependence early in its development.

2. Methods

2.1. Participants

Two hundred and fifty-three smokers (124 male and 129 female) participated in the study. This is the full sample reported previously in Sayette et al. (2003). Seventy-seven percent of the sample was Caucasian, 17.8% African–American, and 4.8% Hispanic or Asian–American. Selection criteria were applied at screening. Smokers who were trying to quit were excluded. Participants had to be between the ages of 21 and 35; this restriction was based on the need to constrain age-related variation in response-time on a cognitive task, which was key to the underlying study in Sayette et al. (2003). Chippers ($n = 123$) had to report smoking at least 2 days/week, but no more than five cigarettes on the days they smoked. Regular smokers ($n = 130$) had to average more than 20 cigarettes/day. Both groups had to report smoking at these rates for at least 2 years continuously (see Shiffman et al., 1994). Empirically, on average, chippers smoked 4.0 (1.7) cigarettes/day, while regular smokers smoked 24.5 (5.1) cigarettes/day. Only 24% of chippers reported smoking daily. On average, chippers smoked an average of 4.7 (0.12) days/week, for an overall daily average (counting non-smoking days) of 2.7 cigarettes/day. Other selection criteria are described in Sayette et al. (2003). The groups did not differ on ethnic make up or on reported income, but showed modest differences on other variables. Chippers were slightly younger ($M = 24.0$, S.D. = 3.9) than the regular smokers ($M = 25.2$, S.D. = 4.3, $F(1, 251) = 6.2$, $p < 0.02$), and had smoked for fewer years ($M = 6.4$ years, S.D. = 4.4 versus $M = 9.3$, S.D. = 5.3, $F(1, 251) = 22.5$, $p < 0.0001$). Chippers also reported more years of formal education ($M = 14.9$, S.D. = 1.7) than did regular smokers ($M = 14.1$, S.D. = 1.8, $F(1, 250) = 14.5$, $p < 0.001$). The samples of chippers were 59% female, while the sample of regular smokers were 43% female (chi-square (1) = 6.7, $p < 0.02$).

2.2. Procedures

As described in Sayette et al. (2003), subjects were recruited through advertisements in local newspapers and radio programs to participate in a laboratory experiment on cue reactivity. Subjects completed the NDSS, the FTQ, and a questionnaire assessing smoking history (Shiffman et al., 1995, 2004). These measures were completed prior to starting the experiment described in Sayette et al. (2003).

We scored the NDSS scales using the algorithms described in Shiffman et al. (2004), which are designed to yield relatively uncorrelated standardized scores (mean = 0, S.D. = 1 on the normative sample) for each subscale. We also scored the NDSS-T summary score. Because the groups had been defined and selected based on different smoking rates, in scoring the FTQ, we used a variant scoring that did not include smoking rate in the scoring. Other self-report measures included self-ratings of addiction and a composite rating of difficulty abstaining for various intervals ranging from an hour to a day (see Shiffman et al., 1995, 2004).

2.3. Data analysis

To contrast the groups, we relied primarily on logistic regression, with group membership as the dependent variable and NDSS scales (and other variables) as predictors. We report odds ratios and their confidence intervals as the primary statistics. We also report the results of logistic regressions, summarized using receiver operating curve (ROC) analysis (Hanley and McNeil, 1982). The ROC curve plots the sensitivity and specificity of the measure as a discriminator of subject status, and the area under the curve can be interpreted as the percentage of pairwise case comparisons that would allow one to correctly discriminate a chipper and a regular smoker based on the score (Hanley and McNeil, 1982). Analysis of demographics had revealed some differences in the composition of the groups. As these differences were presumed to be inherent in the groups, they were not controlled in subsequent analyses, which were meant to assess the ability of the NDSS to distinguish the groups, regardless of their composition.

We also assessed the association between NDSS scales and other variables *within* the chippers group, by conducting multivariate regressions using the NDSS scales as predictors of several dependence-relevant variables: smoking rate, FTQ scores, difficulty abstaining, and self-rated addiction. We report subscale statistics as well as the total amount of variance accounted for (R^2) by all of the NDSS subscales in aggregate, as a measure of the total predictive power across all subscales.

