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Psychometric Characteristics of the Brief Wisconsin Inventory of Smoking Dependence Motives Among a Nonclinical Sample of Smokers

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Abstract

Introduction: Attempts to validate the Brief Wisconsin Inventory of Smoking Dependence Motives (WISDM) have produced mixed results. The objectives for the current research were to (1) evaluate the test-retest reliability, internal consistency, and concurrent validity for each of the motive scales (2) evaluate three models to determine fit based on previous research: (i) 11-factor model, (ii) 11-factor model with four error covariances specified by previous research, and (iii) 11-factor model with two higher order primary and secondary dependence motive factors, and (3) evaluate the discriminant and convergent validity of the Brief WISDM scales.

Methods: Smoking adults aged 18–65 completed a survey about their smoking behaviors and nicotine dependence with a web-based instrument that was administered at a 3-month test-retest interval. Psychometric properties and test-retest reliability were evaluated for each instrument. The 11-factor Brief WISDM was evaluated with confirmatory factor analyses; the scales were evaluated for convergent and discriminant validity.

Results: The Brief WISDM demonstrated good to excellent test-retest reliability. Confirmatory factor analysis showed the model with the second order primary and secondary dependence motive factors demonstrated the best fit for the data at both administrations. Discriminant validity issues were present for most of the primary dependence motive scales.

Conclusions: To date, the theoretically derived smoking motives for the Brief WISDM have demonstrated mixed support when submitted to confirmatory factor analysis. While these scales tap critical motives of nicotine dependence, further refinement of primary dependence motives is necessary to ensure each latent variable assesses a unique construct.

Introduction

Tobacco dependence is typically associated with increased nicotine tolerance and the experience of withdrawal symptoms during periods of abstinence. Successfully quitting smoking and maintaining abstinence is often difficult for nicotine-dependent smokers. Theory and research have shown that nicotine dependence is a multifaceted construct and that a variety of motives lead to continued use or relapse

among quitters.[1,2] Reliable measures to assess factors associated with dependence are necessary to guide cessation interventions, determine optimal approaches to treatment, identify likely triggers for relapse, and compare dependence potential across tobacco and nicotine products. These measures are needed for both clinical and nonclinical samples, though typically dependence measures are evaluated in only clinical settings. Validated dependence measures for use in nonclinical research settings are also needed.

Traditionally, nicotine dependence has been measured with the Fagerstrom Test for Nicotine Dependence (FTND) which measures frequency and timing of smoking[3] and its two-item subscale, the Heaviness of Smoking Index (HSI; how soon after you wake up do you smoke your first cigarette, how many cigarettes a day do you smoke).[4,5] These metrics are readily and conveniently employed; however, the psychometric properties of these measures are tenuous, with some studies demonstrating poor to moderate internal consistency for the measures[6–8] and others indicating that the FTND is unstable when subjected to factor analysis.[9–11]

While the FTND and HSI measures provide a metric for the magnitude of nicotine seeking behavior, they appear unsuited to determine why or what factors contribute to dependence, motivate continued use, and drive relapse after a quit attempt. To better capture the multifaceted nature of nicotine dependence, Piper and colleagues[1] developed the 68-item Wisconsin Inventory of Smoking Dependence Motives (WISDM). This measure, which identifies 13 theoretically driven subscales encompassing the physiological, psychological, and social dimensions that drive nicotine dependence, also has good psychometric properties including concurrent, discriminant, and predictive validity.[12–14] Further research has parsed the subscales into two broader categories—primary dependence motives (PDMs) and secondary dependence motives (SDMs)—that underscore the core and ancillary features of tobacco and nicotine dependence, respectively.[13] Given the length and assessment burden associated with administering the full 68-item measure, Smith and colleagues[15] refined the measure to a 37-item Brief WISDM. This measure maintained 11 of the 13 original subscales and the two higher order primary and SDMs. The PDMs include four subscales: Automaticity, Loss of Control, Craving, and Tolerance. The SDMs include seven scales: Affiliative Attachment, Cognitive Enhancement, Cue Exposure, Social Goads, Taste, Weight Control, and Affective Enhancement.[15] Initial research found partial support for the factor structure; however, these studies did not administer the Brief WISDM independently from the full 68-item assessment.[15–17]

To our knowledge, the psychometric properties of the Brief WISDM have been evaluated independent of the full scale twice with mixed results. Castro et al.[18] was unable to replicate the model among a treatment-seeking Spanish speaking population with the 11-factor model producing a nonpositive definite matrix. The authors speculate that the finding likely results from very strong correlations between four factors: Loss of Control, Cue Exposure, Craving, and Tolerance which may be indicative of issues with discriminant validity. The authors were also unable to find support for the second order model.[18] Pancani et al.[19] evaluated the Brief WISDM among a sample of young daily smokers and found the 11-factor model suitable (with error covariances), but also had significantly better model fit than the second order primary and SDM model. Given these mixed findings, further evaluation of the assessment tool is warranted. Additionally, while the 68-item WISDM has shown long-term stability,[1] no research to date has assessed the test-retest reliability of the abbreviated instrument.

