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The Fagerström Test for Nicotine Dependence: Do revisions in the item scoring enhance the psychometric properties?

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Abstract

Despite widespread use, considerable literature has shown that the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991) has questionable psychometric properties, generally reflecting relatively poor properties of reliability and validity. One factor that may be affecting the psychometric qualities of the scale is the use of a dichotomous, forced-choice response format for certain items, in which respondents are asked to answer each question with a *Yes* or *No* response. This scoring approach is especially problematic when used to measure dimensional constructs, such as nicotine dependence, in which a dimensional construct is forced into a categorical construct. The purpose of the current study was to examine whether revising the response format utilized in the FTND would lead to an enhancement in the psychometric properties of this scale. This question was examined by removing the forced-choice response criteria on items 2, 5, and 6 of the FTND and revising the response options to reflect a 4-point Likert response set (0 = *never*, 1 = *sometimes*, 2 = *most of the time*, 3 = *always*). Participants consisted of 343 smokers from the community. Results revealed that the revised scoring approach resulted in a significant incremental improvement in scale reliability and enhanced convergent validity, showing a stronger association with smoking outcomes than the FTQ or FTND. Findings are discussed in terms of recommendations for scale revision and usage.

Keywords

Fagerström Test for Nicotine Dependence; FTND; psychometrics

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Contributors

Kristina J. Korte conducted literature reviews, designed the study, conducted the statistical analyses, and wrote all drafts of the manuscript. Daniel W. Capron wrote the method section and assisted with editing the final manuscript. Michael Zvolensky reviewed and edited the manuscript and provided the data for the project. Norman B. Schmidt assisted with the conceptualization of the project, edited and proofed the manuscript, and provided data for the project.

Conflict of Interest

All authors declare that they have no conflicts of interest to disclose.

1. Introduction

The Fagerström Tolerance Questionnaire (FTQ; Fagerström, 1978) and the Fagerström Test for Nicotine Dependence (FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) are two of the most commonly used measures of nicotine dependence. Despite widespread use, the use of these questionnaires has been controversial due to the research suggesting that the scale has questionable psychometric properties. The FTQ was originally comprised of eight self-report questions, however, revisions of the scale, led to the development of the FTND. The FTND is a shortened version of the FTQ, which included six of the original eight scale items. Item two (i.e., *What brand do you smoke?*) and item three (i.e., *Do you inhal*e?) on the FTQ were removed due to their failure to predict to biochemical markers and that they appeared to be the primary contributors to the psychometric deficiencies of the FTQ (Heatherton et al., 1991). The FTND also includes a broader range of scoring for two items (*Number of cigarettes per day*; CPD and *Time to first cigarette*; TFC items). It was believed that these scale modifications would resolve some of the psychometric deficiencies observed in this scale thereby enhancing the measurement of nicotine dependence. Although the properties have improved marginally from the FTQ (Heatherton et al., 1991; Payne et al, 1994), the literature shows that these alterations have failed to make substantial improvements to the psychometric properties of the FTND (Payne, Smith, McCracken, Clinton, & Antony, 1994).

Considerable research has shown that the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991) has questionable psychometric properties, generally reflecting poor (Hughes, Oliveto, Riggs, Kenny, Liguori et al., 2004; Etter, Vu Da, & Perneger, 1999) to mediocre (Burling & Burling, 2003) properties of reliability and validity. The FTND has been shown to have poor internal consistency (Burling & Burling, 2003; Heatherton et al., 1991; Payne, et al., 1994; Pomerleau, et al. 1994; Sledjeski et al., 2007; Steinberg, Williams, Steinberg, Krejci & Ziedonis, 2005), low construct validity (Etter et al., 1999), and poor predictive validity (Sledjeski et al, 2007). Several studies have also reported the FTQ and FTND to have poor rates of reliability (Burling & Burling, 2003; Payne et at., 1994; Pomerleau, et al. 1994; Sledjeski et al., 2007). Specifically, reliability estimates have been reported to be as low as .49 for the FTQ and .56 for the FTND (Payne et al., 1994). The FTND has also been shown to have limited ability to predict smoking related outcomes, such as change in smoking behavior over time (Etter, Vu Duc, & Perneger, 1999) and limited ability to predict biochemical markers of smoking dependence. Finally, factor analytic studies have shown this scale to have an unstable factor solution (Etter, Vu Duc, & Perneger, 1999; Haddock et al., 1999; Payne et al., 1994; Steinberg et al., 2005).

