

Review

Assessing tobacco dependence: A guide to measure evaluation and selection

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Tobacco dependence is a key construct in tobacco research. This paper describes a construct validation approach to dependence assessment and describes key conceptual and psychometric criteria on which to evaluate putative measures of dependence. Five current dependence scales—the Fagerström Test for Nicotine Dependence; the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.); the Cigarette Dependence Scale; the Nicotine Dependence Syndrome Scale; and the Wisconsin Inventory of Smoking Dependence Motives—are examined with respect to these critical dimensions. Recommendations are made regarding the use of each measure.

Introduction

Many tobacco researchers and clinicians are interested in the concept of tobacco dependence—a hypothetical construct invoked to explain smoking relapse, heavy drug use, and severe withdrawal symptoms (e.g., U.S. Department of Health and Human Services [USDHHS], 1988), among other phenomena. Throughout this paper, we refer to tobacco dependence rather than nicotine or cigarette dependence so that dependence is not unnecessarily restricted to a single tobacco constituent or to a single delivery device (Fiore et al., 2000).

Progress in tobacco research may depend on improved measurement. At present, measures of dependence are only modestly related to important dependence criteria such as relapse (e.g., Breslau & Johnson, 2000; Kenford et al., 1994), and extant measures of dependence do not consistently agree with one another (e.g., Moolchan et al., 2002). Improved measures of dependence might redress

such problems and illuminate dependence mechanisms (e.g., underlying processes that produce dependence). In keeping with this perspective, the goals of the present paper are to review the principles and procedures relevant to the assessment of a complex construct such as tobacco dependence and to evaluate how extant dependence measures stack up against such psychometric criteria. We believe that greater familiarity with a construct validation approach to assessment will enhance clinicians' and tobacco scientists' evaluation, development, selection, and use of dependence measures.

A construct validation approach to tobacco dependence measurement

A construct is “some postulated attribute of people, assumed to be reflected in test performance” (Cronbach & Meehl, 1955, p.283). A construct cannot be measured directly and no single variable can index it completely—it is defined by the interlocking system of laws that relate it to other constructs and to observable properties or manipulations of the environment (Wiggins, 1973). Cronbach & Meehl (1955) dubbed this interlocking system of laws the nomological network, which depicts constructs and observable variables as interconnected through a set of theory-guided lawful relations. To

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date, measures of tobacco dependence have not been clearly embedded in a theoretically grounded nomological network that defines dependence in terms of its relations to other constructs (e.g., postulated mechanisms of dependence) and observables (e.g., responses on test items and criterion measures).

In a construct validation approach, a theory of dependence should suggest (a) the test items that measure dependence, (b) how these test items are related to one another, and (c) how the test items are related to theoretically, societally, and clinically meaningful outcomes (criteria) that are attributed to dependence (Figures 1 and 2; Meehl, 1995). Once a theory of dependence has been articulated, dependence items developed, and dependence criteria identified, then the measure is evaluated in terms of its psychometric characteristics and utility. Below, we discuss critical steps in the development and evaluation of an assessment of a complex construct.

Measurement development

A theory of dependence should specify the basic structure of the phenomenon. It should specify whether dependence is unitary, produced perhaps by a single process (e.g., the development of withdrawal symptoms), or multifactorial. Regardless of the number of constituents, the theory should specify features or mechanisms of dependence. The features should suggest test items that reflect the presence or

amount of the dependence features or mechanisms. Each of these elements of dependence can be assessed at a variety of levels, ranging from neuropharmacological processes to overt behaviors. For practical reasons, most dependence measures use self-report strategies and, therefore, the measures target constructs and events available to awareness. Figure 1 depicts a multifaceted dependence construct in which dependence is defined on the basis of three processes or features and each of these is measured with multiple items (e.g., the motivational significance of conditional stimuli could be tapped by items that assess the extent to which cigarette cues attract attention or trigger craving). Clark and Watson (1995) provide an excellent review of the steps necessary for theory-based assessment development.

Selection of dependence criteria

A criterion is an outcome that a measure is intended to predict, and it should be defined or chosen based on three considerations. First, a theoretical link must exist between a criterion and the target construct (i.e., dependence). Second, a criterion is of clinical, societal, or research import. In other words, criteria are important constructs or observables that we wish to assess or predict for specific clinical, social, or research reasons. Finally, a criterion should be chosen based on the measurement goal; in other words, the goal driving measure development should guide criteria selection.

Heavy use, withdrawal, and relapse may be considered core criteria of tobacco dependence (e.g., USDHHS, 1988). These criteria have social, research, or clinical import, and they can be clearly linked to hypothesized dependence mechanisms or features. For instance, a theory might posit that the tendency to relapse (a core criterion) is related to the magnitude of affective response to smoking cues (Waters, Shiffman, & Sayette, 2004). A dependence assay could then be developed with items that assess affective responses to smoking cues, and the association between individuals' responses to these items and status on the relapse criterion would be tested. The relation between item responses and the criterion would constitute evidence of the measure's validity. Alternative core criteria might be suggested by other conceptualizations of dependence such as continued drug use despite awareness of harmful consequences or opposing motivation (i.e., a "harmful consequences" criterion; Edwards, 1986), tolerance (Siegel, 1983), or loss of control (DiFranza et al., 2002). The relative importance of such criteria will be determined by the underlying theory. This review focuses on the criteria of heavy use, withdrawal, and relapse when evaluating extant measures of tobacco dependence (Figure 2).

