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## Concordance of different measures of nicotine dependence: Two pilot studies

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### Abstract

Two samples of adult daily smokers completed a structured interview to determine nicotine dependence according to generic (*DSM-IV/ICD-10*), Fagerström [Fagerström Tolerance Questionnaire (FTQ), Fagerström Test for Nicotine Dependence (FTND), Heavy Smoking Index (HSI), and time to first cigarette after awakening (TFC)], consumption [e.g., cigarettes/day (CPD)], and self-rating (e.g., “how addicted are you”) measures. One sample was a population-based sample of 43 smokers from the Vermont site of the *DSM-IV* field trial for substance use disorders. The other sample consisted of 50 smokers evenly distributed across a wide range of CPD to study biochemical markers of smokers. In the first study, *DSM/ICD* criteria were only slightly correlated with Fagerström ( $r=.24-.35$ ) and consumption ( $r=.06-.33$ ) criteria. Self-rating criteria were correlated moderately with most other criteria ( $r=.24-.60$ ). In the second study, generic, Fagerström, and self-rating criteria increased with increasing CPD up to 30 CPD but not thereafter. One interpretation of these results is that generic, Fagerström, consumption, and self-rating criteria each tap different aspects of nicotine dependence.

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## 1. Introduction

The major methods to determine nicotine dependence can be divided into four types based on their central constructs: (1) generic definitions of substance dependence and their derivatives (American Psychiatric Association, 2000; World Health Organization, 1990), (2) Fagerström tests and their derivatives (Fagerstrom & Schneider, 1989; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991; Heatherton, Kozlowski, Frecker, Rickert, & Robinson, 1989; Kozlowski, Porter, Orleans, Pope, & Heatherton, 1994), (3) consumption (Etzel, 1990; Heatherton et al., 1989; US Department of Health and Human Services, 1988b, 1990), and (4) self-rated dependence (Eiser, Van derPlicht, Raw, & Sutton, 1985; Shiffman, 1993; Tate, Schmitz, & Stanton, 1991). The rationale and empirical evidence for these methods have been reviewed previously (Colby, Tiffany, Shiffman, & Niaura, 2000; Giovino, Henningfield, Tomar, Escobedo, & Slade, 1995; Shadel, Shiffman, Niaura, Nichter, & Abrams, 2000).

The generic definitions require fulfilling a minimum number of criteria that are the same for all substances. The two widely accepted generic definitions are those of the American Psychiatric Association's (APA) *Diagnostic and Statistical Manual* (DSM) (American Psychiatric Association, 2000) and the World Health Organization's (WHO) *International Classification of Disease* (ICD) manuals (World Health Organization, 1990). The latest *DSM-IV-TR* criteria includes tolerance, withdrawal, unsuccessful attempts to stop, use in larger or longer amounts, giving up activities to use, spending a great deal of time acquiring, using or recovering from drug use, and use despite harm (American Psychiatric Association, 2000). The *ICD-10* includes the first 5 criteria but also compulsion to use (World Health Organization, 1990). In addition, some authors have begun to develop derivatives of the *DSM/ICD* approach (Cohen, Myers, & Kelly, 2002; Covey & Struening, 1999; Etter, LeHouezec, & Perneger, 2003; Shiffman, Waters, Hickcox in press). The major advantages of the *DSM/ICD* approach are that the criteria are derived directly from well-accepted formulations of dependence (Edwards, 1986) and that their generic nature allows for cross-drug comparisons (Cottler et al., 1995).

The original Fagerström test—the Fagerström Tolerance Questionnaire (FTQ) (Fagerstrom & Schneider, 1989)—consists of three consumption questions [cigarettes/day (CPD), nicotine yield, and depth of inhalation], two impaired control items (difficulty with restrictions and smoking when ill), and two items that could be classified as either consumption or impaired control [time to first cigarette after awakening (TFC) and smoking more in the morning]. The Fagerström Test for Nicotine Dependence (FTND) is a shortened version of the FTQ that excludes nicotine yield and inhalation items and gives a broader response range to the CPD and TFC items (Heatherton et al., 1989). Because TFC is the most helpful item on the FTQ/FTND, it has been used as a dependence index itself (Kozlowski et al., 1994). Finally, a Heavy Smoking Index (HSI) has been composed using both TFC and CPD (Heatherton et al., 1989). The major assets of the Fagerström tests are that they are easy-to-obtain self-report measures and have been shown to have predictive validity in many tests (Fagerstrom & Schneider, 1989; Kozlowski et al., 1994; Pomerleau, Majchrzak, & Pomerleau, 1989). Their major liability is their poor psychometric features plus the fact that much of their validity may depend on their measures of consumption (Etter, Vu Duc, & Perneger, 1999).