Given the widespread use of this scale, attempts aimed at improving the FTND's psychometric qualities may enhance the ability of this scale to accurately measure nicotine dependence. One potentially promising area that has been relatively neglected when evaluating the FTQ and FTND's psychometric properties is the scoring approach and item responses utilized for this scale. Four of the items on the FTND (items 2, 4, 5, and 6) use a dichotomous, forced-choice response format. Three items (items, 2, 5, and 6) use a scoring approach in which respondents are asked to answer each question with a *Yes* or *No* response, while item 4 (corresponds to item 6 on the FTQ), uses the dichotomous scoring choices of

"*first of the day*" or "*all other cigarettes*", when answering the question of Which cigarette of the day would you most hate to give up? This dichotomous scoring approach is typically referred to as *forced-choice item format* (Hicks, 1970). An important consideration in scale construction is determining whether the scoring approach selected is appropriate for the construct of interest. Use of a forced-choice response format can be especially problematic when used to measure dimensional constructs, such as nicotine dependence, in which the construct is forced into a categorical construct, thereby leading to unreliability in construct measurement (Comrey, 1988; Clark & Watson, 1995).

It is possible that the problems observed in the FTND, such as low reliability, questionable validity, and unreliable factor structure, may be partially due to the use of a forced-choice response format for a majority of the scale items. For instance, Radzius, Gallo, Epstein, Gorelick, Cadet et al. (2003) argued that the FTND questions with the *yes* or *no* forced-response may not reflect "true dichotomies", suggesting that these questions may actually have a normal distribution of thresholds in which one may respond, thereby reflecting a dimensional construct. However, given the format of the question, the potential dimensional nature of the construct can not be examined.

The problem of forcing a dimensional structure into a dichotomy can be highlighted in the pattern of response rates for the forced-choice response items. Heatherton et al. (1991) reported the response rates for the FTQ forced-choice items (items 2, 4, 5 and 6), which correspond with the forced-choice items on the FTND. For item 2 (*smoke more in the morning*) a majority of respondents select *No* (no = 78.7%, yes = 21.3%). For item 4 (*cigarette most hate to give up*) a majority of respondents selected morning (morning = 11%; other = 89%). Likewise, a majority of respondents select *No* for item 5 (*difficult to refrain*; no = 71.3%, yes = 28.7%). Unsurprisingly, the final forced-choice item, item 6 (*smoke when ill*), also revealed a highly skewed response rate with a majority of respondents selecting *Yes* (no = 29.9%, yes = 70.1%). Each of these items tend to result in extreme responding in preference to one choice, resulting in very little heterogeneity in participant responding. As suggested by Clark and Watson (1995), items resulting in extreme responding tend to provide very little meaningful information about the construct of interest. Thus, altering the response choices for these items may ameliorate the problems associated with forced-choices responses, possibly providing and incremental enhancement in the reliability and validity of nicotine dependence construct as measured by this scale.

Interestingly, factor analytic studies using the FTQ or FTND have resulted in largely inconclusive findings. Although the scale was designed to measure a unidimensional construct of nicotine dependence (Fagerström, 1978), findings from factor analytic studies have reported the latent structure as a unidimensional (Etter, VuDuc, & Perneger, 1999) and multidimensional, reflecting a two-factor structure (Haddock et al., 1999; Payne et al., 1994; Radzius et al., 2003; Steinberg et al., 2005). The use of forced choice items in factor analytic studies may also limit the interpretability of the factor solution. It has been argued that use of factor analysis with dichotomous variables tends to result in "difficulty factors" reflecting factors that emerge due to variation in response rates of the items and are not an actual reflection of the underlying construct of interest (Floyd & Widaman, 1995). Thus, it is plausible that the failure to identify a stable factor solution of the FTQ and FTND may be

due to the problems associated with the use of factor analytic procedures with the forced choice items in the scale. One unanswered question is whether the factor solution of this scale would be more stable once the dichotomous items are altered to allow for more diverse response options.

1.1. Present Study

The aims of the present study were to evaluate whether changing the forced response criteria on items 2, 5, and 6 to reflect a 4-point Likert response set will enhance the psychometric properties of the FTQ and FTND.[1] A comparison of the revised scoring approach and the original forced-response criteria will be used to examine the ability of the revised scoring approach to enhance the reliability and validity of the FTND. Specifically, we examined the overall scale reliability of the FTQ, the FTND, and the FTND-R. It was hypothesized that the new scoring will show improved reliability over the original scoring approach. Second, the factor structure of the FTND-R also was examined. It was predicted that the FTND-R will reveal a more stable factor solution than the FTND in the present sample and results from prior investigations. Third, we examined the convergent validity of the revised scale by comparing the two scoring approaches on smoking related constructs. Compared to the original approach, it is predicted that the revised scoring approach will show a enhanced relationship with smoking related constructs, such as quit attempts, number of years of smoking, and self-report reasons for smoking, (i.e., addictive behaviors). Finally, we examined the predictive validity of the revised and original scoring approaches. It was hypothesized that the revised scoring approach would enhance the ability of the scale to predict smoking related outcomes, such as nicotine withdrawal severity and smoking reduction, and biochemical markers of smoking, including CO levels.

