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Original Investigation

Psychometric properties of the Wisconsin Inventory of Smoking Dependence Motives (WISDM-68): A replication and extension

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Abstract

Introduction: The Wisconsin Inventory of Smoking Dependence Motives (WISDM-68), a relatively new measure, assesses nicotine dependence in terms of distinct motivations for smoking. We examined psychometric properties of the WISDM-68 in a population-based sample that is on average older and includes heavier smokers than the original sample used for the validation of the instrument.

Methods: Participants were adult regular smokers (N = 431) who were offspring of pregnant women enrolled in the New England sites of the National Collaborative Perinatal Project (1959–1966). We examined the internal consistency of the WISDM-68's 13 subscales, replicated and extended the confirmatory factor analysis (CFA) by Piper et al., assessed the interdependence of the subscales, examined the association between smoking heaviness and subscale scores, and conducted additional validation tests.

Results: Internal consistency for WISDM's 13 subscales ranged from 0.78 for the *Tolerance* to 0.89 for the *Cognitive Enhancement* and *Affiliative Attachment* subscales. Similar reliabilities were obtained for demographic and smoking-relevant subgroups. CFAs suggest that a 13-factor model fit our data better than a single-factor model and better than an empirically derived 10-factor model. Regression models supported the validity of the 13 subscales, although follow-up analyses suggested possibility of maintaining WISDM's 13-factor structure with fewer than 68 items.

Conclusion: The WISDM-68 consists of 13 internally consistent subscales. The independence of the majority of the subscales supports the perspective that nicotine dependence is a heterogeneous construct.

Introduction

Tobacco dependence is an important construct for advancing scientific and clinical insight into the reasons people continue to smoke and the reasons for relapse. Tobacco cessation treatments rely on this construct, with pharmacological and behavioral treatments varying as a function of the degree of dependence. Despite its central role in the etiology and treatment of smokers, there is scant agreement regarding the definition and measurement of tobacco dependence, and existing measures contend with a number of limitations (cf. Colby et al., 2000). While a comprehensive review of the dependence literature is beyond the scope of the present paper, we describe the major assessment approaches to dependence to provide a context for our replication and extension of a relatively new measure, the Wisconsin Inventory of Smoking Dependence Motives (WISDM-68).

One common approach to measure tobacco dependence is categorical, in which dependence is conceptualized as a binary construct reflecting whether prespecified diagnostic criteria are met. For example, the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*; American Psychiatric Association [APA], 1994) defines the latent construct of substance dependence across all psychoactive substances as a cluster of cognitive, behavioral, and physiological symptoms that characterize compulsive use. Although formal diagnostic systems such as *DSM-IV* are considered the "gold standard" for identifying and

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classifying disorders, there are limitations to this approach. For example, simple diagnostic criteria do not explain why a smoker is dependent; they do not distinguish among the considerable heterogeneity of nicotine-dependent smokers, and they tend to be based on expert consensus rather than empirical evidence (cf. Colby et al., 2000). Most importantly, classification systems are based on the premise that nicotine dependence is a unidimensional construct; however, a growing number of studies suggest that nicotine dependence may be a multidimensional phenomenon (e.g., Colby et al., 2000; Gilliard & Bruchon-Schweitzer, 2001; Lombardo, Hughes, & Fross, 1988; Moolchan et al., 2002; Radzius et al., 2004; Shiffman, Kassel, Paty, Gnys, & Zettler-Segal, 1994).

A second approach to measuring nicotine dependence also assumes that it is a unidimensional construct but uses continuous measurement methods rather than categorical. Symptoms of dependence are assumed to arise from a dependence–tolerance process that results in efforts to restore low blood nicotine to desired levels through smoking. An example of this approach is the eight-item Fagerström Tolerance Questionnaire (FTQ; Fagerstrom & Schneider, 1989) and its revised version, the six-item Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991). Despite their widespread use, both Fagerström measures have limitations. Internal consistency of the FTQ and FTND has been low in some, but not all, studies, with α-coefficients ranging from .4 to .7 (Lichtenstein & Mermelstein, 1986; Pomerleau, Pomerleau, Majchrzak, Kloska, & Malakuti, 1990; Payne, Smith, McCracken, McSherry, & Antony, 1994; Etter, Duc, & Perneger, 1999). Also, results from several studies indicate that both Fagerström measures assess a multifactorial construct rather than a unifactorial construct as originally theorized (e.g., Lichtenstein & Mermelstein, 1986; Payne et al., 1994; Radzius, Moolchan, Henningfield, Heishman, & Gallo, 2001).