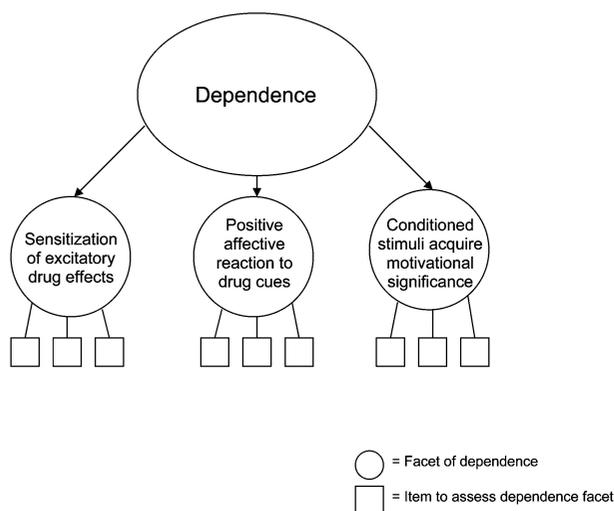


Figure 1. A multifaceted model of tobacco dependence, with three exemplar components of dependence: (a) conditioned stimuli have acquired motivational significance, (b) sensitization of excitatory drug effects, and (c) positive affect reaction to drug cues. These three components represent key mechanisms and events that define dependence within certain theoretical models. Each of these facets is then assessed using specific items indicated by squares.

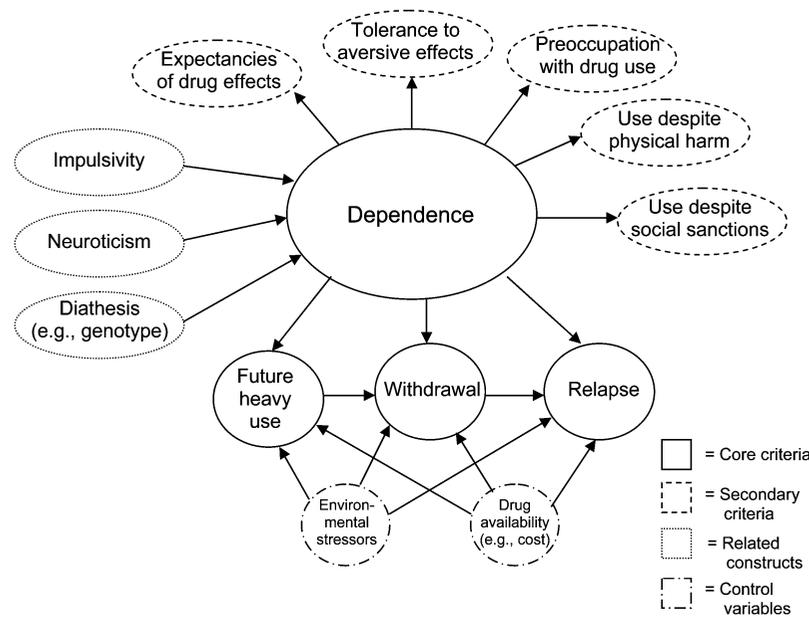


Figure 2. The evaluation context for a positive incentive model of tobacco dependence. The unshaded circles represent the three core criteria: heavy use, withdrawal, and relapse, which serve as key validation criteria. The diagonally shaded ovals represent secondary criteria that are important to dependence theory but either are not intrinsically important or are not the focus of the assessment. The vertically shaded ovals represent related constructs that are conceptually distinct from dependence but provide predictive information. The dotted circles represent the specific influence of control variables on the core criteria. Reciprocal relationships are possible but not indicated (e.g., heavy use reflects dependence but also contributes to it).

Why not assess criteria directly? Why take the circuitous route of assessing the target construct and then using the presence or magnitude of the target construct to predict criteria? For the purposes of classification it is, no doubt, often desirable to measure dependence criteria directly (i.e., directly measure the endpoints of addiction). But this approach has limitations. First, endpoints may be crude, insensitive indicators of dependence. Second, it is often desirable to be able to predict dependence development, or to detect the initial manifestations of dependence. Third, direct assessment of criteria rarely improves understanding of the nature of dependence, that is, adding little scientific insight or explanation. Finally, in many cases it is not practical, economically feasible, or possible on a routine basis to measure criteria directly and accurately.

When developing a measure of dependence, researchers must recognize that similar constructs may occur both as facets of dependence and as criteria. For instance, one may assume that heavy tobacco use is a necessary causal influence on dependence, yet it also seems vital that a dependence measure be able to predict level of tobacco use (i.e., that heaviness of tobacco use be a criterion). This overlap between dependence mechanisms or components and criteria raises the prospect of criterion contamination. Criterion contamination occurs when a researcher claims that the relation between different measures provides insight into the nature

of a construct but inspection reveals significant content overlap between the two measures (e.g., when a dependence scale measures self-reported tobacco use and then is used to “predict” self-reported tobacco use).

Figure 2 also depicts secondary criteria, which are theoretically linked to the construct and can provide information about the construct but do not have the importance of the core criteria. They may be less tightly related to the guiding theory than are core criteria; not be of social, clinical, or research import; or not be relevant to the measurement goal. For example, an investigator might view demand elasticity (e.g., Bickel & Marsch, 2001; Vuchinich & Tucker, 1988) as a secondary criterion because, although it is theoretically relevant, it has little intrinsic clinical importance and its estimation may not be the goal of the assessment.

Finally, Figure 2 depicts related constructs such as impulsivity, neuroticism, and biological vulnerabilities (e.g., genotype). A related construct is not intrinsic to the target construct, as specified by the theory of dependence (i.e., it does not reflect a mechanism of dependence). Rather, it reflects a protective factor or a potential vulnerability (e.g., impulsivity; Bickel, Odum, & Madden, 1999; Mitchell, 1999) to developing the target construct (e.g., dependence). Thus related constructs are conceptually distinct from dependence but may provide information about who is more likely to

become dependent (e.g., individuals high in neuroticism may be more likely to be highly dependent; Breslau, Kilbey, & Andreski, 1993; Kawakami, Takai, Takatsuka, & Shimizu, 2000).