The objectives for the current research were to (1) evaluate the test-retest reliability, internal consistency, and concurrent validity for each of the motive scales outlined in the Brief WISDM (2) evaluate three models to determine fit based on previous research (i) the 11-factor model, (ii) the 11-factor model with four error covariances specified by Smith et al.,[15] and (iii) the 11-factor model with two higher order primary and SDM factors, and (3) evaluate the discriminant and convergent validity of the Brief WISDM scales.

Methods

Participants and Procedure

As part of a larger survey, adult smokers aged 18–65 were recruited from a web-based convenience sample maintained by Global Market Insite (www.gmi-mr.com/global-panel/index.php), a commercial marketing company with access to preenrolled, national panels of smokers with defined sociodemographic characteristics. Respondents were classified as a smoker and selected for this research if they reported having smoked at least 100 cigarettes in their lifetime and reported currently smoking some days or every day. Respondents then completed a set of questions on demographic characteristics, smoking history, and nicotine dependence. The survey was readministered to the same respondents 3 months later. The 3-month period was selected to minimize carryover effects or recall from the original administration, while maintaining a low likelihood of changes in tobacco use or dependence. In this manuscript T1 refers to the first administration and T2 refers to the second administration. Respondents were compensated with 60 Global Market Insite "marketpoints" for completing the first survey (worth US $3) and 90 marketpoints for the second survey (US $4.50). The study protocol was approved by the Institutional Review Board at Roswell Park Cancer Institute, Buffalo, NY.

Nicotine Dependence Measures

Respondents completed the 37-item Brief WISDM as described by Smith et al.[15] Respondents rated each item on a scale of 1 (*not at all true of me*) to 7 (*extremely true of me*). To establish concurrent validity, respondents also completed the FTND; scores on this measure range from 0–10 with higher scores indicative of increased levels of dependence.[3,20] The derivative, the HSI, was also computed (range: 0–6).[5]

Data Analyses

Test-Retest Reliability and Internal Consistency

Test-retest reliability for demographic characteristics and WISDM scales and items were assessed with two criteria: the kappa statistic (κ) for the dichotomous and categorical items, where $\kappa > 0.74$ indicated excellent reliability, between 0.59 and 0.74 indicated good reliability, and $\kappa < 0.40$ indicated poor reliability,[21] and the single measures intra-class correlation coefficient (ICC) for continuous items (a two-way random effects model, see Shrout and Fleiss[22]) where a value above 0.80 indicated strong agreement, 0.60 indicated moderate agreement, and 0.40 indicated poor agreement between the administrations.[22] Scale reliability was assessed using Cronbach's alpha for internal consistency with an alpha above 0.70 considered acceptable for initial scale development and alpha above 0.90 for applied use.[23] Data were not weighted to match the US population as we did not intend to make population estimates.

Tobacco Dependence Scale Validity

The data were first subjected to a series of confirmatory factor analyses using AMOS. Model fit was assessed using several metrics, including the comparative fit index and Tucker-Lewis index (near 0.95),[24] root-mean-square error of approximation less than 0.06, minimum discrepancy (CMIN/DF < 3), and standardized root mean square residual less than 0.05.[25–27] Model comparisons were made with chi-square difference tests.

Concurrent validity of the Brief WISDM was assessed by evaluating the correlation between each of the scales and the FTND and HSI consistent with Smith et al.[15] and Ma et al.[16] The PDMs are likely to exhibit stronger correlations than the SDMs because they assess the magnitude of physical dependence on nicotine as does the FTND. Discriminant validity was assessed using the Fornell and Larcker method for two or more factors.[28] The average variance extracted (AVE) and the maximum shared variance were examined. In order for discriminant validity to be present the AVE for each of the constructs must be larger than the shared variance (square of the correlation) between the constructs.[28,29] Convergent validity was assessed by examining the AVE, where AVE > 0.50 demonstrated validity.

Results

Sample Characteristics

The majority of respondents were white (67%), 12% black, 17% Hispanic, and 5% Asian/Other. Fifty-nine percent were male. One-fifth (19%) obtained a high school diploma or GED (general equivalency diploma), 44% reported some college/technical/associates degree, and 35% had earned a bachelor's degree or higher. At the first administration, among daily smokers, 21% reported seriously thinking of quitting smoking within the next 30 days, and 40% within the next 6 months. Just over half (51%) of daily smokers reported at least one full 24-hour quit attempt within the past year.