To address the shortcomings of previous measures of tobacco dependence, Piper et al. (2004) employed a theory-driven approach to develop the WISDM-68. The WISDM-68 conceptualizes nicotine dependence in terms of 13 motivations (represented with 68 items) for tobacco use. Item selection for the WISDM-68 was based on empirical findings and theories of substance use with the goal of assessing each item's performance in relation to established dependence criteria. This approach yields a broad set of items that are not traditionally included in measures of nicotine dependence, such as items related to weight control or social interactions but that may provide new insights into the phenomenon of dependence.

In this report, we examined the psychometric properties of the WISDM-68 in a regionally representative (Graham et al., 2008) longitudinal birth cohort comprising older, heavier smokers with lower educational attainment. We replicated and extended the WISDM-68 validation procedures utilized by Piper et al. (2004). This included examination of WISDM-68 internal consistency and factor structure, tests of subscales performance, exploration of possible methods for scale abbreviation, and finally, limited concurrent validation.

Methods

Study population

Participants were adult offspring of pregnant women enrolled in the National Collaborative Perinatal Project (NCPP) between 1959 and 1966 (Niswander & Gordon, 1972). Building on the NCPP, the Transdisciplinary Tobacco Use Research Center–New England Family Study (TTURC-NEFS) was established in 1999 to examine nicotine dependence across the lifespan and across generations. TTURC-NEFS located and interviewed 1,625 adult offspring of women who were enrolled in the Providence, Rhode Island, Boston, and Massachusetts sites of the original NCPP.

Measures

Participants completed a paper/pencil version of the WISDM-68. In addition, the following measures were collected and administered by trained interviewers.

Demographic information: Sociodemographic variables including age, gender, race, education, and marital status were obtained from participants.

Composite International Diagnostic Interview—Tobacco Module: DSM-IV nicotine dependence was assessed using a self-administered version of the Composite International Diagnostic Interview (CIDI) Tobacco Module (World Health Organization, 1994) known as the TTURC nicotine dependence inventory. This inventory includes a series of structured True/False questions which include a. This instrument assesses nicotine dependence in terms of the seven criteria specified by the *DSM-IV* diagnosis of substance dependence (APA, 1994) and was administered to respondents who had reported ever becoming "weekly smokers" (i.e., smoking weekly or more often for 2 months or longer). An individual was classified as dependent if he/she experienced at least three of seven *DSM-IV* dependence criteria. Lifetime and current nicotine dependence diagnoses and symptom counts were also obtained.

The FTND: The FTND is a six-item measure of nicotine dependence (considered to be a standard instrument in the field) where greater scores indicate greater dependence. The FTND is positively related to degree of nicotine intake as assessed by saliva cotinine (Heatherton et al., 1991).

Smoking history: Smoking history was assessed with the Lifetime Interview of Smoking Trajectories (LISTs) developed for TTURC-NEFS. The LIST gathered detailed information on participants' lifetime experiences with tobacco smoking. We included onset of daily smoking and history of quit attempts as descriptive variables of interest.

Analytic plan

We followed the approach used by Piper et al. (2004). First, we examined the internal consistency of the WISDM's 13 subscales, both on the entire sample as well as on relevant demographic and smoking subgroups. This work also included assessment of potentially redundant and/or poorly performing items. Second, we replicated the confirmatory models by Piper et al. (2004) and then extended these analyses using additional exploratory and confirmatory factor analyses (CFAs) to determine whether a 1-factor or 13-factor model represented a better fit with our data. CFAs were performed using the LISREL 8.80 software (Joreskog & Sorbom, 1993). We evaluated models generated by CFA and extended the work by Piper et al. by (a) conducting $\Delta\chi^2$ tests to assess improvements (if any) from a single- to a 13-factor solution and (b) conducting additional exploratory analyses and CFAs in order to investigate the possibility of more parsimonious solutions.