Assessment of relations within the nomological network and evaluation context

Elaboration of the nomological network and the full set of variables relevant to the evaluation of a measure (i.e., the evaluation context) provides a theoretical framework within which to design studies and evaluate empirical results. Therefore, the nomological network not only defines the construct but also provides a context for the evaluation of the dependence measures by specifying which variables should be related to dependence.

The evaluation context depicted in Figure 2 reflects the hypothesis that the core criteria of heavy use, withdrawal, and relapse are multiply determined and that dependence is related to these core criteria in a linear, probabilistic manner, such that greater dependence would predict greater use, more severe withdrawal, and greater likelihood of relapse. However, because these criteria are related to other control variables, independent of dependence, the target construct, though related, is not equivalent to a person's status on the criteria. In the language of factor analysis, the target construct may be the general factor influencing the criteria, but researchers need to take into account additional specific influences. Doing so might produce a clearer understanding of how important a person-factor such as dependence is in predicting relapse, versus environmental or contextual factors such as presence of stressors. Conversely, high values on particular criteria may not necessarily indicate dependence (e.g., medical patients may use drugs, such as opiates, heavily but not meet other criteria for dependence, such as relapse back to drug use). In other words, none of the three core criteria is necessary or sufficient to indicate dependence.

At least five different relations should be examined when analyzing empirical data in the context of construct validation:

- Examine how items are related to one another, and how they are related to critical constructs. This would include traditional tests used to establish the psychometric properties of an assessment instrument such as the internal consistency of an instrument (its reliability) and its structure. For example, do the items correlate highly with one another or do correlational or covariance patterns indicate subgroupings of items suggesting that a construct has distinct facets?
- If the measure of dependence has different facets or subfactors, determine how these are related to

one another. Are they meaningfully related to one another as one would expect if they are all components of the same construct (dependence)? Does a single second-order factor explain their covariation?

- Determine whether the measure predicts the criteria it was designed to predict. If theory and obtained data suggest that the measure taps different facets of dependence, then the relation of each facet and the criteria should be examined.
- Are the criteria meaningfully related to one another? If they are essentially unrelated to one another, then the attempt to link them to a common influence (i.e., dependence) will be doomed. These evaluations should be conducted after control variables (Figure 2) are used to remove variance that is not theoretically linked to dependence.
- Determine whether the related constructs perform as predicted. For instance, are individuals high in trait neuroticism or impulsivity more likely to become dependent upon exposure to tobacco?

Measurement development is a process of bootstrapping—an iterative process in which theory guides the refinement of a measure and information gained in the process of measure validation is used to refine or modify the theory, which then may have further impact on the measure (Cronbach & Meehl, 1955; Lakatos, 1970). The analyses described above would allow researchers to evaluate numerous components of the nomological network and to focus on areas of the network that may need modification or further assessment.

Tobacco dependence measures: Traditional and new

Having reviewed psychometric principles relevant to a construct validation approach to measure development and evaluation, we use these principles to review five published measures of tobacco dependence. The measures reviewed here focus on tobacco dependence in adults rather than in children and adolescents (e.g., Clark, Wood, & Martin, 2005; Nonnemaker et al., 2004; Wheeler, Fletcher, Wellman, & DiFranza, 2004). Our review of construct validation revealed that measures should be evaluated with regard to factors such as reliability, structure, construct validity (e.g., convergent or incremental validity), and the degree to which the measure provides insight into, or understanding of, the targeted construct. Convergent validity means that a measure should be strongly associated with other valid measures of dependence, and incremental validity refers to the extent to which a measure predicts important criteria such as relapse risk over and above the predictions yielded by

other measures. Finally, an ideal dependence measure should provide insight: An improved understanding of the mechanisms and processes underlying dependence. The reviews below are summarized in Table 1.

The Fagerström Tolerance Questionnaire and the Fagerström Test for Nicotine Dependence

The most commonly used tobacco dependence measures are the Fagerström Tolerance Questionnaire (FTQ; Fagerström, 1978) and the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991). The FTQ was developed to measure the construct of physical dependence based on Schuster & Johanson's (1974) definition of physical dependence as "a state produced by chronic drug administration, which is revealed by the occurrence of signs of physiological dysfunction when the drug is withdrawn; further, this dysfunction can be reversed by the administration of drug" (as cited in Fagerström, 1978). The FTND assessment of physical dependence (Heatherton et al., 1991) was derived from the FTQ and was intended to overcome the psychometric and validity limitations of the FTQ (e.g., Hughes, Gust, & Pechacek, 1987; Lichtenstein & Mermelstein, 1986; Lombardo, Hughes, & Fross, 1988; Pomerleau, Pomerleau, Majchrezak, Kloska, & Malakuti, 1990).

Psychometrics. The FTND has better internal consistency than the FTQ (Etter, Duc, & Perneger, 1999; Haddock, Lando, Klesges, Talcott, & Renaud, 1999; Payne, Smith, McCracken, McSherry, & Antony, 1994; Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994), but its improved reliability is still below traditionally accepted standards for clinical use ($\alpha = .80$; Nunnally & Bernstein, 1994). Further, some studies show that the FTND has a multifactor structure (i.e., one factor reflecting heaviness of smoking and the other factor reflecting the other items), suggesting that its structure is inconsistent with the theory that spawned it; in other words, it does not assess a unitary construct of physical dependence (cf. Breteler, Hilberink, Zeeman, & Lammers, 2004; Haddock et al., 1999; Payne et al., 1994). Moreover, theory does not clearly link the different FTND factors to particular items or criteria.