The most commonly used consumption measure has been CPD. The major advantage of CPD is that it is easy to measure. CPD does appear to have some validity in that it predicts difficulty quitting and, although not always, often predicts response to dependence-based treatments (US Department of Health and Human Services, 1988b, 1990). It also weakly predicts withdrawal and compensation (US Department of Health and Human Services, 1988a). The major liabilities of CPD are digit bias in its measurement (Klesges, Debon, & Ray, 1995; Patrick et al., 1994), its nonlinear correlation with actual nicotine intake (US Department of Health and Human Services, 1988a) and, at least in the United States, the fact that it is determined to a large degree by smoking restrictions, social disapproval or ethnicity rather than dependence (US Department of Health and Human Services, 1988a).

Another consumption measure is cotinine which is a metabolite of nicotine (Etzel, 1990). Cotinine is a good measure of nicotine intake and is a weak predictor of difficulty in quitting. In some, but not all, studies, it predicts response to dependence-based treatments (US Department of Health and Human Services, 1988a). The major advantage of cotinine is that it is an objective measure. Its major liability is that it requires a biological specimen and is costly to obtain. Although TFC and HSI were previously discussed as variants of Fagerström criteria because their items are measures of how many and when cigarettes are used, they could also be considered consumption-based measures.

Several measures of self-rated dependence have been used; for example, a one-time rating of how difficult it would be to quit smoking or level of addiction (Eiser et al., 1985) and scales on Reasons for Smoking Questionnaires (Etter et al., 1999; Tate et al., 1991). The major advantages of these measures are that they may tap phenomena that are not listed in set criteria and, because they are idiosyncratic, they may have better predictive validity. Their major liability is their poor performance in psychometric tests (Etter et al., 1999; Tate et al., 1991). However, recently more sophisticated measures of motives for smoking have been developed as measures of dependence (Piper et al., *in press*).

Several other measures of nicotine dependence have been put forward but have not been used routinely in clinical research or practice. The 1988 U.S. Surgeon General's report gave a definition of dependence; however, it was focused on evaluating basic science and clinical evidence that the drug nicotine was dependence producing, not on determining dependence among users (US Department of Health and Human Services, 1988a). The Council on Alcoholism has a definition of alcoholism; however, this definition uses many constructs that do not appear to apply to nicotine dependence, for example, denial (Morse & Flavin, 1992). Finally, there are earlier definitions of drug dependence that focused on intoxication, social dysfunction, etc. which have now been discarded as incorrect (Hughes, 1993).

The major purpose of the current article is to examine the concordance of several of the above-described dependence definitions. Prior studies have examined the concordance of one dependence measure vs. 1–2 other measures (Breslau, Johnson, Hiripi, & Kessler, 2001; Cohen et al., 2002; Etter et al., 1999; Fagerstrom & Schneider, 1989; Hudmon et al., 2003; Hughes, Gust, & Pechacek, 1987; Kawakami, Takatsuka, Shimizu, & Takai, 1998; Marks, Pomerleau, & Pomerleau, 1998; Mikami et al., 1999; Moolchan et al., 2002; Strong, Brown,

Ramsey, & Myers, 2003). We conducted a concordance test across multiple measures in two studies. The first was a population-based survey. The second was a study that called for equal numbers of smokers across a wide range of cigarette use (0 to 40+/day).

## 2. Methods of Study 1

The data for this study came from the Vermont site of the multisite *DSM-IV* field trial for substance use disorders. The overall results of this trial (Cottler et al., 1995) and the results from the Vermont site specific to caffeine (Hughes, Oliveto, Liguori, Carpenter, & Howard, 1998) and cross-drug dependence (Hughes, Oliveto, & MacLaughlin, 2000) have been previously published. In 1990, the Vermont site recruited 202 adults via random-digit dial telephone survey of the greater Burlington, VT area. Numbers to be called and one adult per household were selected by the methods of Kish (1965) and Waksberg (1978). The only inclusion criterion was being over age 18. Participants gave verbal informed consent and the study was approved by the University of Vermont Committee on Human Use.