Third, we evaluated subscale performance by testing the associations between number of cigarettes smoked per month as a marker of dependence and scores on the 13 WISDM-68 subscales by fitting linear and quadratic regression terms to the data. Piper et al. (2004) had suggested the presence of two distinct smoking motives, which they labeled "early" and "late" emergent smoking motives (p. 145). To confirm the presence of these two groups of motives in our sample, we fit regression models that included linear and quadratic terms for smoking heaviness: $Y = \beta_0 + \beta_1 X + \beta_2 X^2$, where Y = WISDM-68 subscale scores, $X = \log(\text{cigarettes per month} + 1)$ = "smoking heaviness," and cigarettes per month = cigarettes per day × 30.

The distribution for cigarettes smoked per month was positively skewed. Therefore, we transformed the number of cigarettes smoked per month by taking the log of the score plus one.

Finally, following Piper et al. (2004), we conducted a limited concurrent validation of the WISDM-68, using the FTND scale, the current *DSM-IV* nicotine dependence diagnosis, number of *DSM-IV* clinical symptoms, and number of cigarettes smoked per day.

Results

Sample

Of the 1,625 adults interviewed by TTURC-NEFS, 525 were current smokers (i.e., smoking at least once per week) who had been regular smokers (i.e., smoked weekly or more for at least 2 months) at some point during their lifetime. Complete data were available for 431 (82%) current smokers. These 431 current smokers came from a total of 388 NCPP families, such that 347 NCPP families had a single adult offspring and 41 families had more than one adult offspring included in our sample. Thus, there was a slight violation of statistical independence criterion because 20% of participants were siblings. We utilized two approaches for handling this violation of statistical independence: (a) When possible, we used mixed models and general estimating equations to account for correlated data and (b) we created a reduced sample, where a single offspring was randomly selected from families with multiple participants (N = 388). These results were substantively identical to the unadjusted results obtained from the entire sample. For simplicity reasons, we reported results from the unadjusted analyses.

In some respects, our sample was quite similar to the validation sample by Piper et al. (2004): both samples were predominantly White (81% in current sample vs. 84% in Piper et al.) and female (61.5% in current sample vs. 60% in Piper et al.). However, our sample consisted of participants who were older, less educated, and heavier smokers than the participants of Piper et al. Approximately 50% of the participants of Piper et al. were college students, in contrast to our middle-age participants (M_{Age} = 38.9 ± 1.8), a majority of whom did not complete 4 years of college (89.3%). Our participants smoked an average of 18 cigarettes/day ($M_{\text{cigarettes/day}}$ = 18 ± 10.6 vs. $M_{\text{cigarettes/day}}$ = 10.5 ± 10.8 in Piper et al.) and 22% of our sample reported smoking more than one pack per day. This is a significantly higher consumption than reported in Piper et al. (2004), $t(1204) = 11.63$, $p < .001$; and in this respect, our sample was more similar to Piper's "daily smokers" subgroup, which tended to represent heavier and community-dwelling smokers.

We compared the 431 study participants with the 94 TTURC-NEFS current smokers who did not complete the WISDM-68 (Table 1). Participants who completed the WISDM-68 were more likely to be White and unmarried and to have not completed college than those with missing data.

Internal consistency analyses

All the subscales had α-coefficients > .80, except the *Tolerance* subscale (α = .78). Although all but one of these results met accepted criteria for internal consistency (i.e., α ≥ .80; Nunnally & Bernstein, 1994), they were generally lower than those reported in Piper et al. (2004), where αs for all subscales exceeded .90. We also examined the subscales' internal consistency across relevant demographic and smoker subgroups (Table 2).

Several of the WISDM-68 subscales contained similarly worded items. For example, items "Cigarettes keep me company, like a close friend" and "Giving up cigarettes would be like losing a good friend" both appear on the *Affiliative Attachment* subscale. Reliability analyses revealed that deletion of either item would not compromise the scale's internal consistency, which would change from .89 to .87. In addition, reliability analysis identified several items whose deletion would not compromise (or would even slightly improve) the scale's internal consistency. For example, deletion of the item "I can only go a couple of hours between cigarettes" from the *Tolerance* subscale would change its α-coefficient from .78 to .79. Overall, nine subscales contained items whose elimination would offer a more parsimonious model without sacrificing psychometric properties of the scale.