Validity. Some data support the validity of the FTQ and FTND as measures of physical dependence. The FTQ and FTND have been shown to predict important outcomes, such as smoking cessation attempts (e.g., Bobo, Lando, Walker, & McIlvain, 1996; Pinto, Abrams, Monti, & Jacobus, 1987) and

relapse (e.g., Alterman, Gariti, Cook, & Cnaan, 1999; Campbell, Prescott, & Tjeder-Burton, 1996; Patten, Martin, Calfas, Lento, & Wolter, 2001; Westman, Behm, Simel, & Rose, 1997). However, other studies suggest that the FTQ and FTND do not predict these important outcomes consistently (e.g., Borelli, Spring, Niaura, Hitsman, & Papandonatos, 2001; Gilbert, Crauthers, Mooney, McClernon, & Jensen, 1999; Kenford et al., 1994; Piper et al., 2004; Procyshyn, Tse, Sin, & Flynn, 2002; Silagy, Mant, Fowler, & Lodge, 1994). In addition, some evidence suggests that these dependence measures lack incremental validity, that is, they do not predict better than simpler, competing measures such as the number of cigarettes smoked per day (Dale et al., 2001; Razavi et al., 1999). Some evidence suggests that the FTND is only slightly better than the FTQ at predicting dependence criteria (e.g., cotinine levels, withdrawal), if at all (e.g., Payne et al., 1994; Pomerleau et al., 1994), despite its improved reliability.

Insight. Fagerström designed the FTQ to assess physical dependence, which was loosely defined as the extent to which withdrawal symptoms were affected by tobacco abstinence and administration. Inspecting the newer, psychometrically improved FTND reveals that the items do not address withdrawal severity. For the most part, they assess the individual's rating of the aversiveness of abstinence and the tendency or need to smoke in response to abstinence (e.g., in response to overnight abstinence). Thus content analysis suggests that the FTND equates dependence with the motivational impact of withdrawal, and therefore it suggests a relatively specific motivational basis of dependence. The FTND's ability to predict relapse (e.g., Alterman et al., 1999; Campbell et al., 1996; Patten et al., 2001; Westman et al., 1997) suggests that relapse is highly related to negative reinforcement motives or to abstinence-induced changes in drug incentive value (Baker, Morse, & Sherman, 2004; Robinson & Berridge, 1993).

The insight provided by the FTND is compromised by several considerations. First, the FTND tends not to predict withdrawal severity well (Fagerström & Schneider, 1989; Hughes & Hatsukami, 1986), casting some doubt on its ability to index abstinence effects sensitively. Second, the FTND structure may not be optimal. Ambiguity exists about whether the FTND really measures one or two factors. If it measures one factor, it cannot capture the multiple components of dependence (if indeed dependence is multifactorial; Hudmon et al., 2004). If the FTND is multifactorial (Haddock et al., 1999; Payne et al., 1994), then its structure has been determined by happenstance, and theory does not

Table 1. Summary of published tobacco dependence measures for adult smokers.

Measure	Structure	Research base	Reliability	Primary intended use	Heaviness	Withdrawal	Relapse
FTQ (Fagerström, 1978)	8 items, 2 factors	<ul style="list-style-type: none"> Numerous studies Various populations 	$\alpha = .41-.58$	Clinical/descriptive research	Yes (CPD ^a)	No	Unknown
FTND (Heatherton et al., 1991)	6 items, 2 factors	<ul style="list-style-type: none"> Numerous studies Various populations 	$\alpha = .56-.70$	Clinical/descriptive research	Yes (CPD ^a , cotinine)	No	Yes
DIS (<i>DSM</i> ; Robins et al., 1981)	Structured clinical interview, 2 factors	<ul style="list-style-type: none"> Numerous studies Various populations 	$\kappa = .78$	Clinical/descriptive research	Yes (heavy vs. light smokers)	No	Unknown (abstinence over 1 year)
TDS (<i>DSM</i> ; Kawakami et al., 1999)	10 items	<ul style="list-style-type: none"> Two studies Mainly Japanese men 	$\alpha = .74-.81$	Clinical/descriptive research	Yes (CPD, CO, years smoking)	No	Unknown
CDS-5 (Etter et al., 2003)	5 items, 1 factor	<ul style="list-style-type: none"> Two studies Participants assessed via mail or Internet 	$\alpha = .77-.84$	Clinical/descriptive research	Yes (CPD ^a , cotinine, daily vs. occasional smoking)	Unknown	No
CDS-12 (Etter et al., 2003)	12 items, 1 factor	<ul style="list-style-type: none"> Two studies Participants assessed via mail or Internet 	$\alpha = .90-.91$	Clinical/descriptive research	Yes (CPD ^a , cotinine, daily vs. occasional smoking)	Unknown	No
NDSS (Shiffman et al., 2004)	19 items, 5 factors	<ul style="list-style-type: none"> One paper (3 studies) with adults One study with adolescents (12–18 years) 	<ul style="list-style-type: none"> For 30-item scale: Drive $\alpha = .76$ Priority $\alpha = .69$ Tolerance $\alpha = .55$ Continuity $\alpha = .63$ Stereotypy $\alpha = .70$ Total NDSS $\alpha = .84$ 	Theoretical/mechanistic research	Yes (CPD)	Yes (severity of past withdrawal, urge intensity, restlessness)	Yes (difficulty abstaining; latency to relapse)
WISDM-68 (Piper et al., 2004)	68 items, 13 factors	<ul style="list-style-type: none"> One study Daily and nondaily adult smokers 	<ul style="list-style-type: none"> Subscales, $\alpha = .84-.96$ Total WISDM-68, $\alpha = .98-.99$ 	Theoretical/mechanistic research	Yes (CPD, CO)	Unknown	Yes (end of treatment)

Note. FTQ, Fagerström Tolerance Questionnaire; FTND, Fagerström Test for Nicotine Dependence; DIS, Diagnostic Interview Schedule; *DSM*, *Diagnostic and Statistical Manual*; TDS, Tobacco Dependence Screener; CDS-5, Cigarette Dependence Scale—5 items; CDS-12=Cigarette Dependence Scale—12 items; NDSS, Nicotine Dependence Syndrome Scale; WISDM-68, Wisconsin Inventory of Smoking Dependence Motives—68 items; CPD, cigarettes smoked per day; CO, carbon monoxide. ^aOne or more items directly assess cigarettes smoked per day.

suggest the nature of the factors, how they should be related to items and criteria, and how to interpret obtained data.