Among the participants at the Vermont site, the 43 current daily smokers who did not currently use any other tobacco product were the participants for this analysis. In this sample, 44% were men, 84% had finished high school, 71% were employed, 40% were married, and all were Caucasian. Their mean age was 39 (S.D. = 13). They currently smoked 18 (10) CPD with an age of onset of smoking of 17 (4).

The dependence interview was in several parts. One part was a structured interview developed by the authors that asked the generic substance dependence criteria for *DSM-III*, *DSM-III-R*, *DSM-IV*, *ICD-9*, and *ICD-10*. This interview was developed via three previously described pilot studies that found adequate inter- and intrarater reliability and found rates of reporting via telephone similar to those obtained in person (Hughes et al., 1998). The interview asked only about dependence among current smokers and only about symptoms in the last year because we could not obtain high test–retest reliability for lifetime criteria. When the *DSM* criteria used the adjectives “often,” “frequently,” and “persistently,” we operationalized these as behaviors occurring at least monthly. The questionnaire also asked the items for deriving FTQ, FTND, HSI, and TFC measures. TFC was scored both not as a continuous measure and in the categories recommended in the HSI. The questionnaire also recorded usual CPD and a one-item self-rating of addiction to cigarettes and of difficulty quitting on a 0–10 scale with anchors of *not at all* at 0 and *very much* at 10. The entire interview lasted 20–90 min and participants were reimbursed US\$20 for their time.

Because there is little information about the validity of *DSM/WHO* criteria when applied to nicotine dependence (Colby et al., 2000), we also estimated clinical validity by comparing *DSM/WHO* criteria and ratings of clinical experts. We asked eight substance abuse experts (see Acknowledgements) to rate case reports as showing dependence (i.e., rating the case as moderate or severe dependence) vs. not dependent (rating the case as not present or mild). Eight case reports were developed from interviews in which participant endorsed five or more *DSM-IV* nicotine dependence criteria (i.e., the more

Table 1  
Measures of dependence used

Measure	Continuous measure	Categorical cutoff
DSM-IV	Number of criteria met (0–7)	$\geq 3$
ICD-10	Number of criteria met (0–6)	$\geq 3$
FTQ	Score (0–11)	$\geq 7$
FTND	Score (0–8)	$\geq 5$
TFC	Minutes	$\geq 15$ min
HSI	Score (0–6)	None
CPD	Number	$\geq 25$
SRQD, SRAD	0–10	None

*DSM-IV* = *Diagnostic and Statistical Manual, Fourth Edition* (American Psychiatric Association, 2000).

*ICD-10* = *International Classification of Diseases, 10th Edition* (World Health Organization, 1990).

FTQ = Fagerström Tolerance Questionnaire (Fagerström & Schneider, 1989).

FTND = Fagerström Test for Nicotine Dependence (Heatherton et al., 1991).

TFC = Time to first cigarette (Kozlowski et al., 1994).

HSI = Heavy Smoking Index (Heatherton et al., 1989).

CPD = Cigarettes/day.

SRQD = Self-reported quitting difficulty (Eiser et al., 1985).

SRAD = Self-reported addiction (Shiffman, 1993).

severe cases) and eight from interviews in which participants endorsed two or fewer criteria. In addition, eight of these case reports were rerated several months later to obtain test–retest estimates.

Although dependence is often thought of as a categorical outcome (American Psychiatric Association, 2000), more recent work suggests it is best viewed as a continuous outcome (Colby et al., 2000); thus, we have used both the traditional dichotomous outcome and the number of *DSM/ICD* criteria endorsed (Langenbucher, Morgenstern, & Miller, 1995; Woody, Cottler, & Cacciola, 1993). Most of our measures are ordinal variables; thus, we focus on Spearman correlation coefficients. With a sample size of 43, our ordinal measures have moderate statistical power (they have a 75% and 83% chance of detecting correlation coefficients  $\geq r=.40$ ). We also report some categorical analyses (see Table 1 for category definitions) but remind the reader they have little statistical power.

### 3. Results of Study 1

#### 3.1. Clinical validity test

The overall  $\kappa$  for agreement between the expert rater and the interview-derived diagnosis of nicotine dependence for *DSM-IV* was .66. The 20% discordancies were all expert rater positive/interview negative discordancies. The test–retest  $\kappa$  was .88. These inter- and intrarater  $\kappa$  values are similar to those we and others (Hughes et al., 1998) have found with alcohol and other drug dependencies.