The CFAs

We examined the 68 WISDM items as a single-factor model and a 13-factor oblique model. Neither model had an exceptionally good fit with the data (see fit indices reported in Table 2). However, the 13-factor model had much better root mean squared error of approximation (RMSEA) and comparative fit index (CFI) indices, and the $\Delta\chi^2$ test indicated that the 13-factor model was a better fit than the single-factor model. Although models tested on two different samples cannot be statistically compared, it is noteworthy that we obtained similar fit indices as Piper et al. (2004) for their models: (a) statistically significant χ^2 values for both single- and 13-factor solutions and (b) RMSEA > .10 for the single-factor solution and RMSEA around .06 for the 13-factor solution. However, our CFI indices were above .90 for both models, while Piper et al. reported poor CFIs (.60 and .63) for their single-factor models.

Exploratory Factor Analyses

To determine the degree of independence among the WISDM's 13 subscales, we examined their intercorrelations, which ranged from .13 to .82. Three pairs of subscales displayed correlations of .80 or higher: (a) *Affiliative Attachment* and *Behavioral Choice/Melioration* subscales, (b) *Loss of Control* and *Craving* subscales, and (c) *Positive Reinforcement* and *Negative Reinforcement*. Given this overlap, we explored the possibility of an abbreviated WISDM version through a two-step process. First, we conducted an exploratory factor analysis (EFA) using all 68 items. Using

Table 1. Sample characteristics

Variables	WISDM completed ($N = 431$)	WISDM not completed ($N = 94$)
Age; *M* (*SD*)	38.9 (1.8)	38.8 (1.9)
Female (%)	61.5	54.3
Race		
White (%)	81.2	74.5*
African American (%)	9.3	19.2
Other (%)	9.5	6.4
Education (%)		
<HS (%)	14.2	4.3**
HS or GED (%)	27.9	24.5
Technical/trade school (%)	21.1	19.2
Some college (%)	26.2	36.2
4-year college (%)	8.6	9.6
Graduate school (%)	2.1	6.4
Married (%)	40.6	53.2*
FTND score; *M* (*SD*)	4.2 (2.6)	
DSM-IV symptoms count; *M* (*SD*)	4.1 (1.6)	
DSM-IV current nicotine dependence dx (%)	51.2%	
Age of smoking onset; *M* (*SD*)	13.2 (3.7)	
Current number of cigarettes smoked daily; *M* (*SD*)	18.0 (10.6)	
Current number of cigarettes smoked daily		
1–10 (%)	28.0	
11–20 (%)	29.8	
21+ (%)	22.2	
Number of lifetime quit attempts; *M* (*SD*)	7.7 (16.8)	
Number of lifetime quit attempts		
0 (%)	10	
1–10 (%)	78.3	
10+ (%)	11.7	

Note. DSM-IV = Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition; FTND = Fagerström Test for Nicotine Dependence; HS = High School; GED = High School Equivalency. Reported are results from overall χ^2 tests (comparing categorical variables) and *t* tests (comparing continuous variables). Racial category of "other" includes self-identified Cape Verdean, Indian Portuguese, Mediterranean, Mexican American, and Portuguese. There were 2 missing cases for "age of smoking onset," 17 missing cases for "number of cigarettes smoked daily," and 2 missing cases for "number of quit attempts"—analyses are reported only for cases with all available data.
* $p < .05$; ** $p < .01$.

varimax rotation and extraction criteria of eigenvalue > 1, a principal components analysis yielded 12 rather than 13 factors. Of these 12, we identified eight strong factors with a meaningful number of items (ranging from 4 to 16) and factor loadings ranging from .40 to .85. The remaining four factors were associated with the remaining eight items, with factor loadings ranging from .50 to .70. Of these 12 identified factors, the three strongest ones appeared to be a combination of items from the highly correlated subscales identified above. Given high correlations among several sets of subscales and the results of EFA suggesting fewer than 13 subscales, we fit a final confirmatory model. This model utilized all 68 items but combined the three highly correlated pairs of scales into three single scales. This approach yielded a first-order 10-factor oblique solution. The results of this model were also acceptable (Table 3). However, the $\Delta\chi^2$ tests indicated that this 10-factor model was a significant improvement over a single-factor model but not over the original 13-factor model. These results replicate the original 13-factor solution empirically identified by Piper et al.