Conclusion. The FTQ and FTND often predict smoking relapse, and they suggest that relapse is associated with the motivational impact of abstinence. However, their value is somewhat compromised by marginal reliability, an apparently unstable factor structure that may not match an underlying theory, and an inability to predict well some dependence criteria such as withdrawal severity. However, the scales' brevity and relations with relapse make them valuable clinical tools. The FTND is to be preferred over the FTQ because of its enhanced reliability and equal or better predictive validity. Although the FTND is certainly used in numerous research studies, ambiguity about its structure, its lack of theoretical grounding, and its failure to provide insight into the nature of dependence suggests that it should be considered a descriptive or clinical instrument (Table 1).

The Diagnostic and Statistical Manual of Mental Disorders (4th ed.)

The Diagnostic and Statistical Manual of Mental Disorders (4th ed.) (DSM-IV; American Psychiatric Association [APA], 1994) provides another commonly used measure of tobacco dependence, especially for the purpose of clinical diagnosis and epidemiological research. The *DSM-IV* definition of substance dependence is "a cluster of cognitive, behavioral, and physiological symptoms indicating that the individual continues use of the substance despite significant substance-related problems. There is a pattern of repeated self-administration that usually results in tolerance, withdrawal, and compulsive drug-taking behavior" (APA, 1994, p.176). *DSM-IV* is based on a syndromal medical model, rather than a theoretical model of dependence. The developers of *DSM-IV* arrived at a consensus on the principal features of tobacco dependence and then generated items that would tap these features. Thus the development of *DSM-IV* was essentially atheoretical—there was no need to postulate mechanisms or substrata of dependence. The instrument was designed to tap phenotypic features, some of which would be considered criteria in other models (e.g., withdrawal, relapse likelihood). Therefore, in the case of *DSM-IV*, no construct validation approach was used and no explicit or coherent theory guides the ongoing process of measure development and validation. However, the fact that *DSM-IV* directly indexes major features of dependence affords it face validity and general buy-in from clinicians and researchers.

Psychometrics. Typically, *DSM-IV* questions are administered via an individual interview, as opposed to a paper-and-pencil questionnaire. The interviews may be unstructured or semistructured, such as the Diagnostic Interview Schedule (DIS; Robins, Helzer, Croughan, & Ratcliff, 1981). An individual is given the categorical diagnosis of substance dependence if he or she exhibits three symptoms within the same 12-month period. The concordance between lay interviewers and psychiatrists using the DIS for *DSM-III* is acceptable (Robins et al., 1981). The DIS has been shown to have a two-factor structure (Radzius et al., 2004).

A 10-item self-report questionnaire, the Tobacco Dependence Screener (TDS), was designed to assess *International Classification of Diseases* (10th revision; *ICD-10*), *DSM-III-R* (3rd ed., revised), and *DSM-IV* symptoms of dependence (Kawakami, Takatsuka, Inaba, & Shimizu, 1999) and generates a continuous dependence score. Developed in Japan, mainly with male smokers, it demonstrated acceptable internal consistency in different samples.

Validity. Evidence suggests that the small set of dichotomous *DSM* items can distinguish between light and heavy smoking (Strong, Kahler, Ramsey, & Brown, 2003). However, little evidence indicates that *DSM* items, as traditionally administered, provide a sensitive index of dependence as a dimensional (continuous) construct. Moreover, an epidemiological study found that *DSM-III-R* was a significant, though weak, predictor of cigarette abstinence over 1 year, but that the FTND was a better predictor and that number of cigarettes smoked per day was the best predictor (Breslau & Johnson, 2000). Note, however, that some of the negative findings cited above arose from studies that were underpowered and that did not include control variables to reduce error. Data on the TDS indicate that it is associated with the smoking heaviness measures (e.g., number of cigarettes smoked per day, carbon monoxide levels) and years of smoking (Kawakami et al., 1999; Piper et al., 2004). In addition, individuals who quit smoking after a health risk appraisal were found to have lower TDS scores (Kawakami et al., 1999). Aside from these findings, no data have been published on the validity of a continuous measure of *DSM* symptoms to predict dependence criteria such as withdrawal severity or relapse vulnerability.

DSM-IV and the FTND lack evidence of convergent validity (Moolchan et al., 2002; also Kawakami, Takatsuka, Shimizu, & Takai, 1998). In addition to differential rates of diagnosis, the FTND and *DSM-IV* demonstrate little covariance with one another, with the exception of assessing heavy use (Breslau & Johnson, 2000), and they have

inconsistent relations with other constructs (e.g., depression; Breslau & Johnson, 2000; Moolchan et al., 2002; Tsoh et al., 2001).

Insight. Although *DSM-IV* is a helpful diagnostic tool, it provides little insight into the mechanisms of tobacco dependence because *DSM*-type measures are designed to assess reputed dependence criteria directly. Measuring tobacco dependence with *DSM-IV* criteria is similar to measuring end-state organ damage to assess high blood pressure (versus using a measure of blood pressure per se). In fact, *DSM-IV* could be considered a list of criteria that may be useful for validating other dependence measures. In addition, because the *DSM* approach is not based on a particular model of dependence, *DSM*-type assessments are not designed for theory development or evaluation. Moreover, its items were not selected to provide reliable measures of distinct facets of dependence.