2. Methods

2.1. Participants

Participants consisted of 343 smokers from the community presenting for a smoking treatment designed for individuals high in anxiety sensitivity. Participants were primarily male (56%), Caucasian (85%), and ranged from 18 to 65 (M = 35.96, SD = 13.00) years of age. Participants were randomly assigned to a standard smoking cessation group, or to an anxiety prevention and management smoking cessation group (See Funk, Zvolensky, and Schmidt (2011) for a full description. Participants were recruited through advertisements, medical referrals, media releases, and community postings. Inclusion criteria included: (1) 18 to 65 years old, (2) daily smoker for at least one year, (3) currently smoke an average of at least 8 cigarettes per day, (4) desire to quit smoking. Exclusion criteria included: (1) significant current suicide risk, (2) recent (within past 6 months) psychoactive substance abuse or dependence (except nicotine dependence), (3) current use of psychotropic medication (except if stable for the past 3 months), (4) a history of significant medical condition, (5) inability to give informed consent to participate due to limited mental

[1]The revised four-point Likert scale was not utilized on item 4 (*cigarette most hate to give up*) as use of the revised scoring approach is not meaningful given the nature of the item.

competency, (6) current use of any pharmacotherapy for smoking cessation not provided by the researchers, and (7) use of other tobacco products.

2.2. Procedure

The data used in the present study were collected as part of a smoking cessation intervention study. Interested participants were screened over the telephone to assess for initial eligibility requirements. If they met the initial eligibility requirements, participants underwent a structured clinical diagnostic interview to assess eligibility and the presence or absence of current or previous Axis I diagnoses. Those meeting inclusion and exclusion criteria attended a baseline session to complete demographic, smoking, anxiety, and substance use assessments. Individual treatment consisted of four weekly, 90-minute sessions, and participants were randomly assigned to either the smoking cessation condition, or the anxiety/management smoking cessation condition. After treatment, participants completed follow-up evaluation (See Funk, Zvolensky, & Schmidt, in press for full details of the smoking intervention).

The present investigation utilized baseline data from the intervention study. Specifically, participants attending the baseline appointment completed a battery of questionnaires, including the FTND-R. The questionnaires were completed on a laboratory computer. To avoid the potential method biases associated with administering multiple scales with the same items, only the FTND-R was administered in the baseline questionnaires. This provided the authors with the ability to utilize the revised scoring without administering the questions from the FTQ, FTND, and FTND-R as three separate scales with different response choices. The scores from the revised scoring were dichotomized into the original scoring format (i.e., 0 = *No*, 1 = *Yes*) to provide an estimation of the original scoring of the FTQ and FTND. It should be noted that the response rates for the dichotomized scores in the present study are similar to those reported in studies administering the original format of these scales (Heatherton et al., 1991).

2.3. Measures

Fagerström Tolerance Questionnaire (FTQ)—The FTQ (Fagerström & Schneider, 1989) is an 8-item scale used to measure nicotine dependence. Respondents are asked about their smoking habits including time of and satisfaction of first cigarette of the day, how many daily cigarettes are smoked and if the person has trouble refraining from smoking when they are in places it is forbidden.

Fagerström Test for Nicotine Dependence (FTND)—The FTND (Heatherton, Kozlowski, Frecker, & Fagerström, 1991) is a revision of the FTQ. The FTND contains 6 items and was created by removing FTQ item 7 (nicotine content of cigarettes) and item 8 (*Do you inhale?*) because they were found to be unrelated to biochemical measures of smoking dependence.

FTND – Revised (FTND-R)—The FTND-R was created by removing the forced-choice response criteria on items 2, 5, and 6 of the FTND. The response format was changed to improve the measurement of these items by providing respondents with a larger range of

response choices than the forced-choice format. The revised scoring was composed of a 4-point Likert response set. The 4-point Likert responses included: 0 = *never*; 1 = *sometimes*; 2 = *most of the time*, and 3 = *always*.

Pre-treatment Smoking Rate, Years Smoked, and Past Quit Attempts—The Smoking History Questionnaire (SHQ) was used to assess smoking behaviors at baseline. The SHQ has been successfully used in previous studies as a measure of smoking history (e.g., Zvolensky et al., 2004).

CO Assessment—Self-reports of smoking status were biochemically verified through breath samples. Expired air carbon monoxide levels were assessed with a Bedfont Scientific carbon monoxide monitor (Jarvis, Tunstall-Pedoe, Feyerabend, Vesey, & Saloojey, 1987). Detected values above the stated cutoff scores (6 parts per million) were considered indicative of smoking. Per recommendation of the Proceedings of the National Working Conference on Smoking Relapse (1986), self-report is always overridden by objective verification in the conservative direction. CO readings could not be used as a dependent variable for all smoking outcome measures, however, because the assessment predominantly captures the prior 24-hour period and does not indicate how much a person has smoked over the prior week or longer.

