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Confirmatory factor analysis of the Nicotine Dependence Syndrome Scale in an American college sample of light smokers

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The five-factor structure of the Nicotine Dependence Syndrome Scale (NDSS) obtained with samples of mature, heavy smokers has not been replicated in samples of younger, less experienced smokers. Furthermore, the idea that the interrelationships among the NDSS factors are best explained by a single higher-order factor (nicotine dependence) has not been evaluated empirically. This study examined the first- and second-order factor structure of the NDSS in a first-year college sample of light smokers (N=154). NDSS measures completed at the end of the first semester of college were analyzed using confirmatory factor analysis. The hypothesized five-factor model provided adequate fit to the data. The second-order factor model did not fit the data as well as the correlated first-order factor model, suggesting that an overarching dependence factor may not account for the interrelationships among the five first-order factors. This study provided support for the multidimensional structure of the NDSS among a first-year college sample of light smokers.

Introduction

Tobacco use continues to create substantial health and economic consequences for individuals and society, and it remains a serious public health problem in the United States (Centers for Disease Control and Prevention, 2005). Despite gains achieved by prevention and cessation campaigns among many adults over the past three decades, young adults aged 18–25 report the highest rates (45.3%) of tobacco use among individuals aged 12 and older (Substance Abuse and Mental Health Services Administration, 2003), and the prevalence of tobacco use among college students (45.7%) is higher than previously thought (Rigotti, Lee, & Wechsler, 2000). The most common form of tobacco use, cigarette smoking, showed a 28% increase in prevalence among college students between 1993 and 1997 (Wechsler, Rigotti, Gledhill-Hoyt, & Lee, 1998) before leveling off in 1999 (Rigotti et al., 2000).

The college years have been described both as "a time of transition in smoking behavior, with many college students beginning to smoke regularly" (Choi, Harris, Okuyemi, & Ahluwalia, 2003, p. 72), and "an opportune time to intervene to prevent transition from occasional smoking to regular nicotine-dependent smoking" (Wechsler et al., 1998, p. 1677). Although nicotine dependence has been linked with higher levels of cigarette use (Kandel & Chen, 2000), dependence symptoms also have been found at relatively low consumption levels among nondaily adolescent smokers (DiFranza et al., 2000; Karp, O'Loughlin, Paradis, Hanley, & DiFranza, 2005) and first-year college students smoking no more than a pack of cigarettes a week (Dierker et al., 2007). Given that a majority (75.6%) of current college smokers report consuming 10 or fewer cigarettes per day (Rigotti et al., 2000), the college years may represent a favorable time to study

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emerging nicotine dependence (Colby, Tiffany, Shiffman, & Niaura, 2000; Patterson, Lerman, Kaufmann, Neuner, & Audrain-McGovern, 2004) among relatively light smokers.

Pursuing this line of research requires measures that are (a) able to assess degrees of nicotine dependence on a continuum, rather than its categorical presence or absence, (b) multidimensional, tapping the diverse underlying factors that may contribute to the development of nicotine dependence, and (c) appropriate to relatively nascent as well as established smokers (Tiffany, Conklin, Shiffman, & Clayton, 2004). Shiffman, Waters, and Hickcox (2004) developed the Nicotine Dependence Syndrome Scale (NDSS) to address the need for nicotine dependence measures that fulfill these criteria, and to complement popular unidimensional measures of nicotine dependence such as the Fagerström Tolerance Questionnaire (FTQ; Fagerström, 1978) and its revision, the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991).

The NDSS was designed to measure multiple aspects of dependence that have figured prominently in current conceptions of dependence as expressed in Edwards's work (1986) on the dependence syndrome, which influenced the conceptual foundation of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*-IV; American Psychiatric Association, 1994) criteria for dependence (Kassel, 2000). Although symptoms of craving and withdrawal have long been viewed as fundamental to dependence, Edwards and the framers of the *DSM*-IV criteria also regarded other aspects of addictive behavior, such as development of tolerance, insensitivity to negative consequences of use, and the "driven" quality of addictive behavior, as central to the syndrome. Whereas *DSM*-IV dependence diagnoses aggregate these diverse aspects into a single decision, the NDSS assesses each separately, so that empirical analyses can examine their interrelationships and any differential predictions.