As a rather small set of dichotomous items, *DSM-IV* and the TDS can distinguish between heavy and light use of tobacco but appear to have limited ability to assess dependence as a continuum. Moreover, the structure of the measures is unknown, and the putative unidimensional structure of *DSM-IV* and the TDS make them inappropriate for examining different facets of dependence.

Conclusion. *DSM-IV* was not designed to provide theoretical insight into the construct of dependence, nor was it designed to provide a continuous measure of what may be a multidimensional construct. In fact, relatively little evidence exists to support the convergent or incremental validity of the *DSM* items as predictors of withdrawal severity and relapse. *DSM-IV* dependence criteria have substantial face validity among researchers and clinicians though, and this promotes general acceptance. Based on such considerations, *DSM*-type measures seem better suited for descriptive or clinical purposes than for research purposes (Table 1).

The Cigarette Dependence Scale

The Cigarette Dependence Scale (CDS) was developed by surveying smokers via the mail and Internet to assess signs that smokers believed indicated addiction to cigarettes (Etter, Le Houezec, & Perneger, 2003). The authors then used the strength of smokers' endorsements, psychometric considerations, and content coverage to construct the 5- and 12-item scales. Unlike a construct validation approach, this empirical approach to measure development was not based on a theory of dependence. However, the authors explicitly selected items to ensure coverage of *DSM-IV* and *ICD-10* symptoms.

Moreover, although not stated as an explicit goal, the authors apparently sought some coverage of the FTND content domain. For example, two of the CDS-5 and CDS-12 items are essentially the same as two FTND items. Thus the CDS is an amalgam of *DSM/ICD*, FTND, and smoker-generated items that is intended to generate a continuous measure of dependence.

Psychometrics. To date, only two studies report data on the two versions of the CDS, using data collected via mail or the Internet (Etter, 2005; Etter et al., 2003). The CDS-12 had strong internal consistency, and the CDS-5 was within the acceptable range; both scales were slightly skewed toward higher values. Test-retest correlations were .60 or higher for all items and .83 or higher for the full scales. Factor analysis suggested a unidimensional structure for the CDS-12.

Validity. The CDS scales were significantly correlated with number of cigarettes smoked per day, whether a smoker was a daily or occasional smoker, strength of urges during the last quit attempt, and cotinine level (Etter et al., 2003). The CDS-12 and CDS-5 appeared somewhat better than the FTND at differentiating occasional from daily smokers and were more strongly correlated with urge to smoke during the participants' previous quit attempt than the FTND. However, whether these differences in validity coefficients achieved statistical significance is unknown. Curiously, the FTND and CDS-5 were more strongly correlated with cotinine levels than was the CDS-12. In one study, none of the three dependence measures (i.e., FTND, CDS-5, or CDS-12) was a significant predictor of relapse likelihood (Etter et al., 2003); however, only a third of potential respondents participated in the follow-up study, which may reflect considerable response bias. In a second study, only the CDS-12 predicted smoking abstinence at 1-month postquit but in a counter-intuitive direction (e.g., higher CDS-12 scores predicted abstinence; Etter, 2005).

Insight. Similar to the FTND and *DSM-IV*, overlap exists between validation criteria and CDS items. For instance, the CDS elicits information on smoking heaviness, and smoking heaviness is also used as a criterion in validation research (Etter et al., 2003). Moreover, like *DSM* measures, the CDS scales largely target outcomes or consequences of dependence (e.g., subjective sense of the difficulty of quitting and of being addicted to cigarettes). In addition, the CDS-12 (and presumably the CDS-5) has a unidimensional structure. Therefore, these measures are not designed to elucidate dependence

processes or mechanisms, or to assess the multidimensional nature of dependence.

Conclusion. The CDS is a continuous measure of dependence that appears to reflect both *DSM-IV/ICD-10* as well as FTND content and that has good reliability. The CDS is a new instrument; therefore, only a modest amount of validity evidence supports its use. In particular, little evidence indicates that it assesses relapse vulnerability. The instrument was designed to index dependence outcomes and not dependence mechanisms, and it appears to have a unidimensional structure. The face validity of its content, its high reliability, and the availability of brief forms should promote its clinical use when more validity data are available (Table 1).

The Nicotine Dependence Syndrome Scale

The Nicotine Dependence Syndrome Scale (NDSS), a 19-item self-report measure, was developed as a multidimensional scale to assess nicotine dependence based on Edwards's (1976) theory of the dependence syndrome (Shiffman, Waters, & Hickcox, 2004). Edwards developed a construct of the alcohol dependence syndrome comprising multiple core elements: A narrowing in the repertoire of drinking behavior, salience of drink-seeking behavior, increased tolerance, withdrawal symptoms, use of alcohol to avoid or relieve withdrawal symptoms, subjective awareness of a compulsion to drink, and a reinstatement of the syndrome after abstinence (Edwards, 1976). As with any syndrome, no single element is necessary or sufficient for the syndrome to be present, but with increasing severity, the syndrome indicators will become increasingly coherent (Edwards, 1986). Edwards also stated that although greater dependence would result in increased alcohol intake and diminished responsiveness to social controls, these outcomes were secondary to the syndrome itself. Applying this syndromal approach to tobacco dependence, Shiffman and colleagues developed a 23-item scale, but psychometric analysis led to a revised 30-item scale, which was ultimately pared to a 19-item version. None of the psychometric, or validity, data presented in the sole publication on this instrument are based on this specific 19-item set. Much of the validity data (prediction of relapse and withdrawal) was derived from the initial 23-item instrument. Some additional convergent validity information was obtained using the subsequent 30-item instrument (e.g., relations with heaviness of smoking, self-rated addiction).

Scoring of the NDSS is somewhat complex in that it requires that item responses be multiplied by factor loadings before summing for scale scores. The NDSS was intended to complement, not replace, traditional

dependence measures such as *DSM-IV*. The authors note that little content overlap exists between the two types of measures.