Reasons For Smoking (RFSS) – addictive, negative affect reduction, and habitual subscales—The RFSS (Russell, Peto, & Patel,1974) assess an individual's motivation for smoking on several dimensions. Respondents are asked to indicate the reasons they use cigarettes and the frequency in which they use cigarettes for those reasons. Example items include: *I smoke cigarettes to give me a lift*; *I light up a cigarette when I feel angry*; and I smoke cigarettes automatically without being aware of it. Responses are made on a 5-point Likert scale with 1 = *never*, 3 = *occasionally*, and 5 = *always*. Three of the 6 subscales were used, including: (1) addictive subscale, (2) negative affect reduction subscale, and (3) habitual subscale. The psychometric properties of the RFS are well-established, showing adequate internal consistency, test-retest reliability, and a replicable factor structure (Shiffman, 1993).

3. Results

3.1. Preliminary analyses

All analyses were performed using Predictive Analytic Software, PASW (version 18.0; SPSS Inc., Chicago, IL, USA). Before conducting analyses, the data was screened ensure they were entered accurately (e.g., data-entry errors, missing data). The data was then examined for variations in normality and examining residual scatter plots to assess for non-normality (e.g., skew and kurtosis) of the dependent variables before proceeding to the primary analyses.

3.2. FTND-R Scoring

Scores on the FTND-R range from 0 to 16. Altering the response options from a two to four point Likert scale on items 2, 4, and 5 resulted in an increase in the range of scores that were

previously observed in the FTND (range 0 to 10; Heatherton et al., 1991). The FTND-R items, answer choices, and scoring can be found in Appendix I.

3.3. Item statistics and internal consistency

Scale reliabilities were estimated using Cronbach's alpha coefficients. Consistent with prediction, results revealed enhanced reliability in the FTND-R (alpha = .69) scale in comparison to the FTND (alpha = .63) and the FTQ (alpha = .48). Although the reliability coefficient for the FTND-R does not meet the recommended reliability cutoffs of .80 and above (Clark & Watson, 1995), the altered scoring did result in a modest improvement in reliability, placing the FTND-R reliability close to the moderate range of internal consistency (Kline, 2005), which is an incremental improvement over the reliability coefficients for of the FTQ and FTND in the present study and as reported in prior investigations (Payne et al., 1994).

Table 1 displays the descriptive statistics of nicotine dependence in the present sample. On average the participants of the study had smoked for 17 years and smoked 17 cigarettes per day. They also reported multiple previous quit attempts prior to enrolling in the study. Mean scores on the FTND-R were slightly higher than on the FTND. The FTQ mean was the highest among the three scales. It is interesting to note that the standard deviation is the highest in the FTND-R, thereby possibly suggesting that the increase in variability in the responses may be associated with the altered scoring approach in this scale.

Table 2 displays the inter-item bivariate correlation matrix for the scales. The inter-item correlations for the FTND-R ranged from .46 to .07. The range for the inter-item correlations of the FTND items ranged from .46 to .05. While the range of correlations for both scales are similar, the difference becomes more explicit when examining the full inter-item correlation matrix. As can be seen in Table 2, inter-item correlations improved for the three altered items with use of the revised scoring approach in the FTND-R. For example the correlation between item 6 (*smoke when ill*) and item 5 (*difficult to refrain*) increased from . 20 in the FTND to .32 in the FTND-R. Likewise, the inter-item correlation for item 6 (*smoke when ill*) and item 2 (*smoke more in morning*) increased from .15 in the FTND to .27 in the FTND-R, reflecting an increase which is close to double that of the original correlation estimate. Corrected item-total correlations (see Table 3) for both the FTND-R and FTND show all items on each scale to be positively associated; however, items utilizing the revised scoring on the FTND-R show stronger corrected item-total correlations than the corrected item-total correlations observed in the FTND items.

3.4. Item response rates

As expected, item level descriptive statistics for the FTND-R and FTND revealed a more even distribution in responding with the revised response choices used in the FTND-R, while the FTND and FTQ reflected extreme response rates. For example, item response rates for item 2 (*smoke more first two hours*) was 40% for *no* and 60% for *yes*, using the forced choice response format, while use of the revised scoring reflected more dimensional responding with 40% of respondents answering *never*, 38% endorsing *sometimes*, 11% endorsing *most of the time*, and 10% answering *always*. Response rates for item 5 (*difficult*

to refrain), reflected a similar pattern, in which 50% *no* and 50% responding *yes*, when using the original forced choice responding. On the other hand, a more nuanced pattern emerges from the revised scoring format with only 2% responded *always*, with 39% indicating *sometimes*, and 9% *most of the time*. Likewise, the response rates for item 6 (smoke when ill) reflected a similar pattern. Twenty-six percent of respondents marked *no*, while 74% responded *yes*, reflecting an extreme response pattern when using the forced-choice response format. However, the response rates reflect a more dimensional pattern when using the revised scoring in which 26% selected *never*, 54% selected *sometimes*, 11% *most of the time*, and 9% of the respondents selecting the answer choice, *always*, in response to smoking when ill.