### 3.2. Concordance of measures

The scores on the dependence scales and the incidence of meeting the various criteria for dependence (Table 2) are similar to those reported in other studies of U.S. current daily smokers (Anthony, Warner, & Kessler, 1994; Breslau et al., 2001; Breslau, Kilbey, & Andreski, 1994; Giovino et al., 1995; Kandel, Chen, Warner, Kessler, & Grant, 1997; Moolchan et al., 2002). Measures *within* each of the four types of criteria (generic, FTQ, consumption, and self-rating) ask about similar constructs; thus, as expected, they were highly correlated (Table 3, below the diagonal). In addition, because the Fagerström scales include questions on consumption, they were highly correlated with consumption items (Table 3, below the diagonal).

On the other hand, measures *across* the different types were poorly correlated. Generic scores (*DSM/ICD*) were either not correlated or correlated only somewhat with the FTQ

Table 2  
Mean (95% CI) and prevalence scores for dependence scales<sup>a</sup>

	Study 1 ( <i>n</i> = 43)	Study 2 ( <i>n</i> = 50)
<i>DSM-IV</i> (0–7)		
Number of criteria	3.4 (2.9–3.9)	4.5 (3.9–4.8)
% ≥ 3	63%	86%
<i>ICD-10</i> (0–6)		
Number of criteria	2.7 (2.2–3.2)	3.8 (3.4–4.3)
% ≥ 3	51%	82%
<i>FTQ</i> (3–11)		
Mean	5.0 (4.4–5.6)	6.5 (5.8–7.1)
% ≥ 7	38%	44%
<i>FTND</i> (0–8)		
Mean	3.8 (3.0–4.5)	5.8 (5.0–6.7)
% ≥ 5	40%	58%
<i>TFC</i>		
Mean	45.2	33.1
<i>CPD</i>		
Mean	17.7 (14.6–20.9)	26.8 (22.7–30.5)
<i>HSI</i>		
Mean	2.7 (2.3–3.2)	3.7 (3.1–4.3)
<i>SRQD</i>		
Mean (0–10)	8.1 (7.4–8.9)	8.8 (8.1–9.4)
<i>SRAD</i>		
Mean (0–10)	7.9 (7.2–8.7)	8.9 (8.3–9.5)

<sup>a</sup> See Table 1 for abbreviations.

Table 3

Correlations among dependence scales within same category (below the diagonal) and across different categories (above diagonal)<sup>a</sup>

	DSM-IV	ICD-10	DSM-III	FTQ	FTND	TFC	HSI	CPD	SRQD	SRAD
DSM-IV		–	–	<b>.35</b>	<b>.32</b>	–.06	.20	.33	<b>.37</b>	<b>.48</b>
ICD-10	<b>.87</b>		–	.23	.32	–.06	.22	.32	<b>.57</b>	<b>.58</b>
DSM-III	<b>.75</b>	<b>.71</b>		.29	.24	–.01	.15	.22	.24	<b>.30</b>
FTQ	–	–	–		–	–	–	–	<b>.39</b>	<b>.42</b>
FTND	–	–	–	<b>.88</b>		–	–	–	<b>.58</b>	<b>.53</b>
TFC	–	–	–	– <b>.67</b>	– <b>.80</b>		–	–	– <b>.50</b>	– <b>.50</b>
HSI	–	–	–	<b>.71</b>	<b>.90</b>	– <b>.90</b>		–	<b>.60</b>	<b>.58</b>
CPD	–	–	–	<b>.60</b>	<b>.76</b>	– <b>.65</b>	<b>.84</b>		<b>.51</b>	<b>.49</b>
SRQD	–	–	–	–	–	–	–	–		–
SRAD	–	–	–	–	–	–	–	–	<b>.89</b>	–

Numbers in bold =  $P < .05$ .

<sup>a</sup> See Table 1 for definitions of abbreviations.

( $r = .23$ – $.35$ ), FTND ( $r = .24$ – $.32$ ), or consumption ( $r = .06$ – $.33$ ) measures (Table 3, above the diagonal). Self-rated difficulty quitting and addiction ratings were moderately correlated with generic, Fagerström, and consumption measures ( $r = .24$ – $.60$ ; Table 3, above the diagonal).