Initial investigations of the NDSS were conducted with samples of mature, heavy smokers who were trying to quit smoking, and exploratory principal components analyses produced a five-factor structure (see Measures section for a description of each factor) that the authors labeled *drive*, *priority*, *stereotypy*, *continuity*, and *tolerance* (Shiffman et al., 2004). In addition, a single summary measure (NDSS-total), derived from the first principal component and computed using a regression-based algorithm, was described as a way "to capture overall severity of dependence" (Shiffman et al., 2004, p. 345). The authors found the NDSS-total and individual scale scores were correlated with putative indicators of nicotine dependence such as difficulty abstaining from smoking and (with the exception of the continuity scale) smoking rate and FTQ score. Moreover, multivariate regression analyses indicated that each scale independently predicted smoking rate, difficulty abstaining, and (with the exception of continuity) past severity of withdrawal (Shiffman et al., 2004).

Because the NDSS is a relatively new measure, research on its psychometric properties in samples of younger, lighter smokers is ongoing. Given the scarcity of theoretical information on nicotine dependence in this subpopulation (Shadel, Shiffman, Niaura, & Nichter, 2000), and the absence of a gold standard for measuring dependence among less experienced smokers (DiFranza, Savageau, Rigotti et al., 2002; Kassel, 2000; O'Loughlin, Tarasuk, DiFranza, & Paradis, 2002; Wellman, DiFranza, Savageau, & Dussault, 2004), much of this work has focused on examining the validity of the NDSS in terms of its relation to nicotine dependence indicators established in research with older, chronic smokers. Using an extreme-groups design to assess the NDSS scales' validity, Shiffman & Sayette (2005) contrasted heavy and dependent smokers with "chippers" (i.e., light, nondependent smokers). The authors found that each of the scales successfully discriminated between these groups, and (with the exception of the priority scale) continued to do so in a multivariate model that included all the NDSS scales. Sledjeski et al. (in press) analyzed the predictive validity of NDSS measures collected at the end of the first semester and found (a) drive and tolerance scores predicted smoking quantity and shorter periods of smoking abstinence, and (b) drive scores predicted smoking frequency at the end of the second semester in a sample of light-smoking first-year college students.

Clark and colleagues (2005) used a confirmatory (rather than exploratory) factor analytic approach to examine the NDSS five-factor structure in a primarily clinical sample of daily smoking adolescents aged 12–18 who were at risk for substance abuse problems. The analysis was based on 23 items from the initial version of the NDSS rather than the final 19-item version proposed by Shiffman et al. (2004). The authors concluded that the five-factor model did not fit the data after obtaining a significant chi-square statistic, and an exploratory factor analysis was conducted to examine alternative factor structures using 27 of the initial NDSS items evaluated by Shiffman et al. (2004). The results of this exploratory analysis supported the selection of a four-factor model (based on 26 items) in which the drive and tolerance factors were combined. Of the four scales, only drive/tolerance (which contained 13 of the 26 NDSS items in the model) demonstrated strong internal consistency (α=.90). Each of the NDSS

scales was correlated with FTND scores and predicted smoking quantity at the follow-up assessment (1.9 ± 1.2 years).

Taken together, these findings provide some evidence relating the NDSS scales to different dependence indicators derived from research with older, regular smokers. However, these associations appear to be stronger for some of the scales (i.e., drive, tolerance, priority, and stereotypy) than for others (i.e., continuity). The different patterns of findings also highlight the need for further examination of the performance of the NDSS with younger, less frequent smokers. In particular, the five-factor structure of the 19-item NDSS has not been replicated in other samples of smokers, and the idea that these factors reflect a higher-order latent construct of nicotine dependence has not been evaluated empirically.