3.5. Factor Structure

Principal component analyses (PCA) and principal axis factoring (PAF) analyses were conducted in SPSS for the FTND-R and FTND [2]. Consistent with prior investigations, PCA with varimax rotation was used as the primary analytic method to allow for comparisons with other factor analytic studies (Heatherton et al., 1991; Payne et al, 1994, Radzius et al., 2003). Analyses were repeated using PAF to assess for consistency in factor structure across analytic approaches. Extracted factors were based on scree test (Cattell, 1966), unrotated eigenvalues of greater than one (Kaiser, 1961), and factor structure interpretability. Indicators were dropped based on having significant cross-loadings or a lack of salient loadings on any of the extracted factors ($\lambda > .40$; Brown, 2006). Table 4 outlines the initial PCA solution, showing the factor pattern to be similar for both the FTND-R and FTND, both of which were comprised of a two factor solution with items 2, 3, and 4 loadings on the first factor and items 1, 5, and 6 loading on the second factor, mirroring the solution identified in Breteler, Hilberink, Zeeman and Lammers (2004). Because of the significant cross-loadings, items 1 and 3 were dropped from the final solution, revealing a unifactoral solution for the FTND-R, and a two-factor solution for the FTND. The unifactorial solution of the FNTD-R was comprised of the four remaining items (items 2, 4, 5, and 6), explaining 40.10% of the model. Alternatively, items 2 and 4 formed one factor for the FTND, while items 5 and 6 formed the second factor explaining 60.55% of the variance in the model (see Table 5 for complete PCA results). While the multidimensional structure of the FTND has been found in prior investigations (Lichtenstein & Mermelstein, 1986; Haddock et al., 1999), the unifactoral structure of the FNTD-R is consistent with the scale developer's original intention for the FTQ and FTND to measure a unidimensional structure (Fagerström & Schneider, 1989).

3.6. Construct Validity

3.6.1. Prediction of smoking variables—A series of linear regression equations were computed separately with either the FTND-R, FTND, or FTQ total scores entered as the predictors and the smoking measures entered as the dependent variable (RFS – addictive, negative affect reduction, and habitual subscales; SHQ -- number of quit attempts, years smoking, and mood related variables of withdrawal).

[2]Because the FTQ contains more items, two of which are different than the items in the FTNDR and FTND, the FTQ was not used for the factor structure comparison.

Reasons for Smoking (RFS – addictive, negative affect reduction, and habitual subscales): The FTND-R was shown to be a better predictor of the RFS addictive and negative affect subscales than the FTND or the FTQ. The FTND-R accounted for 21.6% of the variance in the regression model for the RFS – addictive subscale (F (1, 332) = 92.69, ß = .47, $p < .0001$), while the FTND accounted for 17.8% of the variance (F (1, 332) = 73.09, ß = .42, $p < .0001$), and the FTQ accounting for 10.9% of the variance in the regression model (F (1, 332) = 41.58, ß = .33, $p < .0001$). Likewise, for the RFS – negative affect subscale, the FTND-R accounted for 12.9% of the variance in the regression model (F (1, 332) = 50.47, ß = .36, $p < .0001$), while the FTND accounted for 10.2% of the variance (F (1, 332) = 38.92, ß = .32, $p < .0001$), and the FTQ accounting for 4.8% of the variance in the regression model (F (1, 332) = 17.81, ß = .23, $p < .0001$). Both the FTND-R and the FTND were shown to predict 18% of the variance in the respective regression models for the RFS – habitual subscale (F (1, 332) = 75.96, ß = .43, $p < .0001$ for the FTND-R, and F (1, 332) = 76.58, ß = .43, $p < .0001$, for the FTND). Thus, the revised scoring of the FTND-R was shown to result in enhanced prediction of self-report addiction and reduction of negative affect as perceived reasons for continued smoking, however the FTND-R and FTND were equal in the prediction of the habitual RFS subscale, out performing the predictive ability of the FTQ.

Smoking History (SHQ -- number of quit attempts, years smoking, and mood related variables of withdrawal): Contrary to predictions, number of quit attempts was not significantly associated with the FTND-R, FTND, or the FTQ (all $p = ns$). Number of years smoking showed a stronger association with the FTND than the FTQ and FTND-R. The SHQ – number of years smoking accounted for 5.4% of the variance in the regression model for the FTQ (F (1, 332) = 19.90, ß = .24, $p < .0001$), while the FTND accounted for 7.6% of the variance (F (1, 332) = 28.23, ß = .28, $p < .0001$), and the FTND-R accounted for 5.1% of the variance in the regression model (F (1, 332) = 18.96, ß = .23, $p < .0001$).