A second exploratory step assessing possible abbreviation of the WISDM scale was the elimination of redundant and weaker items initially identified through reliability analysis. We conducted a CFA following the 13-factor model by Piper et al. (2004) without previously detected redundant/weak items. Most of these items were also part of the weaker four factors identified through EFA reported above. Four subscales did not have redundant items: *Loss of Control*, *Craving*, *Positive Reinforcement*, and *Social and Environmental Goads* and they were modeled in their original format, whereas one questionable item was deleted from each of the remaining nine subscales. This item reduction procedure resulted in utilization of 59 (vs. original 68) items. The corresponding 13-factor model had an acceptable fit: $\chi^2 = 3748$, $df = 1574$, $p < .0001$; RMSEA = .061, and CFI = .98 (Table 3), suggesting that, perhaps, the most parsimonious solution would be to retain the 13-factor structure but to eliminate such weak or redundant items from individual subscales.

Differential subscale performance

Piper et al. (2004) characterized WISDM-68's 13 smoking as either "early emergent motives" or "late emergent motives." Early emergent motives are influential among all smokers, irrespective of their experience (p. 145), while late emergent motives are most influential among moderately heavy smokers or smokers with considerable lifetime exposure to nicotine. These characterizations were based on the shape of the association between the 13 subscales and smoking heaviness variable. Early emergent motives are characterized with a linear curve that grows consistently as the rate of smoking increases. Late emergent motives are characterized with a quadratic curve that grows slowly initially and then accelerates at higher levels of smoking heaviness (and also has a lower intercept than the linear curve).

We fit both linear and quadratic terms to model the association of the 13 WISDM-68 subscales with a log-transformed variable measuring smoking heaviness (i.e., number of cigarettes smoked per day multiplied by 30 days). Piper et al. (2004) identified *Cue Exposure*, *Social and Environmental Goads*, and *Taste and Sensory Properties* as early emergent based on their significant linear and insignificant quadratic curves. Using these criteria, we did not identify any early emergent motives in our sample (Table 4). Second, Piper et al. identified *Affiliative Attachment*, *Automaticity*, *Behavioral Choice*, *Cognitive Enhancement*, *Craving*, and *Tolerance* as late emergent based on their significant linear and significant quadratic curves. Using these criteria, we also found these six motives to be late emergent motives. Finally, Piper et al. identified *Loss of Control*, *Negative Reinforcement*, and *Positive Reinforcement* as more similar to late emergent than early emergent motives based on insignificant linear but significant quadratic terms. Based on these criteria, we suggest that development of *Negative Reinforcement* and *Positive Reinforcement* occurs among smokers who are neither new nor experienced smokers but rather moderate smokers. In other words, they are middle emergent. We found *Loss of Control*, *Cue*

Table 2. Cronbach's α-coefficients for 13 WISDM-68 subscales

Scale	Whole sample ($N = 431$)	Gender		Race		Age of onset of regular (daily) smoking		Current nicotine dependence		History of quit attempts	
		Male ($N = 166$)	Female ($N = 265$)	White ($N = 348$)	Non-White ($N = 83$)	<17 ($N = 168$)	≥17 ($N = 215$)	No ($N = 203$)	Yes ($N = 213$)	No ($N = 42$)	Yes ($N = 386$)
1. Affiliative Attachment	.89	.90	.89	.90	.84	.91	.87	.86	.90	.90	.89
2. Automaticity	.88	.85	.89	.88	.85	.87	.89	.86	.88	.92	.87
3. Loss of Control	.83	.86	.81	.84	.76	.79	.86	.83	.77	.87	.82
4. Behavioral Choice	.86	.88	.85	.87	.79	.86	.85	.84	.86	.85	.86
5. Cognitive Enhancement	.89	.90	.88	.90	.83	.88	.90	.87	.89	.90	.89
6. Craving	.83	.86	.81	.84	.79	.82	.83	.83	.78	.83	.83
7. Cue Exposure	.82	.82	.81	.82	.78	.81	.82	.81	.80	.84	.80
8. Negative Reinforcement	.87	.86	.88	.88	.83	.87	.88	.87	.85	.87	.87
9. Positive Reinforcement	.83	.86	.81	.85	.75	.84	.83	.80	.85	.85	.83
10. Social and Environmental Goads	.86	.84	.87	.88	.80	.87	.86	.86	.87	.86	.87
11. Taste and Sensory Properties	.85	.85	.85	.86	.78	.87	.80	.81	.87	.88	.85
12. Tolerance	.78	.79	.79	.79	.75	.80	.74	.76	.78	.80	.79
13. Weight Control	.88	.88	.88	.88	.88	.87	.89	.87	.88	.86	.89

Note. In all, 48 cases had no data on age of daily smoking onset, 15 cases had no data on current nicotine dependence, and 3 cases had no data on quit attempts. Age of onset was selected as 17 per Weiss et al. (2008). Subscale performance on all the studied subsamples was similar to the performance on the entire sample. The only exception was the non-White subsample of smokers, where internal consistency was mostly in the .70 range. This was most likely due to this group's small sample size ($n = 83$).