Using data collected by the Tobacco Etiology Research Network (TERN) from college freshman enrolled at Purdue University (S. Tiffany, C. Agnew, N. Maylath, L. Dierker, B. Flaherty, E. Richardson, R. Clayton, M. Segress, & Tobacco Etiology Research Network, unpublished information), we examined (a) whether the NDSS factor structure obtained among samples of long-term, heavy smokers enrolled in smoking cessation programs (Shiffman et al., 2004) could be replicated in a college sample of light smokers, and (b) whether a second-order factor, nicotine dependence, could account for the interrelationships among the five hypothesized NDSS factors.

Method

Participants

Participants were selected from responses to a screener survey administered to incoming freshmen during the orientation program in the summer of 2002 (N=4,690, response rate=71%). In all, 2,001 (42%) individuals completing the screener reported at least some experience with smoking (i.e., one or more puffs during their lifetime) and were therefore invited by mail to participate in the study. A total of 912 (46%) of these individuals completed the baseline survey and agreed to take part in 35 weekly Web-based assessments throughout their freshman year. The sample was 48% female and largely White. The data used in these analyses were drawn from surveys completed at week 14, which coincided with the end of the first academic semester. At that time, the NDSS items were presented to 181 participants who reported smoking during the past week. Of these, 7 cases (4%) were set aside because they were missing responses on the NDSS items. Because we were interested in evaluating the factor structure of the NDSS among light smokers (which we defined as those individuals who smoked fewer than 11 cigarettes/day), we also set aside 20 cases (11%) who reported smoking 11 or more cigarettes per day in the last 10 days, yielding an analytic sample of 154 participants.

Measures

The NDSS is a multidimensional measure consisting of 19 items rated on a scale ranging from 1 ("not at all true) to 5 ("extremely true") designed to assess five nicotine dependence factors.

- *Drive* was measured by five items reflecting a strong urge to smoke motivated by feelings of craving and the desire to avoid nicotine withdrawal symptoms. In this sample, the estimated Cronbach's alpha reliability coefficient (α) for this factor was .83.
- *Priority* was measured by three items representing the extent to which greater value is placed on smoking compared with other competing sources of reinforcement (α=.91).
- *Stereotypy* was measured by four items corresponding to a consistent pattern of smoking that is impervious to situational influences (α=.60).
- *Continuity* was measured by four items referring to the tendency to smoke consistently, without interruption (α=.82).
- *Tolerance* was measured by three items reflecting decreased sensitivity to nicotine suggested by reported increases in the amount of smoking since smoking onset (α=.88).

Each week the NDSS items were presented to participants who reported any smoking at all during the past week.

Data analyses

For these analyses we used confirmatory factor analysis, a special case of structural equation modeling. To answer our first research question concerning whether the NDSS factor structure obtained among samples of mature, heavy smokers enrolled in smoking cessation programs could be replicated in a college sample of light smokers, we fitted a first-order five-factor model to the sample data. In this model we allowed the factors to correlate with each other. Next we estimated a second-order factor model to determine whether the latent construct of nicotine dependence could account for the intercorrelations among the five hypothesized NDSS factors.

Because the chi-square statistic can lead to rejection of true models when sample size is small (Bollen, 1989; Hu & Bentler, 1995), we considered other recommended measures in addition to the chi-square statistic to evaluate overall model fit. First, we

examined the root mean square error of approximation (RMSEA), a measure of absolute fit that assesses how well the hypothesized model describes the sample data (Hu & Bentler, 1999). RMSEA values range from 0 to 1; values less than .05 indicate close fit, values between .06 and .08 indicate fair fit, and values greater than .10 indicate poor fit (Browne & Cudeck, 1993). Next we looked at Bentler's comparative fit index (CFI), an incremental fit index shown to be less affected by sample size (Byrne, 1994; Hu & Bentler, 1995) and violations of distributional assumptions (Bentler, 2004). The CFI measures the adequacy of the hypothesized model relative to a baseline model in which the correlations among the indicators are 0. Values range from 0 to 1, and values of .95 or higher indicate adequate fit (Hu & Bentler, 1999). Further, we inspected the distribution of the residuals for signs of model misspecification.