Respondent Retention

Of the respondents who reported having smoked at least 100 cigarettes in their lifetime and reported current smoking (N = 615) some days (26%) or every day (74%) with complete dependence data at the first administration, over half (53%, N = 328), completed the re-administration 3 months later. The final sample included 328 smoking respondents; some day smokers (26%) and every day smokers (74%). The demographic characteristics of respondents indicated perfect agreement between administrations (Table 1) verifying that participants were the same for both administrations. There was also high reliability between administrations for quit attempts within the past year.

Test-Retest Reliability of Tobacco Dependence Measures Among Smokers

Table 2 presents the test-retest reliability coefficients and single measures ICCs for each of the tobacco dependence measures and their subscales. The FTND total scale demonstrated acceptable internal consistency (T1:0.695, T2:0.698), and the single measures ICC was 0.799. Internal consistency for the HSI was below the acceptable cutoff level. The WISDM scales each demonstrated good to strong reliability at both administrations (alphas > 0.85), except for the cue exposure scale which showed moderate reliability. The ICCs for each of the 11 dependence domains showed moderate to strong stability between administrations (range: 0.67–0.82). Overall the total score (0.796) and the primary (0.815) and secondary (0.780) dependence motive scales demonstrated strong or near strong agreement between administrations.

Concurrent Validity, Confirmatory Factor Analyses of the Brief WISDM at Each Wave

Table 3 presents the concurrent validity of the brief WISDM. This was assessed by examining significant correlations between each of the dependence domains and the scores on the six-item FNTD and the two-item HSI. The WISDM subscales at each wave were significantly associated with the FTND and were similar and often stronger than those reported by Smith et al.[7] In addition, the scales that tap into the increased nicotine tolerance and dependence were more strongly correlated with the FTND than those that tap the more ancillary motives.

The data were next subjected to confirmatory factor analysis in three stages (Table 4). First, Model 1 tested the 11-factor model. Second, Model 2 tested the 11-factor model with the four correlated error terms identified in the initial development in the Brief WISDM. This includes error covariances between items (1) "I usually want to smoke right after I wake up" and "I smoke within the first 30 minutes of waking," (2) "cigarettes control me" and "sometimes I feel like cigarettes rule my life," (3) "my smoking is out of control" and "I consider myself a heavy smoker," and (4) "other smokers would consider me a heavy smoker" and "I consider myself a heavy smoker."[15] Finally, Model 3 included the second order primary and SDM factors. At T1 the initial model (M1, T4) demonstrated moderate fit and produced the following result: χ^2 (df = 574) = 1382.952, comparative fit index = .922, root-mean-square error of approximation = 0.066, standardized root mean square residual = 0.0436. Model 2 with the four error covariance produced a nonpositive definite covariance matrix. Inspection of the correlations between factors showed extremely high (near 1) correlations between some factors (eg, between loss of control and tolerance: r = 0.92). Model 3 with the second order primary and SDM factors (Model 3 T4) also

Table 1. Test-Retest Reliability of Respondents' Demographic and Tobacco Use Data (N = 333)

	Time 1	Time 2	ICC or kappa	95% CI or *SE*
Demographics				
Age, years, mean (*SD*) range 18–64	45.95 (11.74)	45.98 (11.73)	1	—
Sex: male, %	59	59	1	—
Race: non-Hispanic white, %	67.1	67.1	1	—
Tobacco use				
Do you now smoke, every day %	74.1	80.5	0.594	0.05
Considering quitting in next 30 days (daily smokers)	24.4	19.5	0.551	0.045
How many times have you quit for 24 hours in past year among daily smokers, mean (*SD*)	1.43 (2.40)	1.84 (3.50)	0.638	0.557–0.707

CI = confidence interval; ICC = intra-class correlation coefficient; *SE* = standard error.