3. Results

3.1. Between-group contrasts

3.1.1. Univariate analyses

Table 1 shows the mean NDSS scores for chippers and regular smokers, along with odds ratios based on logistic regression. Fig. 1 shows the logistic function distinguishing the groups based on NDSS scores. Each NDSS subscale significantly discriminated the two groups. The NDSS-T score significantly discriminated the groups, with an odds ratio of 17.1. (In other words, every 1-point increase in NDSS-T scores increased the odds that the respondent was a regular smoker 17-fold.) The group distinction accounted for 33% of the variance in NDSS-T. The plot demonstrates that positive NDSS-T scale scores were associated almost exclusively with regular smokers; conversely, scores below −1.5 were almost exclusively the domain of chippers. Indeed, the area

Table 1
Differences between chippers and regular smokers in NDSS scales and FTQ scores

Scale	Chippers ($n = 123$)		Regular smokers ($n = 130$)		Univariate statistics				Multivariate ORs	
	Mean	S.D.	Mean	S.D.	OR	95% CI	p	ROC	All scales[a]	FTQ[b]
Drive	−1.81	1.04	0.15	0.86	6.45	4.19–9.92	<0.0001	0.92	7.15*	3.58*
Priority	−0.41	0.47	−0.08	0.94	1.88	1.30–2.71	<0.0008	0.58	1.52	0.99
Tolerance	−0.98	0.97	0.16	0.88	3.58	2.55–5.04	<0.0001	0.81	4.40*	3.11*
Continuity	−1.35	1.16	−0.36	1.00	2.35	1.79–3.10	<0.0001	0.74	2.14*	1.67*
Stereotypy	−0.56	0.88	−0.10	0.99	1.72	1.30–2.29	<0.0002	0.65	2.98*	1.51*
NDSS-T	−1.76	0.72	0.12	0.71	17.15	8.89–32.80	<0.0001	0.96	–[c]	9.47*
FTQ	2.28	0.95	4.86	1.54	4.06	2.93–5.64	<0.0001	0.91	1.64*	–

[a] With all five NDSS scales in the logistic regression model; in a MANOVA model, cannonical correlation = 0.77.
[b] ORs for single NDSS scales, with FTQ in the model.
[c] Models including the NDSS-T could not be evaluated because of collinearity with individual scales.
* $p < .05$.