Together with these measures of overall model fit, we examined whether individual parameter estimates contributed significantly to the model (Byrne, 1995) and made sense from a substantive standpoint (e.g., the factor loadings were in the expected direction; Bollen, 1989).

An assumption of the maximum likelihood estimation procedure used in these analyses is that the data are multivariate normally distributed (Bentler, 2004). However, the normalized estimate of multivariate kurtosis for this sample (35.17) was substantially greater than the recommended range of ± 3 (Bentler, 2004) and indicated the data were not drawn from a multivariate normal distribution. One way to correct this problem is to transform the variables (Bollen, 1989). Although transformed variables cannot be interpreted in their original metric, Kline (1998) noted that "[i]f the original metric is arbitrary, then this may not be problematic" (p. 83). Given that the NDSS items were measured using a scale that lacked objective meaning, we decided to apply a logarithmic transformation to all the items. Because the normalized estimate of multivariate kurtosis for the transformed data remained unacceptably high (21.88), we followed the recommended strategy of using robust maximum likelihood methods to estimate all models (Byrne, 2005), available in EQS for Windows version 6.1 (Bentler, 2004). Thus we report the Satorra–Bentler scaled chi-square (S-B χ^2) statistic (Satorra & Bentler, 1988), which incorporates a scaling correction that takes non-normality into account (Bentler, 2004), as well as Bentler's CFI, which is computed from the S-B χ^2 statistic. Similarly, the individual parameter tests that guided our assessment of each indicator's statistical significance were based on robust standard errors.

In general, a likelihood ratio test is used to compare two nested models (in our analyses, the second-order factor model is nested within the first-order factor model) and to evaluate the null hypothesis that both models fit the data equally well. Although the difference between the standard chi-square statistics of two nested models follows a chi-square distribution, that is not the case for the S-B χ^2 statistic (Shermelleh-Engel, Moosbrugger, & Müller, 2003). To address this issue, Satorra and Bentler (2001) developed a scaled difference chi-square test statistic (ΔS-B χ^2) that can be used to compare the S-B χ^2 statistics of two nested models. Crawford (2003) implemented that algorithm in a computer program, which we used to automate the calculations for our analyses.

Results

Smoking behavior and NDSS items

Participants reported smoking an average of 2.86 cigarettes/day (SD=2.76), with responses ranging from less than a full cigarette to 10.4 cigarettes/day. Although smoking in the past 10 days varied from infrequent (1 day) to frequent (every day), on average, participants reported smoking 4.34 days (SD=2.75) out of the past 10 days. Thus some degree of variability existed in tobacco use, even among these light smokers.

Participants' average assessments of how well each of the NDSS items described them (Table 2, Item mean column) were generally skewed toward the lower end of the response scale (i.e., 1="not at all true" to 3="moderately true"), although responses to most of the items spanned the full range of possible values (1–5).

Confirmatory factor analysis of the first-order model

The overall goodness-of-fit measures for the first-order five-factor model (Table 1) suggested that the hypothesized model provided acceptable fit to the sample data. Although the S-B χ^2 statistic was significant, the other measures of model fit (CFI=.95 and RMSEA=.06) offered support for the adequacy of the five-factor model.

In addition, the majority (86%) of the standardized residuals were between $\pm .10$ and were distributed symmetrically around 0. All the individual parameter estimates were statistically significant and loaded as expected on their respective latent factors (Table 2).

The low to moderate interfactor correlations between the majority of the hypothesized factors (Table 3) may imply that they tap different aspects of nicotine dependence.

Post-hoc analysis of the first-order model

Although the interfactor correlations between drive and stereotypy (.68) and tolerance (.71) shown in

Table 1. Goodness-of-fit indicators for the first- and second-order factor models of the NDSS in a college sample of light smokers (N=154).

Model	*df*	S-B χ^2	CFI	RMSEA[a]
First-order five-factor	142	217.27***	.95	.06 (.04–.07)
Second-order	147	259.57***	.92	.07 (.06–.08)
Satorra–Bentler scaled difference chi-square test statistic	5	99.75***		

Note. S-B χ^2, Satorra–Bentler scaled chi-square statistic; CFI, Bentler's robust comparative fit index; RMSEA, root mean square error of approximation. [a]90% confidence interval in parenthesis. *p<.05; **p<.01; ***p<.001.