Psychometrics. To date, one paper has published data from three studies on the NDSS among adults (one study has reported on the NDSS in adolescents aged 12–18 years; Clark et al., 2005). Psychometric data presented here are based on the revised 30-item scale. The authors developed items to address five different dimensions of nicotine dependence with adequate to strong internal consistency (Table 1). *Drive* reflects craving, withdrawal, and smoking compulsions; *priority* reflects preference for smoking over other reinforcers; *tolerance* reflects reduced sensitivity to the effects of smoking; *continuity* reflects the regularity of smoking rate; and *stereotypy* reflects the invariance of smoking. The internal consistency for the total scale, the NDSS-T, is good (Shiffman et al., 2004). However, unpublished data ($N=608$) collected by the authors of the present paper suggest that the internal consistencies of the scales from the 19-item version may be somewhat lower: *Drive* ($\alpha=.59$), *priority* ($\alpha=.40$), *tolerance* ($\alpha=.26$), *continuity* ($\alpha=.44$), *stereotypy* ($\alpha=.44$), and total NDSS ($\alpha=.79$). Principal components analysis revealed a five-factor structure for the NDSS (Shiffman et al., 2004), as predicted by the underlying theory. Significant differences in the scores on the subscales between White and Black smokers suggest the scale may operate differently in subpopulations, although no ethnic differences were found in the total NDSS (Shiffman et al., 2004). The test-retest correlations for the five scales and the total using the 30-item NDSS ranged from .71 to .83.

Validity. The 30-item NDSS was significantly related to other dependence measures, such as the FTQ, indicating convergent validity (Shiffman et al., 2004). Both the 23-item and the 30-item NDSS were significantly related to dependence criteria such as number of cigarettes smoked (r 's=.37 and .48), difficulty abstaining (r 's=.44 and .52), and severity of past withdrawal (r 's=.36 and .50; Shiffman et al., 2004). These relations were maintained, though reduced in magnitude, after controlling for the FTQ, consistent with the assertion that the NDSS possesses incremental validity. Evidence indicates that the 23-item NDSS has predictive validity, in that the total score and certain scale scores (*drive* and *priority*) were related to dependence criteria, including withdrawal elements such as urge intensity and restlessness, and the total score was related to latency to relapse (Shiffman et al., 2004). However, those analyses were conducted using factor scores different from those presented in the final 19-item scale.

The current 19-item version might show a different pattern of validity relations.

Insight. The NDSS may provide insight into the construct of dependence. For instance, this multidimensional scale revealed that the dependence subscales had distinct patterns of relations with criteria. Whereas the drive and priority scales were associated with urge intensity during the first 2 days of abstinence, only the drive scale was associated with restlessness and attention disturbances during withdrawal. The results also support the value of a multidimensional approach. Most criteria were best predicted by two or more subscale scores. However, only the total NDSS predicted latency to relapse, suggesting that although some components of dependence may be related to certain outcomes (e.g., withdrawal), the confluence of these components predicts other outcomes such as relapse. Finally, the contents of the subscales provide some insight into the nature of dependence processes. The drive scale appeared to have the most consistent relations with criteria such as withdrawal symptoms.

Conclusion. The total NDSS has promising psychometric properties, although low reliability of some subscales may hinder parsing of the multidimensional nature of dependence. However, the NDSS has the potential to yield insight into the multidimensional nature of dependence, and the authors noted that it was intended to supplement, rather than supplant, traditional measures that are more focused on dependence outcomes. In addition, evidence indicates that the NDSS has incremental validity relative to the FTQ. Further research with the final 19-item questionnaire is needed.

The Wisconsin Inventory of Smoking Dependence Motives

The Wisconsin Inventory of Smoking Dependence Motives (WISDM-68) is a 68-item measure developed to assess dependence as a motivational state (Piper et al., 2004). The primary goal in developing this measure was to create a theory-based research instrument that would identify fundamental dependence processes that ultimately influence dependence criteria (e.g., withdrawal, relapse). In other words, this scale attempted to assess the processes that lead to dependence, in the way that a physician would use blood pressure to predict end-state organ damage. The authors assumed that criteria tend to be influenced by a range of factors outside of dependence processes per se (e.g., relapse vulnerability may be influenced by availability of cigarettes). The intent was to craft self-report measures that were relatively direct indicators of the motivational press to use drug in a dependent manner. Such scales could then be

used with other research measures (e.g., genotype, imaging assays) to better characterize the nature and magnitude of dependence processes. This measure has 13 theoretically based subscales designed to tap different smoking dependence motives (Table 2).

Psychometrics. To date, only one study has published data on the WISDM-68. Across two different samples all 13 subscales had strong internal consistencies (Table 1), which were consistent across gender and between Whites and Blacks (Piper et al., 2004). Factor analytic strategies indicated that the WISDM-68 is multidimensional. However, factor analyses and interscale correlations revealed that some of the scales were highly correlated with one another, which suggests that some scales tap related or overlapping dimensions of dependence. In the initial research report on the WISDM-68, the test developers did not attempt to merge or discard the theoretically derived subscales. The decision was made to shorten and distill this measure only after more validity information is obtained.