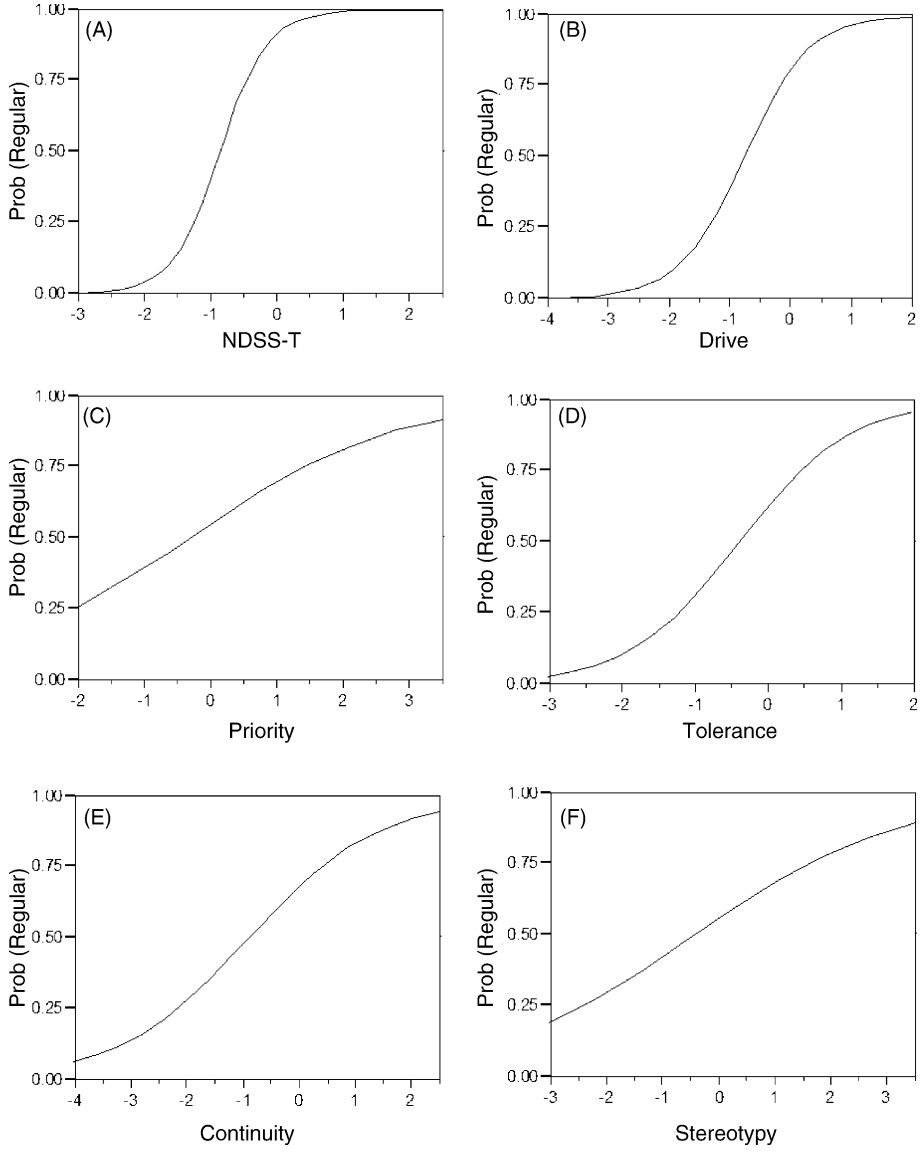

Fig. 1. Logistic regression plots showing the relationship between NDSS scales (*X*-axis, showing the observed range of scores for each scale) and the probability of being in the regular smoker group (*Y*-axis).

under the ROC curve was 0.96, indicating that comparison by NDSS-T scores could successfully distinguish chippers and regular smokers 96% of the time. Among the subscales, the Drive scale was the most robust correlate of group membership, with an odds ratio of 6.45, accounting for 54% of the variance. The area under the ROC curve for Drive was 0.92, again indicating very high degree of discrimination. Scores above 0 were almost exclusively seen among regular smokers; scores below −1.5 were almost exclusively the domain of chippers. Each of the other subscales also significantly discriminated the groups. The weakest effect was seen for the priority subscale, still a significant discriminator with an odds ratio of 1.88, but with only 0.58 area under the ROC curve.

3.1.2. Multivariate analyses

These data demonstrate that each NDSS subscale significantly distinguishes chippers and regular smokers. To test the independent contributions of the scales, we conducted a multivariate logistic regression including all the NDSS scales. Table 1 shows the resulting odds ratios and significance. The analysis shows that Drive, Tolerance, Stereotypy, and Continuity contribute independently to the discrimination (accounting for approximately 69% of the variance). In this analysis, Priority has a positive odds ratio of 1.52, but its contribution is not significant in this multivariate context. Exploratory analyses (not reported in detail) reveal that Priority is pushed out of the model by Drive, which apparently captures its associations with the group difference.

Table 1 also shows the means and group statistics for the FTQ. The FTQ significantly discriminated the groups, with an odds ratio of 4.06, and accounting for 47% of the variance. The FTQ was a good discriminator of chippers, with an area under the ROC curve of 0.91. When entered into a multivariate logistic regression with NDSS scale scores, the FTQ still made significant, though reduced, contributions (OR = 1.64), demonstrating that the FTQ captures variance not included in the NDSS. We also tested the contributions of individual NDSS subscales while controlling for FTQ scores. Even with the FTQ in the equation, the contributions of four of the NDSS subscales remained significant and substantial. Only the incremental contribution of the Priority scale was not significant. Thus, NDSS subscales (excepting Priority) capture variance that is not incorporated in the FTQ.