Table 3 were below the threshold of .80 believed to suggest poor discriminant validity (Brown, 2006), Clark et al.'s (2005) exploratory factor analyses, in which the drive and tolerance factors were combined, provided a substantive rationale for investigating a more parsimonious model. We fitted a three-factor model, combining drive, stereotypy, and tolerance into a single factor, while the priority and continuity factors were left unchanged. The results for this three-factor model, S-B χ^2 (149, N=154)=419.48, p<.0001; CFI=.82; RMSEA=.11, suggested it was a poor fit to the data. Because we were not aware of alternative, theoretically derived multidimensional models of nicotine dependence that were related to

Table 2. Item means (standard deviations), and standardized factor loadings[a] (robust standard errors) for a five-factor model of the Nicotine Dependence Syndrome Scale (NDSS) in a college sample of light smokers (N=154).

Item	Mean (*SD*)	Drive	Priority	Stereotypy	Continuity	Tolerance
After not smoking for a while, I need to smoke in order to keep myself from experiencing any discomfort, anxiety, or restlessness.	1.64 (0.92)	.80 (.07)				
I feel a sense of control over my smoking. I can take it or leave it at any time.[c]	2.62 (1.39)	.54 (.09)				
When I'm really craving a cigarette, it feels like I'm in the grip of some unknown force that I cannot control.	1.42 (0.70)	.70 (.07)				
Whenever I go without smoking for a few hours, I experience craving.	1.65 (0.95)	.92[b]				
After not smoking for a while, I need to smoke to relieve feelings of restlessness and irritability.	1.62 (0.93)	.86 (.05)				
Even if traveling a long distance, I'd rather not travel by airplane because I wouldn't be allowed to smoke.	1.12 (0.43)		.83 (.10)			
Sometimes I decline offers to visit with my parents or nonsmoking friends because I know they'll feel uncomfortable if I smoke.	1.15 (0.48)		.99[b]			
I tend to avoid restaurants that don't allow smoking, even if I would otherwise enjoy the food.	1.15 (0.50)		.90 (.06)			
My smoking is not much affected by other things. I smoke about the same amount whether I am relaxing or working, happy or sad, alone or with others, etc.	1.96 (1.14)			.48 (.16)		
I smoke consistently and regularly throughout the day.	1.38 (0.73)			.74[b]		
My cigarette smoking is fairly regular throughout the day.	1.45 (0.78)			.79 (.15)		
I smoke about the same amount on weekends as on weekdays.	1.66 (0.98)			.42 (.14)		
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.[c]	2.73 (1.50)				.64 (.12)	
I smoke at different rates in different situations.[c]	2.62 (1.27)				.92 (.09)	
It's hard to estimate how many cigarettes I smoke per day because the number often changes.[c]	3.28 (1.46)				.65 (.10)	
The number of cigarettes I smoke per day is often influenced by other factors—how I'm feeling, what I'm doing, etc.[c]	2.75 (1.32)				.81[b]	
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.	2.14 (1.16)					.90 (.08)
Compared to when I first started smoking, I can smoke more now without feeling nauseated or ill.	2.60 (1.23)					.73 (.09)
Since I began to smoke, the amount I smoke has increased somewhat.	2.40 (1.17)					.83[b]

Note. [a]All loadings (except those fixed to 1.00) are significant at p<.05. [b]Unstandardized factor loading was fixed to 1.00 to set the factor scale; thus no significance test was performed. [c]Reverse scored.

Table 3. Interfactor correlations from a five-factor model of the NDSS in a college sample of light smokers (N=154).

Factor	1	2	3	4	5
1. Drive	—				
2. Priority	.36	—			
3. Stereotypy	.68	.53	—		
4. Continuity	−.09	.11	.24	—	
5. Tolerance	.71	.13	.51	−.21	—

the NDSS constructs, and thus lacked a conceptual or empirical justification to respecify the model further (Brown, 2006), we retained the original five-factor model.