The concordance of categorical diagnoses of generic vs. FTND, CPD and TFI measures was also poor ( $\kappa = .06$ – $.29$ ; Table 4).

### 3.3. Methods of Study 2

The major aim of Study 2 was to compare the utility of blood, urine, and saliva thiocyanate as a measure of smoke exposure across smokers who varied widely in CPD. Those results have not been published. We successfully recruited all participants in this study to also complete the survey of nicotine dependence described in Study 1 in return for reimbursement of US\$20 for their time.

Table 4

Concordance of selected dependence measures

		Yes	No	
		<i>FTND ≥ 5</i>		
DSM-IV ≥ 3	Yes	14	3	$\kappa=.29$
	No	13	13	
		<i>TFC ≤ 15</i>		
DSM-IV ≥ 3	Yes	10	7	$\kappa=.06$
	No	17	9	
		<i>CPD &gt; 20</i>		
DSM-IV ≥ 3	Yes	8	19	$\kappa=.17$
	No	2	14	



Fifty participants were recruited via newspaper ads for a nontreatment smoking study. Eligibility criteria were as follows: smoke daily, >18 years old, smoked >1 year, no attempt to change the number of CPD in last month, and no use of tobacco or nicotine products other than cigarettes in the last month. We recruited until we obtained 10 smokers in each of five categories: 1–10, 11–20, 21–30, 31–40, >40 CPD. Thus, unlike the prior study, this sample was not population based.

Among these participants, 46% were men, 92% had finished high school, 60% were employed, and 28% were married. They had a mean age of 45 (S.D. = 13). Their mean age of onset of smoking was 17 (3). Participants underwent informed consent and the study was approved by the University of Vermont Committees on Human Research.

Participants provided a breath, urine, saliva, and blood sample and then underwent our previously described interview which included *DSM* criteria, FTQ/FTND, and usual number of CPD. Unfortunately, due to lack of funding, analyses of cotinine are not available.

Because we were mostly interested in the relationship of CPD with measures of dependence that are conceptually independent, we did not examine the relationship of CPD with TFC or HSI as CPD. The FTQ and FTND measures also include CPD as part of their scoring; thus, to examine the independent relationship of these measures to CPD, we removed the CPD and TFC items from their scoring prior to their analysis. The statistical test was an *a priori* specified linear contrast within a one-way ANOVA with five cells (1–10, 11–20, 21–30, 31–40, >40 CPD).

### 3.4. Results of Study 2

The generic criteria, the Fagerström measures (minus CPD and TFC) and the self-rated addiction were dose-related to CPD (Fig. 1; all  $P$ s < .04). Self-rated difficulty quitting showed a similar nonstatistical trend to increase with dose ( $P=.08$ ). Post hoc analyses indicated

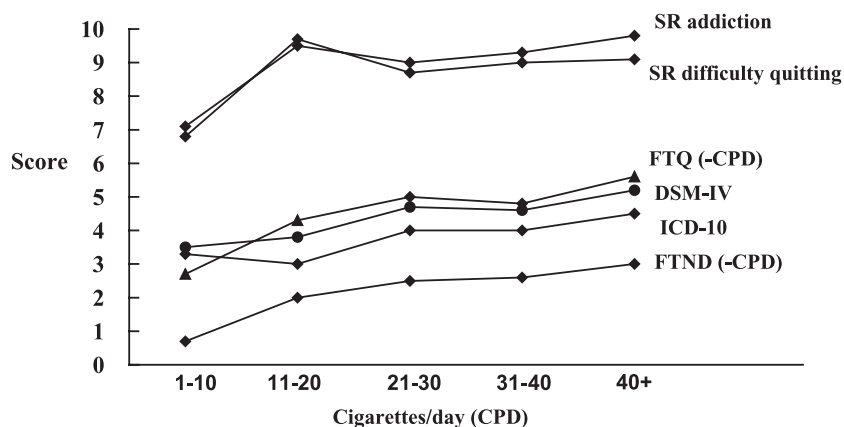


Fig. 1. Dependence measures vs. CPD. See Table 1 for abbreviations. FTQ and FTND measures were modified by removing CPD and TFC scores.



dependence scores increased across the three 1–30 CPD range cells ( $P < .05$ ) but not at the two higher levels of CPD ( $P > .10$ ).