3.2. Within-group analyses among chippers

To test whether the NDSS could capture the limited variance *within* the chippers group, we assessed the within-group correlations between NDSS scores and other measures of dependence. We conducted multivariate regression equations, predicting selected dependence-relevant measures from the five NDSS subscales, entered simultaneously. Results are displayed in Table 2. Among chippers, NDSS scales were significantly associated with all of the measures tested. Drive, Tolerance, and Stereotypy were each independently associated with variations in smoking rate among chippers, jointly accounting for 37% of the within group variance. Drive was the only significant multivariate predictor. NDSS scales jointly accounted for 51% of the variance in reported difficulty abstaining. All NDSS scales made significant unique contributions. Self-rated addiction was associated with Drive (only), which accounted for 55% of the variance. Finally, NDSS scales were associated with FTQ scores, accounting for 28% of the within-group variance, with all NDSS scales except Continuity as independent predictors. We also examined correlates of the number of days per week the subjects

Table 2
Associations between NDSS scales and indicators of dependence, within the chippers group

	Smoking rate	Days smoke	Self-rated addiction	Difficulty abstaining	FTQ
Multivariate models with NDSS scale scores					
Drive	0.56*	0.43*	0.73*	0.61*	0.41*
Priority	0.11	−0.08	0.05	0.13*	0.23*
Tolerance	0.26*	−0.07	−0.01	0.13*	0.22*
Continuity	−0.04	−0.05	0.07	0.28*	−0.07
Stereotypy	0.38*	0.28*	0.07	0.14*	0.31*
Variance (%)	37	30	55	51	27
Univariate models with FTQ					
FTQ	0.40*	0.22*	0.30*	0.34*	–
Variance (%)	16	5	9	12	–
Multivariate models with FTQ + NDSS scale scores					
FTQ + NDSS (%)	37	31	55	52	–

Entries in the top panel are standardized regression coefficients (βs) for NDSS scales (rows) to indicators of dependence (columns), based on a multivariate linear regression, with simultaneous entry of all NDSS subscales. The model fit is summarized by R^2 for each model. Entries in the middle panel represent standardized regression coefficients (βs) for FTQ, along with R^2 for each model. The bottom panel represent R^2 for regression models including both NDSS scales and FTQ scores.

* $p < .05$.

smoked. NDSS scales accounted for 26% of the variance, with Drive, Stereotypy, and Continuity as predictors.

We also examined the within-group associations with FTQ scores. FTQ was associated with within-group variation in all variables examined. However, the magnitude of associations was considerably smaller than that for the NDSS scales. We also ran multivariate models including both NDSS scales and FTQ scores. In every case, FTQ was non-significant indicating that its variance was subsumed by the NDSS scores (statistics not shown). Table 2 also shows that adding the FTQ to the NDSS models did not generally increase the variance accounted for, another indicator that the FTQ did not contain additional relevant variance.

4. Discussion

Using an extreme-groups design contrasting chippers (non-dependent smokers) and regular, relatively heavy smokers, this study demonstrated the validity of the NDSS and each of its constituent subscales as measures of nicotine dependence. The NDSS-T summary score and each of the five NDSS subscales provided robust discrimination of chippers and regular smokers. Furthermore, each of these NDSS measures discriminated the groups even when we controlled for a valid and widely used measure of nicotine dependence, the FTQ. This demonstrates that the NDSS captures aspects of dependence that are not incorporated or captured in the FTQ. Finally, the NDSS scales showed themselves to be sensitive to variations in dependence even among chippers.

The discrimination between non-dependent smokers and regular smokers was very robust. On the NDSS scales most associated with compulsive use – Drive and the omnibus NDSS-T – there was essentially no overlap between the groups. On the other scales, the groups overlapped somewhat, but the logistic probability plots (Fig. 1) suggested even discrimination across the full ranges of the scales. Thus, each scale of the NDSS demonstrated validity.