Confirmatory factor analysis of the second-order model

In contrast to the first-order five-factor model, results for the second-order factor model did not provide consistent evidence of adequate fit (Table 1). The CFI (.92) was below the minimum value of .95, whereas the RMSEA (.07) approached the upper threshold of "fair" model fit. Compared with the first-order factor model, fewer (73%) of the standardized residuals were between ±.10 and their distribution was less symmetric. In addition, the ΔS-B χ^2 test indicated the fit of the second-order factor model was significantly worse than that of the first-order factor model, ΔS-B χ^2 (5, N=154)=99.75, p<.001. The continuity factor appeared to be the primary source of this decline in fit. Whereas the standardized loadings of the other four factors on the second-order factor were acceptable and in the expected direction (ranging from .38 to .97), the loading for continuity (−.07) was not. In light of Brown's (2006) warning that "analysis of a higher-order solution should be fully confirmatory. This is particularly important, considering the fact that higher-order factors are specified without indicators" (p. 325), we decided against respecifying the second-order factor model by omitting the continuity factor.

Discussion

The NDSS is one of only a few tools (cf., The Hooked on Nicotine Checklist; DiFranza, Savageau, Fletcher et al., 2002) available to researchers aimed at assessing multiple dimensions of nicotine dependence. However, the unresolved question of whether *qualitative* differences exist between younger adults' experiences of nicotine dependence and those of mature, heavy smokers (Colby et al., 2000) suggests the need to determine if adult dependence measures are applicable to younger populations in the early stages of smoking. Because the NDSS is a relatively new measure, further study of its psychometric properties among diverse samples of cigarette smokers (e.g., adolescents and young adults, light smokers) is a research priority.

Using confirmatory factor analysis, we found that the five-factor model developed using samples of long-term, heavy smokers enrolled in smoking cessation programs (Shiffman et al., 2004) was appropriate for college students who are light smokers. Although our findings diverge from the confirmatory factor analysis results reported by Clark et al. (2005), the fact that we used the 19-item (rather than a 23-item) version of the NDSS may be one possible explanation for this discrepancy. Along with the chi-square statistic that Clark and colleagues relied on to reject the five-factor model, we considered other indices of overall model fit that were more appropriate to the characteristics of our data (e.g., a relatively small sample, multivariate nonnormality), which also might account for the difference in our findings.

The results of the second-order factor analysis were in partial conflict with the notion that "the NDSS is best conceptualized as having a multidimensional structure with correlated factors reflecting a higher-order construct of dependence" (Clark et al., 2005, p. 241). Although the first-order factor model demonstrated support for the multidimensional structure of the NDSS, the weak, negative loading of continuity on the higher-order factor offered a plausible explanation for the inability of a higher-order factor to account for the observed relationships among the five NDSS factors. In addition, the patterns of correlations we observed between continuity and the other NDSS factors were consistent with the average scale score correlations that Clark et al. (2005) found during their exploratory analyses. These results raised questions regarding what the continuity construct actually taps among young adults who are light smokers. As Edwards (1986), noted "Not all elements [of the syndrome] need always be present, or present in the same degree, but with mounting intensity the syndrome is likely to show increasing coherence" (p. 172). Perhaps, at this early stage in the development of smoking, continuity of self-administration may not yet be linked to other expressions of dependence. That is, the concept of smoking consistently and without interruption may have been less salient to these smokers, given their light and relatively infrequent patterns of cigarette consumption. On the other hand, more than one latent construct may account for the interrelationships among the first-order factors in this population of smokers. We were, however, unable to investigate this alternative within a confirmatory factor analytic framework (Brown, 2006). These possibilities argue for cautious interpretation of our results

and highlight the need for further empirical and theoretical exploration of emerging nicotine dependence in order to model the higher-order latent construct(s) that may influence the dimensions of dependence captured by the NDSS.