## 4. Discussion

### 4.1. Summary of results

The generic and Fagerström criteria were poorly correlated in Study 1. This result is similar to those in most of the prior studies of generic vs. Fagerström criteria. In those studies, the correlations between Fagerström scores and number of *DSM* criteria were .17 (Marks et al., 1998), .22 (Cohen et al., 2002), .32 (Strong et al., 2003), and .70 (Mikami et al., 1999) vs. our .23–.35. Similarly,  $\kappa$  values for meeting diagnosis for *DSM* vs. FTQ measures across prior studies were .04 (Hughes et al., 1987), .08 (Kawakami et al., 1998), .10–.18 (Moolchan et al., 2002), and .21 (Breslau & Johnson, 2000) vs. our .06–.29. Unexpectedly, self-perceived difficulty quitting and addiction were modestly correlated with generic, Fagerström, and consumption items. Finally, the dependence measures increased with increasing CPD in light but not heavy smokers. This result is consistent with the one prior study (Kandel & Chen, 2000).

### 4.2. Interpretation of results

The major limitations of the current analysis are its small sample size and reliance on self-report measures. The major assets are the use of multiple measures of nicotine dependence and its finding of results similar to those in prior studies.

One possible interpretation of the poor concordance across dependence measures is that it indicates that these measures lack validity (Atrens, 2001; Frenk & Dar, 2000). However, given that most of these measures have been shown to predict ability to stop smoking, response to medication, changes in smoking due to nicotine manipulation, or prevalence of psychiatric comorbidity (Breslau et al., 2001; Etter et al., 1999; Fagerstrom & Schneider, 1989; Henningfield, Malvestutto, & Burns, submitted for publication; Kozłowski et al., 1994; Pomerleau et al., 1989; US Department of Health and Human Services, 1988a, 1988b, 1990), we believe a more reasonable interpretation is that these measures tap different aspects of nicotine dependence (Etter et al., 1999; Shadel et al., 2000). For example, the generic criteria focus on impaired control over drug use and ignore consumption, whereas the Fagerström measures rely heavily on consumption items and, depending on interpretation, have only 1–3 items indexing impaired control.

Another alternate explanation of the poor correlation is that several of the measures that were originally developed based on filling out written forms (e.g., the CPD, Fagerström, and self-rating measures) were asked in a telephone format in this study. In addition, the poor correlation may arise from the poor psychometrics of each of the measures themselves (Colby et al., 2000; Etter et al., 1999; Shiffman et al., 1995). Finally, one could argue that because the generic criteria were developed to be dichotomous variables (American

Psychiatric Association, 2000), using the number of criteria endorsed as ordinal variables is inappropriate. However, recent data suggests ordinal variables are valid (Langenbucher et al., 1995; Woody et al., 1993).

If our interpretation is correct, it implies that nicotine dependence is not a unidimensional construct (Breslau & Johnson, 2000; Colby et al., 2000; Johnson, Breslau, & Anthony, 1996; Shadel et al., 2000). This would not be unexpected considering several, but not all, studies that indicate dependence on nonnicotine drugs is multidimensional (Bryant, Rounsaville, & Babor, 1991; Kosten, Rounsaville, Babor, Spitzer, & Williams, 1987; Muthen, Grant, & Hasin, 1993). Interestingly, the fact that one-item self-ratings of dependence were correlated with most other dependence measures suggests global ratings are, in fact, based on several types of information; that is, when asked this question, smokers consider their impaired ability to quit, how soon they smoke upon waking, how many CPD they smoke, etc.

If the dependence measures are tapping different aspects of nicotine dependence, then the measures should differ in their ability to predict different outcomes: cessation, response to treatment, family aggregation, comorbidity, biological markers, and natural course of tobacco use. The only study to test this found that consumption best predicted ability to abstain but generic criteria best predicted psychiatric comorbidity (Breslau & Johnson, 2000). Perhaps the ultimate confirmation of the multidimensional nature of nicotine dependence would be to show that by combining generic, Fagerström, consumption, and self-perception measures, one improves validity.

Finally, because our results and those of prior studies indicate measures of nicotine dependence are not highly correlated, future studies should include several dependence measures. If this is done, we may begin to find whether one dependence measure outperforms another, or, as we think more likely, measures differ in which outcomes they are good at predicting.

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