The incremental utility of the NDSS subscales was also demonstrated in a multivariate analysis, where the Drive, Tolerance, and Stereotypy scales each made incremental and independent contributions to discriminating chippers and regular smokers. The incremental contributions observed for Drive and Tolerance stand in contrast to a recent analysis of the NDSS in a teen sample (Clark et al., in press), which suggested that Drive and Tolerance could not be distinguished in factor analyses. This suggests the possibility that the structure of dependence may shift with age and progression in smoking. Of course, other differences, particularly in sampling, could account for the difference in observations.

In our analysis, Continuity and Priority were robust univariate discriminators, but did not add to the discrimination once the other NDSS subscales had been accounted for. This contrasts with our analyses of Priority in older and more dependent samples (Shiffman et al., 2004), where Priority was a robust predictor of smoking rate, perceived addiction, and withdrawal symptoms, even when all other scales were covaried. Notably, Priority did help discriminate degrees of dependence among chippers. These results suggest that Priority can help discriminate subtle variations in dependence, but adds little to gross discriminations between dependent and non-dependent smokers, once more powerful scales such as Drive have been accounted for. The same may be true of Continuity, which also added to discrimination within chippers, even though it did not contribute incrementally to between-group discrimination.

Otherwise, the findings were generally consistent with those of Shiffman et al. (2004), who evaluated the validity of the NDSS in two large samples of smokers, and Clark et al. (in press), who evaluated the NDSS in a teen sample. In those samples, as in this one, the NDSS and its subscales appeared to capture variance in nicotine dependence, and appeared to go beyond the variance tapped by the FTQ—the leading measure of nicotine dependence. In these analyses as in the prior ones, the FTQ also appeared to capture some relevant variance that was not tapped by the NDSS. This suggests that both measures may be useful, and that an omnibus scale incorporating both may be worth developing. (The NDSS was not intended as a replacement for the FTQ or FTND and thus did not attempt to incorporate its content, which focuses, for example, on smoking immediately after waking, when nicotine has been cleared overnight.)

The present study also extends the prior findings. Whereas the prior samples in Shiffman et al. (2004) were older, relatively heavy smokers seeking treatment for smoking cessation, the present samples were not treatment-seekers and, by design, represented a large range of nicotine dependence. They were also approximately 20 years younger than the subjects in Shiffman et al. (2004). Thus, the study suggests the ability of the scales to distinguish degrees of dependence at earlier stages in the smoking career, consistent with Clark et al. (in press). Whereas the prior studies analyzed variance in nicotine dependence (as indexed by psychometric variable) within somewhat homogeneous samples, the present study assessed the validity of the NDSS using an extreme-groups or criterion-group design. The consistency of the results confirms the robust validity of the NDSS.

The multivariate analyses, by establishing the independent contributions of multiple subscales, validate the importance of conceptualizing and measuring dependence as a multidimensional construct. The multi-dimensional nature of dependence and of smoking motives is also incorporated in a new measure (the WISDM) developed by Piper et al. (2004), which assesses 13 motives for smoking. Some of the motives assessed by the WISDM overlap with those on the NDSS; for example, both scales contain measures of Tolerance, and our Drive scale incorporates elements contained in their Craving, Negative Reinforcement, and Loss of Control scales. However, Piper et al. aimed to survey a broad variety of motives for smoking, rather than assess the Edwards model of dependence, so the WISDM includes motives such as sen-

sory pleasure and social motives for smoking. In any case, both scales emphasize the multi-dimensional nature of dependence and suggest the promise of differential prediction by different aspects of dependence, and the potential to characterize different manifestations of dependence as a profile over multiple dimensions. The correlation between NDSS scales and WISDM scales remains to be determined, as does their relative performance.