As we noted in the introduction, the NDSS-total score was obtained from a principal components analysis rather than a factor analysis and was computed using the regression-based algorithm described in Shiffman et al. (2004). The goal of principal components analysis is to account for the variance in the observed items, and this method is often used as a data reduction technique to obtain a summary score of multiple items (Harlow, 2005). In contrast, factor analysis attempts to explain the correlation among measures in terms of a set of hypothesized constructs or factors (Tabachnick & Fidell, 2001). Given the different goals of these two approaches, the fact that we did not identify a higher-order factor that could account for the correlations among the five NDSS factors should not be interpreted as discounting the utility of the principal components analysis–derived NDSS-total score.

A feature of the data used in these analyses is that they were drawn from a larger study (S. Tiffany et al., unpublished information) in which the criteria for administering nicotine dependence measures included individuals exposed to nicotine at relatively low levels of use. The NDSS was presented to anyone who reported smoking at all in the previous week. This approach differs from the majority of tobacco use studies that measure dependence symptoms only among individuals who meet clearly established smoking thresholds (e.g., daily use) and allowed us to examine the NDSS factor structure among a relatively understudied group of smokers.

Limitations of the present study are worth noting. This racially homogeneous sample restricts our ability to generalize these results to college students from other racial and ethnic groups. The evidence that, compared with White smokers, Blacks, Asian Americans, Pacific Islanders, and Hispanics smoke fewer cigarettes and are more likely to be occasional smokers (Centers for Disease Control and Prevention, 1998) suggests the need for further study with more diverse samples.

The relatively small sample size is another study limitation. One direct effect of the small sample size was that we were unable to fit confirmatory factor analysis models that treated the indicators as ordinal (rather than continuous) variables. Models based on polychoric correlation matrices failed to converge, which kept us from examining how important the assumption of normality was to the results. We sought to address this issue by considering model fit indices that were less affected by sample size (Byrne, 1994; Hu & Bentler, 1995) and violations of distributional assumptions (Bentler, 2004). In addition, because of the small size of the sample, we may not have had sufficient power to reject the hypothesized five-factor model (Bollen, 1989). Therefore, our results should be considered preliminary until they are replicated with a larger sample.

Our analysis was limited conceptually by the dearth of theory on nicotine dependence in younger, less experienced smokers (Shadel et al., 2000) and by a lack of consensus regarding how to assess dependence in this population. As Kassel (2000) noted, the "operationalization of the construct of nicotine dependence is still a work in progress, and as such, there is no gold standard with respect to its assessment" (p. 32). We presented conceptual and empirical evidence suggesting that the NDSS scales were associated with indicators of nicotine dependence established in research with older, chronic smokers. However, as our results also suggested, those associations may be more robust for some of the scales (i.e., drive, tolerance, priority, and stereotypy) than for others (i.e., continuity).

A characteristic of latent variable models that has important implications for our analysis is that the underlying (and unobservable) dependence constructs we examined were measured indirectly by the manifest NDSS items (Byrne, 1994). Thus the plausibility of the model depends on the extent to which the self-reported measures of smoking-related behaviors and physiological states captured by the NDSS reflect these underlying constructs. Ultimately we believe questions as to whether the NDSS taps underlying dimensions of nicotine dependence, and how they are best represented in the early stages of smoking, will be answered by evolving theoretical and conceptual explanations of the development and expression of dependence among different groups of smokers.

In summary, our results provide evidence of the multidimensional structure of the NDSS among a college sample of light smokers. Answering the need for multivariate approaches to and tools for assessing nicotine dependence (Colby et al., 2000; Piper et al., 2004; Piper, McCarthy, & Baker, 2006; Shadel et al., 2000; Shiffman et al., 2004), the NDSS shows promise as a useful measure for studying the multiple dimensions and "motivating influences" (Tiffany et al., 2004, p. 83) that may contribute to the formation of nicotine dependence. However, the utility of this multidimensional approach to assessing nicotine dependence remains to be firmly established by further empirical work. In particular, it would be useful to examine differential success in predicting future smoking behavior of the individual scales, which could prove useful for developing empirical profiles of dependence. Further research illuminating

the points of convergence and divergence in the experience of nicotine dependence in different groups of smokers will encourage ongoing refinement of the NDSS.

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