Table 3. Summary of model fits

Model	N	χ^2 (p)	df	CFI	RMSEA
1. Single-factor model (68 items)	431	9584 (p <.0001)	2210	.94	.12
2. 13-factor model (68 items)	431	5135 (p <.0001)	2132	.98	.064
3. 10-factor model (68 items)	431	5342 (p <.0001)	2165	.98	.065
4. Reduced 13-factor model (59 items)	431	3748 (p < .0001)	1574	.98	.061
Model comparisons		$\Delta\chi^2(p)$	Δdf		
Model 1 vs. Model 2		4449 (p < .001)	78		
Model 1 vs. Model 3		4242 (p < .001)	45		
Model 2 vs. Model 3		207 (p < .001)	33		

Note. CFI = comparative fit index; RMSEA = root mean squared error of approximation. Model 4 specified 13 unique subscales but eliminated items with redundant wording or items whose omission would not compromise the scale's reliability. Following items were eliminated from these subscales: (a) "Cigarettes keep me company, like a close friend" (*Affiliative Attachment*); (b) "Sometimes I'm not aware that I'm smoking" (*Automaticity*); (c) "It would take a pretty serious medical problem to make me quit smoking" (*Behavioral Choice*); (d) "Smoking helps me think better" (*Cognitive Enhancement*); (e) "If I always smoke in a certain place, it is hard to be there and not smoke" (*Cue Exposure*); (f) "I reach for cigarettes when I feel irritable" (*Negative Reinforcement*); (g) "I enjoy the sensations of a long, slow exhalation of smoke" (*Taste and Sensory Properties*); (h) "I can only go a couple of hours between cigarettes" (*Tolerance*); and (i) "Weight control is the major reason I smoke" (*Weight Control*).

Exposure, *Social and Environmental Goads*, and *Taste and Sensory Properties* to fit the criteria for late emergent. Overall, our findings were consistent with experiences of an older and more experienced group of smokers.

Validation

We assessed concurrent validity of WISDM-68 by examining correlations of the whole scale and the 13 subscales with four measures of nicotine dependence: (a) the FTND, (b) *DSM-IV* current nicotine dependence diagnosis, (c) *DSM-IV* symptom counts, and (d) number of cigarettes smoked per day.

WISDM-68 subscales *Tolerance*, *Craving*, and *Loss of Control* displayed highest, while *Taste and Sensory Properties*, *Social and Environmental Goads*, and *Weight Control* displayed lowest associations with FTND measure (Table 5), replicating the results of Piper et al. (2004). WISDM-68 subscales were also moderately correlated with *DSM-IV* symptom counts and daily smoking rates, as well as with our additional criterion (current *DSM-IV* nicotine dependence diagnosis), but these associations were weaker than those reported in Piper et al. However, WISDM-68 performed better than FTND in detecting *DSM-IV*-related criteria (Table 5). Multiple regression analyses, in which all WISDM-68 subscales were entered as predictors, revealed that the 13 subscales accounted for 66% of the variance in FTND scores; 18% of the variance in *DSM-IV* dependence diagnosis; 29% of the variance in *DSM-IV* symptoms count; and 41% of the variance in daily smoking rates. These values were lower than those reported in Piper et al. Again, the WISDM-68 subscales

Table 4. Linear and quadratic coefficients from the quadratic regression models describing the association between the WISDM-68 subscales and smoking heaviness, *N* = 414

Outcome	Linear coefficient	t	Quadratic coefficient	t
1. Affiliative Attachment	−.80	−2.46**	.13	4.06**
2. Automaticity	−1.12	−3.49**	.20	6.28**
3. Loss of Control	−1.23	−3.74**	.21	6.30**
4. Behavioral Choice—Melioration	−.57	−2.0*	.12	4.15**
5. Cognitive Enhancement	−.85	−2.64**	.13	4.08**
6. Craving	−.94	−3.20**	.18	6.10**
7. Cue Exposure—Associative Process	−.72	−2.60**	.12	4.34**
8. Negative Reinforcement	−.29	−0.98	.08	2.66**
9. Positive Reinforcement	−.35	−1.19	.08	2.75**
10. Social and Environmental Goads	−.48	−1.34	.10	2.73**
11. Taste and Sensory Properties	−.39	−1.40	.09	3.25**
12. Tolerance	−1.24	−4.4**	.23	8.40**
13. Weight Control	−.33	−0.87	.05	1.43