In contrast, the FTND-R was found to be most strongly associated with mood variables related to withdrawal. Specifically, the SHQ – anxiety, depression, and irritability variables were significantly associated with the FTND-R, FNTD, and FTQ. However the association was strongest for the FTND-R, with F (1, 332) = 11.88, ß = .19, $p < .001$) for SHQ – anxiety, (F (1, 332) = 8.29, ß = .16, $p < .0001$), for SHQ – depression, and (F (1, 332) = 6.82, ß = .14, $p < .01$) for SHQ – irritability. There was also a significant association among SHQ – anxiety and irritability variables with the FTND (F (1, 332) = 8.29, ß = .16, $p < .001$) for SHQ – anxiety, (F (1, 332) = 8.29, ß = .12, $p < .05$), for SHQ – irritability. However, the regression model for SHQ - depression variable with the FTND was not significant ($p = ns$). Likewise, the FTQ was significantly associated with SHQ – anxiety, depression, and irritability, with F (1, 332) = 12.86, ß = .19, $p < .0001$) for SHQ – anxiety, (F (1, 332) = 4.03, ß = .11, $p < .05$), for SHQ – depression, and (F (1, 332) = 9.57, ß = .17, $p < .01$) for SHQ – irritability. Therefore, the association among these variables for the FTND and FTQ were lower than the association with the FTND-R.

3.7. Association with biochemical markers of nicotine dependence

CO level was available for only a subset of the original sample (N = 123). For this reason, the analyses for CO level with the FTND-R and FTND was restricted to this subset. Bivariate correlations were computed to measure the association of CO level with the FTND-R, FTND, and FTQ. The FTND-R, FTQ, and FTND were shown to have moderate associations with CO level (r = .47, p < .001; r = .45, p < .001, r = .48, p < .001, respectively). Item level analyses were conducted to further explore the association among CO level and the original and revised scored items of the FTND. Because only 3 of the 6 items were revised (items 2, 5, and 6), item-level comparisons were reported for these items only. Interestingly, the three revised items (items 2, 5, and 6) showed stronger associations with CO level than the original scored items. Specifically, revised items 2, 5, and 6 of the FTND-R were significantly associated with CO level (r = .20 for item 2; r = .21 for item 5; and r = .19 for item 6, all p's < .05), while the associations among items 2, 5, and 6 with the original dichotomous scoring were not significantly associated with CO level (all p's = ns). It is interesting to note that one item utilizing the original scoring of FTND, item 4, appears to be the primary contributor for the overall association among CO level and the total score of the FTND (r = .33, p < .001), providing the single strongest association between CO level and any individual scale item on the FTND. While item 4 item demonstrated the strongest item- level association with CO level, it is important to underscore that this is the only item with the original scoring that significantly predicted CO level, while all items with the revised scoring were significantly associated with CO level.

4. Discussion

The aim of the present study was to address some of the psychometric limitations of the FTQ and FTND by removing the dichotomous, forced response criteria on items 2, 5, and 6 and altering the response option to reflect a 4-point Likert response format, and to examine the ability of the revised scoring approach to enhance the reliability and validity of the FTND. As predicted, the use of the revised response format in the FTND-R incrementally improved the internal consistency of the scale, increasing the reliability coefficient alpha from .63 in the original FTND to .69 in the FTND-R. This increase in internal consistency places the scale close to the .70 range for moderate reliability, which is a substantial increase from an alpha of .63, which typically reflects a low reliability coefficient. The revised scoring also revealed less extreme item response rates, as evidenced by a more even distribution in scores on the FTNDR than the FTND, resulting in more precision in measurement of the nicotine dependence construct.

Interestingly, the inter-item correlations in the FTND-R were shown to be higher than those in the FTND. These elevations in inter-item correlation estimates are important to mention, as the significant increase in inter-item correlations based on a revision in scoring highlights the problems associated with the use of a forced-choice response, in which the correlations among forced-choice items tend be distorted due to the highly unbalanced response distributions (Clark & Watson, 1995; Comrey, 1988). That is, by measuring nicotine dependence as a dichotomous variable with a forced choice response format, the scale items

appear to be less related to one another than the correlations observed when the response options reflect a dimensional approach utilizing the revised scoring in the FTND-R.