Substantively, the findings refine our understanding of chippers (Shiffman et al., 1994) suggesting that they are most distinct from regular smokers in their lack of smoking Drive. That is, their biggest distinction is in their lack of craving and withdrawal and consequent subjective compulsion to smoke. Indeed, differences between chippers and regular smokers on the behavioral priority they give to smoking and in the continuous nature of their smoking appear to be secondary to the very large differences in Drive. This suggests specific processes by which dependence may develop or fail to develop in these groups, and may have general implications for the development of nicotine dependence, emphasizing the central role of craving and withdrawal in the process.

Besides evaluating the ability of the NDSS to discriminate dramatic differences in nicotine dependence, we also evaluated the sensitivity of the NDSS to the much narrower range of variance in dependence among chippers, by examining within-group associations with other variables such as smoking rate and reported difficulty abstaining. The range of variance in dependence was likely further narrowed by the young age of the subjects: the average age was 24 and no subject was older than 35. Among chippers, the NDSS showed significant associations with each of the variables examined, indicating that the NDSS is sensitive to subtle variations in dependence even within a narrow range at the low end of dependence. Every NDSS subscale demonstrated independent within-group associations with external criterion variables, demonstrating the value of the different scales and the need for multiple dimensions to fully capture the variance in nicotine dependence. In contrast, the FTQ discriminated among chippers in univariate analyses, but did not contribute independent variance to multivariate analyses including NDSS scale scores.

The ability of NDSS scales to discriminate degrees of dependence among chippers was in some ways surprising, as these smokers were selected for the presumed absence of nicotine dependence. The scales' ability to discriminate differences among young adult smokers at this very low end of the dependence continuum bodes well for the scales' potential to discriminate the early stages of dependence, and thus help describe the development of dependence in recent initiates to smoking. Very little is known about how dependence develops early in smokers' careers or how to sensitively assess dependence in that period (see Colby et al., 2000; DiFranza et al., 2000; Shadel et al., 2000, Shiffman, 1991, Tiffany et al., 2004); a measure of dependence sensitive to very low levels of dependence or small increases in dependence could potentially be very useful. A multi-dimensional measure might be particularly useful, as it might help map the differential developmental trajectory of different components of dependence, describing their order of appearance, and so on (Shadel et al., 2000). However, the analyses reported by Clark et al. (in press) suggest caution in generalizing the NDSS factor structure developed based on adult smokers to assessment in teen smokers.

4.1. Limitations

The present study was subject to several limitations. The subjects in the sample were relatively young and their smoking behavior may not be well established. Thus, it is possible that some of the smokers who were classified as chippers may later progress to dependent smoking, and some of the heavier smokers will stop smoking or become chippers. However, these processes work against the measures' ability to distinguish the groups, and thus make the findings conservative. The samples were also relatively small samples of convenience, without claim to population representativeness. However, they were well distinguished on the basis of established criteria for identifying chippers and comparison groups of heavy smokers (Shiffman et al., 1995; Shiffman, 1989). All of the measures examined in the study were self-report assessments. Confirmation using behavioral measures would be valuable.

4.2. Summary and conclusions

In sum, this study confirmed the validity of the NDSS as a measure of nicotine dependence by showing that the summary scale and each of the subscales could achieve robust discrimination between chippers and regular smokers. The analyses also confirmed the utility of assessing multiple dimensions of nicotine dependence, consistent with conceptual models of dependence as a multi-dimensional syndromal process (Edwards and Gross, 1976; Shadel et al., 2000; Piper et al., 2004), and with prior findings (Shiffman et al., 2004). Finally, the ability of the NDSS and its subscales to discriminate degrees of dependence or its precursors within the chippers sample suggests that the scales are sensitive at low levels of dependence. This suggests that the NDSS can fruitfully be used to assess dependence across the full range of smoking rates and degree of dependence, allowing the scales to be used in a range of epidemiological, research, and clinical studies. The scales' sensitivity to subtle differences even within the low end of dependence also suggests that the scale may also be useful in tracing the developmental trajectory of dependence in its earliest stages.

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