Note. WISDM-68 = Wisconsin Inventory of Smoking Dependence Motives; shown are nonstandardized linear and quadratic coefficients for smoking heaviness predicting each of the WISDM-68 13 subscales. Only cases with all available data on "smoking heaviness" were included in the analyses. Smoking heaviness = log [(no. cigarettes/day × 30 days) + 1].

$^*p < .05$; $^{**}p < .01$.

Table 5. Zero-order correlations between WISDM-68 subscales and validation criteria

Measure	Correlation coefficient: FTND, *N* = 410	*DSM-IV* current dependence dx, *N* = 416	*DSM-IV* symptoms count, *N* = 422	Number of cigarettes per day, *N* = 414
1. Affiliative Attachment	.45**	.27**	.41**	.34**
2. Automaticity	.58**	.25**	.37**	.49**
3. Loss of Control	.55**	.37**	.51**	.45**
4. Behavioral Choice—Melioration	.48**	.27**	.38**	.40**
5. Cognitive Enhancement	.37**	.27**	.40**	.32**
6. Craving	.60**	.35**	.45**	.46**
7. Cue Exposure—Associative Process	.41**	.29**	.42**	.31**
8. Negative Reinforcement	.38**	.32**	.43**	.30**
9. Positive Reinforcement	.37**	.19**	.33**	.30**
10. Social and Environmental Goads	.33**	.13**	.11*	.27**
11. Taste and Sensory Properties	.35**	.12*	.22**	.35**
12. Tolerance	.81**	.27**	.39**	.61**
13. Weight Control	.18**	.17**	.24**	.11*
Total WISDM-68	.61**	.34**	.48**	.49*
FTND		.20**	.30**	
DSM-IV current dependence dx	.20**		.46**	.16**
DSM-IV symptoms count	.30**			.22**
Number of cigarettes per day		.16**	.22**	

Note. WISDM-68 = Wisconsin Inventory of Smoking Dependence Motives; FTND = Fagerström Test for Nicotine Dependence; *DSM-IV* = *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*. "Number of cigarettes smoked per day" is an item from the FTND scale; thus, correlations between these associated measures were not provided. The WISDM-68 subscales were also moderately correlated with *DSM-IV* symptom counts and daily smoking rates, but these associations were weaker than those reported in Piper et al. The overall WISDM-68 scale showed significant associations with all four validation criteria but performed weaker in our analysis than in Piper et al. Although WISDM-68 subscales underperform in comparison to Piper et al. (2004), this measure performed better in detecting *DSM-IV* nicotine dependence symptoms and diagnosis (dx) than FTND (details available from authors).

$^{*}p < .05$; $^{**}p < .01$.

performed better prediction-wise than FTND, which explained only 4% of the variance in *DSM-IV* dependence diagnosis and 10% of the variance in *DSM-IV* symptom counts.

Multivariate logistic regression analyses using all the WISDM-68 subscales as predictors of *DSM-IV* dependence diagnosis revealed significant effects of *Loss of Control* [exp*B* = 1.3, *CI* (95%) = 1.05–1.6, $p = .02$], *Negative Reinforcement* [exp*B* = 1.6, *CI* (95%) = 1.12–2.1, $p = .002$], and *Positive Reinforcement* [exp*B* = .71, *CI* (95%) = .52–.96, $p = .03$]. Our results are in contrast with the report of Piper et al., where *Craving*, *Tolerance,* and *Cue Exposure* were most predictive of *DSM-IV* dependence criteria. Similar results were obtained from multivariate regressions predicting *DSM-IV* symptom count, where the only significant predictors were *Loss of Control* ($\beta = .34$, $p = .001$), *Negative Reinforcement* ($\beta = .20$, $p = .02$), and *Affiliative Attachment* ($\beta = .16$, $p = .04$).