Table 2. Test-Retest Reliability Statistics for Tobacco Dependence Measures

Scale	Scale	Cronbach's alpha T1	Cronbach's alpha T2	Cronbach's alpha T1T2	Single measures ICC	ICC, 95% CI lower bound	ICC, 95% CI upper bound	Mean T1	*SD* T1	Mean T2	*SD* T2
Fagerstrom Test for Nicotine Dependence	0–10	0.695	0.698	0.890	0.799	0.755	0.836	4.024	2.509	4.271	2.502
HSI	0–6	0.677	0.621	0.885	0.790	0.745	0.828	2.302	1.610	2.448	1.546
How soon after waking do you smoke	0–3	—	—	0.850	0.737	0.683	0.783	1.491	1.040	1.585	1.028
How many cigarettes do you smoke a day	0–3	—	—	0.873	0.773	0.725	0.813	0.811	0.794	0.863	0.767
WISDM scales											
Total score	11–70	0.967	0.966	0.888	0.796	0.751	0.833	46.762	13.873	48.025	13.740
Primary dependence motives	1–7	0.955	0.956	0.900	0.815	0.774	0.849	4.361	1.494	4.513	1.472
Automaticity	1–7	0.915	0.922	0.851	0.740	0.687	0.785	4.333	1.708	4.451	1.731
Loss of control	1–7	0.902	0.894	0.880	0.783	0.737	0.822	4.372	1.697	4.520	1.623
Tolerance	1–7	0.860	0.858	0.905	0.820	0.777	0.855	4.094	1.7	4.312	1.695
Craving	1–7	0.896	0.892	0.883	0.788	0.743	0.826	4.648	1.569	4.768	1.539
Secondary dependence motives	1–7	0.943	0.942	0.877	0.780	0.733	0.819	4.188	1.259	4.282	1.259
Taste	1–7	0.850	0.882	0.800	0.666	0.602	0.723	5.182	1.373	5.2222	1.377
Cognitive enhancement	1–7	0.904	0.927	0.840	0.720	0.662	0.769	4.151	1.685	4.353	1.733
Weight control	1–7	0.876	0.886	0.875	0.777	0.730	0.816	3.366	1.759	3.476	1.791
Cue exposure	1–7	0.736	0.762	0.810	0.681	0.618	0.735	4.471	1.434	4.544	1.455
Affective enhancement	1–7	0.869	0.895	0.841	0.726	0.670	0.773	4.321	1.609	4.396	1.652
Social goads	1–7	0.935	0.938	0.847	0.735	0.681	0.781	4.047	1.808	4.069	1.836
Affiliative attachment	1–7	0.894	0.895	0.857	0.747	0.695	0.792	3.776	1.783	3.916	1.821

CI = confidence interval; HSI = Heaviness of Smoking Index; *SE* = standard error; WISDM = Wisconsin Inventory of Smoking Dependence Motives. T1 refers to the first administration; T2 the second administration; Cronbach's alpha T1T2 refers to the alpha for the full scale; ICC refers to the single measures intraclass correlation coefficient.

produced a result within the acceptable range for some fit indices (χ^2 [df = 613] =1496.909, P < .001, comparative fit index = 0.915, root-mean-square error of approximation = 0.066, standardized root mean square residual = 0.0597), and was an improved fit from Model 1. Results were replicated at T2.

Discriminant and Convergent Validity

Discriminant and convergent validity statistics for each of the scales at T1 and T2 are presented in Supplementary Table 1. At T1 discriminant validity issues were identified for three of the primary and four of the SDM scales: loss of control, tolerance, craving, cognitive enhancement, cue exposure, and affective enhancement, affiliative attachment. Convergent validity was not observed for cue exposure (AVE < 0.50). At T2 discriminant validity issues were present for three of the PDMs: loss of control, tolerance, and craving, and one SDM: cue exposure.

Discussion

Over a 3-month interval, among a sample of current daily and nondaily smokers, the total WISDM score, SDMs, and all subscales met the criteria for good long-term stability and the PDMs demonstrated strong (ICC: 0.815) long-term stability. Each of the scales also showed a moderate to high degree (α: 0.736–0.967) of internal consistency at each administration. As expected, the PDMs were more strongly correlated with the FTND and HSI, consistent with previous research demonstrating that the PDMs measure physical dependence on nicotine while the SDMs measure more ancillary motivations to smoke. It should be noted that each of the SDMs (except for the association between weight control and HSI at T1) was also significantly associated with the FTND and HSI highlighting the relationship between each of the latent factors and the multidimensional nature of nicotine dependence.

The 11-factor model indicated an acceptable fit for the data for most indices, though the model that included the four specified error covariances produced a nonpositive definite matrix (likely due to strong correlations between factors). The final model with the second order factors fit the data best. Results were replicated at the second administration. This finding is inconsistent with Vajer et al. (2011) and Pancani et al.,[19] who found the 11 factor model fit the data better than the proposed second order factor model that represented primary and SDMs.