Results from the PCA analyses highlight some issues associated with using dichotomous variables in factor analytic studies. It is interesting that the revised scoring of the FTND-R revealed a unidimensional structure of the remaining four items, while the FTND revealed a two-factor structure. The dimensional structure is consistent with the goals of the scale creators who designed the FTQ and FTND to measure a dimensional construct of nicotine dependence (Fagerström & Schneider, 1989; Heatherton et al.1991). It is possible that some of the difficulties associated with replicating a dimensional structure of the FTQ and FTND may be due to the limitations of the forced-choice items utilized in these scales. It is also important to underscore the finding that the two-factor solution for the FTND explained more variance in the PCA model than unifactorial structure for the FTND-R. This finding further highlights the problems associated with using a forced-choice item response. While it can be argued that having more variance explained in the FTND is suggestive of a more stable solution, it should also be emphasized that this finding could be the result of a method effect due to the use the forced choice responses. As previously discussed, use of dichotomous variables in factor analysis tends to result in “difficulty factors” which reflect factors emerging due to variation in response rates of the items (Floyd & Widaman, 1995). Because the findings from the present study revealed more extreme responding than the revised responding in the FTND-R, it is possible that the increased variance explained in the PCA analyses for the FTND is a result of this method bias as opposed to the underlying construct. Consistent with Breteler et al. (2004), the results in the present study revealed significant cross-loadings for items 1 and 3 of the FTND and the FTND-R in the initial PCA analyses. Future studies would benefit from further examination and possible refinement of these items.

The results from item-level bivariate correlation analyses with CO level show the three revised scored items (items 2, 5 and 6) on the FTND-R as being significantly associated with CO level, while the same items with the dichotomous scoring fail to have a significant bivariate correlation. This points to the enhanced predictive ability of the revised scoring over the forced-choice responses. That is, the revised scoring allows for more variability in responding, thereby increasing predictive ability in CO, whereas the original scoring did not reveal significant associations with CO level for the item-level analyses. Contrary to prediction, the FTND-R was not a stronger predictor of previous quit attempts and years smoking than the FTQ. In addition, the FTND-R, FTND, and FTQ were not found to be significant predictors of quit attempts. The reason for these findings is unclear; however it may be partially due to the assessment of these constructs (i.e., quit attempts, years smoking) with a single item rather than a composite self-report measure. It would be beneficial for future studies to assess these constructs with measures that include multiple items to assess these domains.

Future research should continue to examine methods to improve the psychometric qualities of the FTND. Although the revised scoring resulted in several improvements in the scale, the scale still displays some psychometric deficiencies. The revised scoring in the present study was limited to the three items in which the four-point Likert scale was relevant, thus

one item, *cigarette most hate to give up*, was administered as the only forced choice item on the FTND-R. Future research may benefit from investigating the effect of altering the scoring for this item, in which one would not be forced into the morning cigarette, or all others. It would be informative to know whether altering this last forced-choice item would provide further enhancement of the FTND. In addition, the sample used for the present study was comprised of smokers with elevated levels of anxiety sensitivity, thereby potentially limiting the generalizability of the results. It would be beneficial to replicate the results from the present study in a sample of individuals in the community that were not pre-selected based on levels of an individual difference variables, such as anxiety sensitivity. Further, because our sample was limited to those who smoked eight cigarettes per day who were also presenting for a smoking cessation treatment, we are unable to generalize our finding to those who smoke less than eight cigarettes who are not treatment seeking. It should also be noted that a majority of our participants were Caucasian, thereby limiting the generalizability of our findings to those with different racial and ethnic backgrounds. Finally, as has been found with the use of the FTQ and the FTND, the FTND-R is unlikely to be an appropriate measurement tool when assessing nicotine dependence in those using other forms of tobacco (i.e., smokeless tobacco; Ebbert, Patten, & Schroder, 2006).

Despite these limitations, the present study provided evidence of improved psychometrics by altering the dichotomous, forced choice response option of three items to a 4-point Likert format, thereby allowing a more nuanced pattern of responding to emerge. This new scoring approach provided an increase in internal consistency, resulting in improved reliability of the scale. In addition, a unidimensional structure of the FNTD-R emerged in the PCA analysis, which is consistent with the original design of the scale as measuring a unidimensional construct (Fagerström, 1978). The revised scoring used in the FTND-R also revealed stronger item level association with CO level than compared to the original scoring, thereby supporting the notion that altering the response format increases the predictive ability of the scale. Given this improvement in the psychometric qualities of the FTND, future research would benefit from using this revised scoring approach to enhance the measurement of nicotine dependence in these studies.

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Highlights

- We examined the psychometric properties of the FTND.
- We created a revised version of the FTND by altering the scoring on the dichotomous items.
- The revised version of the FTND resulted in improved psychometric properties.

Table 1

Descriptive statistics of sample characteristics

	M	SD
Number of years smoking	17.46	12.68
Cigarettes per day	17.26	9.92
Quit attempts	3.36	2.48
FTND-R	5.80	3.06
FTND	5.09	2.32
FTQ	6.07	1.73

Note. *N* = 343, FTND-R = Fagerström Test of Nicotine Dependence-Revised, FTND = Fagerström Test of Nicotine Dependence, FTQ = Fagerström Tolerance Questionnaire.