Discussion

We examined the psychometric properties of the WISDM-68 among a population-based sample of adult smokers who were, on average, older, less educated, and heavier smokers than the sample analyzed by Piper et al. (2004). We found most subscales to have high internal consistency (even across relevant demographic subgroups), but there was also some redundancy among items on most scales. We found that the original 13-factor model by Piper et al. better fit our data than a single-factor model. However, note that all hereby reported models were estimated without accounting for possible error covariance because the original models by Piper et al. (2004) were specified in this manner. Additional models, which would include modeling of error terms, may provide useful information relevant in further development and refinement of WISDM measure. In general, our findings are in accord with those reported by Piper et al., suggesting that there is value in recognizing the latent construct of nicotine dependence as multidimensional. This heterogeneity does not necessarily suggest that the optimal model has 13 factors. We tested a proposition that a model with fewer subscales may be more appropriate. A 10-factor confirmatory model was fit, and although this model showed an acceptable fit, the original 13-factor solution remained a better fit. Thus, empirical support for the original 13 subscales remained relatively strong, despite high intercorrelations among some subscales. Specifically, we found, as did Piper et al., high correlations between three pairs of subscales (i.e., *Affiliative Attachment* and *Behavioral Choice/Melioration*; *Loss of Control* and *Craving*; and *Positive Reinforcement* and *Negative Reinforcement*), suggesting that each pair of motives may be tapping into identical constructs and could be combined into a single subscale. However, because scales that are highly correlated with one another may be differently related to third variables, it is best if the decision to combine these subscales is informed by validity data concerning other relevant factors. Our CFA results suggest that a better approach to abbreviating the WISDM-68 may be elimination of redundant and weaker items from individual scales rather than truncating the number of subscales. This shortens the time needed to administer the instrument without compromising reliability or number of constructs measured.

Next, we examined the association of the WISDM-68 subscales with smoking heaviness and found that all 13 subscales predicted smoking heaviness reasonably well. We also sought to identify patterns that might suggest the existence of "early" and "late" emergent smoking motives. In this regard, our results diverge from those reported by Piper et al. (2004). In our analysis, none of the subscales evinced a pattern of coefficients that would suggest "early emergent motives." In contrast, in our models, *all* the subscales evinced patterns consistent with "late emergent motives." This may be, in part, due to the relatively limited range of smoking heaviness among our respondents, who are, on average, older and heavier smokers than respondents, in the samples by Piper et al. The higher prevalence of heavy smokers in our sample may have produced a ceiling effect, thus masking a linear association with smoking heaviness—a statistical marker for an early-onset motive.

Finally, our examination of concurrent validity yielded similar but weaker associations than in Piper et al. (2004). The lower associations observed in our study may be due to considerable sample differences between the two studies. Further, our multiple regression analyses identified different WISDM-68 subscales as the best predictors of *DSM*-related criteria. This is most likely due to inherent differences between the Kawakami Tobacco Dependence Screener (which was validated only in samples of Japanese men) used to measure *DSM-IV* symptoms in Piper et al. and the interviewer-administered CIDI used to measure *DSM-IV* symptoms in our study.

This work has several limitations. First, the original NCPP cohort and the participating adult offspring may have had inherent selection biases of unknown implications for interpretation of these results. Second, there were demographic differences between NCPP participants who completed the WISDM-68 and those that did not, with survey completers more likely to be White, unmarried, and of lower educational attainment. The under representation of racial and ethnic minorities in our sample reflects the demographic characteristics of Rhode Island and Massachusetts in the 1960s when the cohort was initiated. Regardless, the assumption of universal applicability of standardized scales normed on majority populations needs to be explicitly tested across domains (such as racial/ethnic background) to ensure their utility among specific subgroups.

In conclusion, we found the WISDM-68 to consist of internally consistent subscales, whose independence supports the perspective of nicotine dependence as a heterogeneous construct. The multidimensional nature of the nicotine dependence construct as captured by the WISDM-68 is also reflected in the moderate correlations between most of the instrument's subscales and the FTND, *DSM-IV* diagnosis, *DSM-IV* symptom counts, and smoking heaviness. Conceptualizing nicotine dependence in terms of independent motivations for tobacco use provides a comprehensive understanding of the putative mechanisms at work in the tobacco dependence process. Use of WISDM-68 in a population-based sample may advance scientific and clinical insight into the reasons people continue to smoke and the reasons for relapse.

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Declaration of Interests

None declared.

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