Validity. Using participants from a smoking cessation clinical trial ($N=238$), researchers found that all of the WISDM-68 subscales were significantly correlated with the FTND ($r=.11-.78$), except for the social/environmental goads subscale, which was unrelated to the FTND. All of the subscales were significantly correlated with the TDS ($r=.31-.73$), thereby demonstrating convergent validity (Piper et al., 2004). The total WISDM-68 was correlated with dependence criteria such as smoking heaviness (cigarettes per day $r=.63$; carbon monoxide $r=.55$). However, validity analyses revealed heterogeneity among subscales in terms of their relations with dependence criteria. The tolerance subscale was the best predictor of carbon monoxide level, but the craving, cue exposure/associative processes, and tolerance subscales were the best predictors of *DSM-IV* dependence when entered together into a multiple regression equation. Although the total score was not a significant predictor of relapse after controlling for treatment, the combination of automaticity, behavioral choice/melioration, cognitive enhancement, and negative reinforcement subscales predicted relapse by the end of treatment in a multivariate model. Finally, the fact that the taste/sensory processes subscale predicted phenothiocarbamide (PTC) haplotype status among smokers suggests some specificity or discriminative validity for that subscale (Cannon, et al., in press). (PTC status is related to the ability to taste a bitter flavor.)

Insight. The differential relations among dependence subscales and criteria, and the finding that multiple

Table 2. Descriptions and theoretical bases for the 13 WISDM-68 subscales.

Subscale	Theory
Affiliative attachment	Based on data that suggest smokers develop an emotional attachment to smoking (Baker, Morse, & Sherman, 1987).
Automaticity	Reflects smoking without awareness or intention based on Tiffany's (1990) theory of automaticity.
Behavioral choice/melioration	Based on behavioral theories of choice (Vuchinich & Tucker, 1988) that suggest that drug use is inversely proportional both to constraints on access to the drug and to the availability of other reinforcers and melioration theory (Heyman, 1996), which refers to the use of a "local bookkeeping strategy" for deciding among competing reinforcers that emphasizes the current value of each. It reflects smoking despite constraints or negative consequences or a lack of other reinforcers.
Cognitive enhancement	Based on research showing that nicotine can improve attention and vigilance (Bell, Taylor, Singleton, Henningfield, & Heishman, 1999). Reflects smoking to improve cognitive functioning.
Craving	Based on traditional addiction theories that posit cravings to be a strong motivational prod for return to drug use (e.g., Siegel, 1983). Reflects smoking in response to cravings or experiencing urges.
Cue exposure/associative processes	Reflects basic learning processes. For example, nonsocial cues paired with smoking can increase smoking motivation (e.g., Niaura, Rohsenow, & Binkoff, 1988).
Loss of control	Based on the idea that dependent drug use results in a sense of hopelessness or helplessness to affect use and that this would undercut efforts to control use.
Negative reinforcement	Based on the operant conditioning learning theory that operant behaviors that alleviate an aversive physical or psychological state are reinforcing and increase the probability that those behaviors will be repeated. Reflects smoking to ameliorate negative internal states (Baker et al., 2004).
Positive reinforcement	Based on Thorndike's law of effect. Reflects a desire to experience or enhance a positive feeling (e.g., Stewart, de Wit, & Eikelboom, 1984).
Social/environmental goods	Based on social learning theory (Bandura, 1997). Reflects the potency of social stimuli that model or invite smoking.
Taste/sensory properties	Reflects a specific type of positive reinforcement: smoking to experience orosensory or gustatory effects (e.g., Ikard & Tomkins, 1973).
Tolerance	Based on the theory that homeostatic adaptations to the presence of drug in the body oppose the drug effect, rendering the tissues less sensitive to the drug (Siegel, 1983). Reflects the need for increased amounts of drug over time or the ability to use large quantities of drug without experiencing the toxic effects.
Weight control	Reflects smoking to control body weight or appetite.

subscales contributed to the prediction of relapse, support a multidimensional perspective regarding dependence. The WISDM-68 provided information regarding the relative importance of various dependence motives in novice or occasional smokers versus heavy smokers, suggesting that certain motives may develop at different rates. In addition, path analyses revealed heterogeneity among the 13 subscales in their relations with dependence criteria. Thus, similar to the NDSS, the WISDM-68's multidimensional approach to dependence has the potential to provide insight into the various components of dependence and their relations with dependence criteria. Subscale contents were designed to elucidate the nature of dependence processes (to the extent permitted by self-report).

Conclusion. The WISDM-68 has good psychometric properties that allow dependence to be assessed as a multidimensional motivational state. It has the potential to provide insight into different facets or mechanisms of dependence. However, little research currently supports its validity; more research is needed before the worth of this measure can be gauged. Also, some subscales likely will ultimately be discarded because they are redundant with other

subscales or lack validity. The clear theoretical basis of this measure and its length suggest that the WISDM-68 is more appropriate for theory-driven research than for clinical purposes.

Conclusions

This paper has illustrated the application of the principles of construct validation to the problem of defining and measuring tobacco dependence. We have presented a construct validation approach to measuring and assessing tobacco dependence as a three-step process: (a) Theory-based selection of dependence components used to develop test items, (b) theory-based elaboration of the evaluation context, including selection of criteria and related constructs, and (c) use of data analysis to revise and improve the definition and subsequent measurement of dependence. Two traditional measures of dependence, the FTND and *DSM-IV*, have been found to have marginal psychometric properties (e.g., only fair reliabilities), inconsistent or unknown structures that are not clearly related to theory, and modest predictive and convergent validities. However, the continued use of the FTND is promoted by the presence of substantial prior research, its ability to

predict relapse, and its brevity. *DSM-IV* criteria have great face validity and should be useful in clinical or epidemiological contexts in which direct assays of dependence criteria are sought. In light of the weaknesses in the FTND and *DSM*-type measures, new measures of tobacco dependence—the CDS, NDSS, and WISDM-68—are being developed, some using a construct validation approach, but they require more research that demonstrates their incremental and convergent validities. In addition, more research on the performance of these measures in diverse populations of smokers is needed (e.g., in different genders and races, and with psychiatric comorbidities). With more research into the construct validity of these new measures, researchers may develop a better understanding of mechanisms underlying tobacco dependence and their relation to various theoretically, societally, and clinically important criteria.

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