Table 2

Inter-item correlations for the FTND-R and the FTND.

	1	2	3	4	5	6
FTND-R						
1. Cigarettes per day	--					
2. Smoke more first 2 hours of day	.26**	--				
3. Time to 1st cigarette	.46**	.40**	--			
4. Cigarette most hate to give up	.17**	.24**	.32**	--		
5. Difficult to refrain	.20**	.14**	.21**	.07	--	
6. Smoke when ill	.36**	.27**	.42**	.15**	.32**	--
FTND						
1. Cigarettes per day	--					
2. Smoke more first 2 hours of day	.24**	--				
3. Time to 1st cigarette	.46**	.33**	--			
4. Cigarette most hate to give up	.17**	.20**	.32**	--		
5. Difficult to refrain	.21**	.11*	.17**	.05	--	
6. Smoke when ill	.26**	.15**	.34**	.10	.20**	--

Note. $N = 341$, FTND-R = Fagerström Test of Nicotine Dependence-Revised, FTND = Fagerström Test of Nicotine Dependence.

** $p < .01$

* $p < .05$.

Table 3

Response endorsement and corrected-item correlations for the FTND-R and FTND.

	Response option endorsement (%)				Corrected item-total correlations
	0	**1**	**2**	**3**	
FTND-R Items					
1. Cigarettes per day	32	52	10	7	.47
2. Smoke more first 2 hours of day	40	38	11	10	.41
3. Time to 1st cigarette	13	14	47	25	.60
4. Cigarette most hate to give up	50	49	--	--	.59
5. Difficult to refrain	50	39	9	2	.29
6. Smoke when ill	26	54	11	9	.49
FTND Items					
1. Cigarettes per day	32	52	10	7	.48
2. Smoke more first 2 hours of day	40	60	--	--	.35
3. Time to 1st cigarette	13	14	47	25	.57
4. Cigarette most hate to give up	50	49	--	--	.29
5. Difficult to refrain	50	50	--	--	.24
6. Smoke when ill	26	74	--	--	.36

Note. *N* = 343. For FTND-R, items 2, 5, and 6: 0 = *never*, 1 = *sometimes*, 2 = *most of the time*, 3 = *always*. For FTND: 0 = *no*, 1 = *yes*, except for item 6 in which 0 = *all other cigarettes*, 1 = *1st cigarette of the day*. Items 1 and 4 for the FTND-R and FTND have identical scoring for both scales. For item 1 on FTND-R and FTND: 0 = *less than or equal to 10*, 1 = *11 – 20*, 2 = *21 - 30*, 3 = *31 or more*. For item 4: 0 = *Any other*, 1 = *First of the day*.

Table 4

Initial factor loadings, eigenvalues, and variance explained in the principal component analyses for the FTND-R and FTND.

Item	Factor 1	Factor 2
FTND-R		
1. Cigarettes per day	.44	.53
2. Smoke more first 2 hours of day	.65	.21
3.Time to 1st cigarette	.67	.42
4. Cigarette most hate to give up	.76	−.12
5. Difficult to refrain	−.11	.79
6. Smoke when ill	.28	.72
Eigenvalue	2.38	1.02
Percent Variance (total = 56.66%)	39.73%	16.92%
FTND		
1. Cigarettes per day	.46	.54
2. Smoke more first 2 hours of day	.63	.14
3. Time to 1st cigarette	.68	.43
4. Cigarette most hate to give up	.75	−.13
5. Difficult to refrain	−.11	.76
6. Smoke when ill	.20	.66
Eigenvalue	2.18	1.02
Percent Variance (total = 53.37%)	36.30%	17.06%

Note. *N* = 343, FTND-R = Fagerström Test of Nicotine Dependence-Revised, FTND = Fagerström Test of Nicotine Dependence.

Table 5

Final factor loadings, eigenvalues, and variance explained in principal component analyses for the FTND-R and FTND.

Item	Factor 1	Factor 2
FTND-R		
2. Smoke more first 2 hours of day	.67	
4. Cigarette most hate to give up	.52	
5. Difficult to refrain	.60	
6. Smoke when ill	.73	
Eigenvalue	1.60	
Percent Variance	40.10%	
FTND		
2. Smoke more first 2 hours of day	--	.71
4. Cigarette most hate to give up	--	.82
5. Difficult to refrain	.81	--
6. Smoke when ill	.72	--
Eigenvalue	1.41	1.01
Percent Variance	35.34%	25.21%

Note. *N* = 343, FTND-R = Fagerström Test of Nicotine Dependence-Revised, FTND = Fagerström Test of Nicotine Dependence.