The Brief WISDM outlines important dimensions and motives that drive nicotine dependence; however, these findings coupled with results from previous assessments, suggest that further refinement of the subscales and model specification may be necessary. This research found that the second order model fit the data best; however issues with discriminant validity were present—especially among the PDMs indicating that some of the subscales may be measuring the same underlying construct. In particular, the highly correlated PDMs may benefit from a reduction in scales and consolidation of items or refined question wording to more distinctly identify the constructs—if indeed they are intended to measure conceptually distinct dimensions.

Importantly, the Brief WISDM was originally designed to measure motives and dependence among established daily smokers. This research included both daily and nondaily smokers and the model fit the data well. Future research should evaluate the measure with a larger sample of nondaily smokers to ensure the effectiveness of using this measure in this population. Understanding how both daily and nondaily smokers struggle with dependence based on this measure may help to identify appropriate cessation techniques and evaluate dependence on cigarette products.

Some limitations for the current research should be considered. The sample was not representative of the US population or of tobacco users limiting the generalizability of findings. Specifically, our population was more highly educated than the general smoking population. Additionally, only half of the sample provided follow-up data. While this is typical in a consumer based internet panel it may introduce error. However, the current research was not designed to

Table 3. Concurrent Validity—Correlation With Fagerstrom Test for Nicotine Dependence (FTND) and Heaviness of Smoking Index (HSI) Validity Measure

	Time 1		Time 2	
WISDM scales	FTND	HSI	FTND	HSI
Total score	0.587**	0.435**	0.623**	0.464**
Primary dependence motives	0.690**	0.575**	0.708**	0.589**
Automaticity	0.577**	0.450**	0.575**	0.470**
Loss of control	0.593**	0.504**	0.605**	0.515**
Tolerance	0.737**	0.656**	0.764**	0.668**
Craving	0.538**	0.426**	0.580**	0.446**
Secondary dependence motives	0.456**	0.295**	0.498**	0.330**
Taste	0.240**	0.178**	0.237**	0.196**
Cognitive enhancement	0.449**	0.314**	0.426**	0.302**
Weight control	0.204**	0.057	0.282**	0.115*
Cue exposure	0.363**	0.234**	0.471**	0.335**
Affective enhancement	0.402**	0.286**	0.439**	0.293**
Social goads	0.275**	0.177**	0.304**	0.204**
Affiliative attachment	0.509**	0.344**	0.468**	0.309**

WISDM = Wisconsin Inventory of Smoking Dependence Motives.
*P < .05; **P < .01.

Table 4. Degree of Model Fit for Competing Measurement Models for the Brief Wisconsin Inventory of Smoking Dependence Motives (WISDM)

	Model	CMIN/DF	CFI	TLI	RMSEA	SRMR
Model 1 T1	11 first-order factors	2.409	0.922	0.912	0.066	0.0436
Model 2 T1	11 first-order factors with four error covariances	The covariance matrix was nonpositive definite				
Model 3 T1	11 first-order factors, error covariances, and two second order factors	2.442	0.915	0.907	0.066	0.597
Model 1 T2	11 first-order factors	2.306	0.929	0.918	0.063	0.0450
Model 2 T2	11 first-order factors with four error covariances	The covariance matrix was nonpositive definite				
Model 3 T2	11 first-order factors, error covariances, and two second-order factors	2.284	0.926	0.919	0.063	0.0608

CFI = comparative fit index; RMSEA = root-mean-square error of approximation; SRMR = standardized root mean square residual; TLI = Tucker-Lewis index.

make population estimates, but rather evaluate the test-retest reliability and psychometric characteristics of smoking measures such as the Brief WISDM. It is possible that the composition of the sample, including nondaily smokers, affected the assessment of the factor structure for the Brief WISDM, as their patterns of responding may differ from the treatment-seeking groups on which the measure was developed. Indeed, others have found that smokers with ADHD (Attention Deficit Hyperactivity Disorder),[30] nondaily smokers,[31] and black smokers[16] show different response patterns on the full WISDM. Disparate findings across subpopulations argues for further examination of the psychometric properties of the Brief WISDM.

Conclusions

In conclusion, the Brief WISDM provided a reliable and stable measure of nicotine dependence over a 3-month interval among a web-based sample of smokers. Furthermore, the Brief WISDM demonstrated concurrent validity with established measures of nicotine dependence (FTND, HSI). The current research found the greatest support for the 11-factor model with the four correlated error terms and the second order factors for Primary and Secondary Dependence domains. Despite this, issues with discriminant validity were present—especially among the PDMs. Further research should test additional question formats designed to tap these critical components of dependence such that the scale items assess measurably distinct latent variables and assess the revised version for construct validity in larger samples of both treatment seeking and general population smokers.

Supplementary Material

Supplementary Table 1 can be found online at http://www.ntr.oxfordjournals.org

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Declaration of Interests

None declared.

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