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Comparing the predictive validity of five cigarette dependence questionnaires

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ABSTRACT

Background: To determine whether the long and short versions of the Cigarette Dependence Scale (CDS), the Fagerström Test for Nicotine Dependence (FTND), the Heaviness of Smoking Index (HSI) and the Nicotine Dependence Syndrome Scale (NDSS) predicted smoking abstinence.
Method: We collected data via Internet in 2004–2007 in 2343 current smokers. Follow-up surveys were conducted after 8 days ($N = 456$) and 31 days ($N = 486$). We assessed the ability of dependence ratings to predict smoking abstinence, controlling for confidence and intention to quit smoking.
Results: All dependence scales were significant predictors of smoking abstinence at the 8-day follow-up, with the CDS being the best predictor (OR: 3.98 per SD unit, 15% of variance explained). Results were similar but stronger among respondents intending to quit (OR: 6.68, 26% of variance explained). At the 31-day follow-up, only the FTND, HSI and NDSS Continuity subscale were still significant, albeit weak, predictors of abstinence (OR: 1.56, 2% of variance explained).
Conclusion: Among the scales under scrutiny, the CDS had the best predictive validity after 8 days. None of the scales explained more than 2% of the variance in abstinence after 31 days.

1. Introduction

Valid and reliable measures of cigarette dependence are needed for research and clinical purposes. Several brief, self-report questionnaires measuring cigarette dependence are available, and at least four of them have already been extensively studied and validated. The best known and oldest is the Fagerström Tolerance Questionnaire (FTQ; Fagerstrom, 1978; Fagerstrom and Schneider, 1989), and its revised version, the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991). Both were developed to provide short and practical self-report measures of dependence on nicotine, for use in clinical practice. The internal consistency of the FTND is below the recommended threshold of 0.70 (Nunnally and Bernstein, 1994). Even though FTND predicts smoking cessation, it is usually a weak predictor (Baker et al., 2007; Etter et al., 2003; Kozlowski et al., 1994; Sledjeski et al., 2007), and it is modestly correlated with biochemical indicators of exposure to cigarette smoke (e.g., plasma cotinine; $r = 0.33$–0.46; Pomerleau et al., 1990). Two items of the FTND are included in the Heaviness of Smoking Index (HSI). This index has adequate reliability (.72) and good test–retest validity (0.87; Etter et al., 1999). Several studies have found that the HSI is the best predictor of smoking cessation among the dependence scales (Chaiton et al., 2007; Etter, 2005; Hughes et al., 2004; John et al., 2004; Kozlowski et al., 1994; Uysal et al., 2004).

The Cigarette Dependence Scale (CDS) was developed more recently (Etter, 2005; Etter et al., 2003; Okuyemi et al., 2007). There are a 5-item (CDS-5) and a 12-item versions of this scale (CDS-12), both are reliable (Cronbach's $\alpha > 0.85$ and test–retest $r > 0.83$ for both versions). This scale was designed to assess the criteria listed in the DSM-IV and the ICD-10 definitions of dependence. Both versions of CDS are associated with saliva cotinine levels and predict urge to smoke during a quit attempt, but lower levels of dependence, as measured by CDS, have not reliably predicted smoking abstinence (Etter, 2005; Etter et al., 2003). A third questionnaire is the Nicotine Dependence Syndrome Scale (NDSS; Shiffman and Sayette, 2005; Shiffman et al., 2004). The NDSS was based on Edwards' multidimensional model of dependence (Edwards, 1986; Edwards and Gross, 1976). Five facets were found empirically, using exploratory factor analysis. A linear combination of 14 of its 19 items (the NDSS-T) is used as a general measure of dependence. The internal reliability of the NDSS-T is high, around 0.85 (Shiffman and Sayette, 2005; Shiffman et al., 2004), but the NDSS-T has not reliably predicted smoking cessation (Sledjeski et al., 2007).

According to the DSM-IV (American Psychiatry Association, 1994), dependence is related to unsuccessful efforts to cut down on substance use. Thus, in theory, dependence scales should predict smoking cessation. However, studies on the prediction of abstinence by dependence levels show contradicting results. Two

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Table 1
Baseline characteristics of the participants according to which surveys they answered.

Variables	Modalities	Answered only survey 1 (N = 1742)	Answered survey 1 and 2 (N = 456)	p	Answered survey 1 and 3 (N = 486)	p
Sex	F	60.2%	71.6%	<0.01	66.8%	0.02
	M	39.8%	28.4%		33.2%	
Age (mean)		36.9	39.9	<0.01	39.9	<0.01
Smokes	Daily	94.0%	95%	0.50	93.0%	0.14
	Occasionally	6.0%	5.0%		7.0%	
Cpd		19.3	20.5	0.08	19.4	0.15
Decided to quit in the next 30 days	Yes	54.3%	39.1%	<0.01	34.7%	0.01
	No	45.7%	60.9%		65.3%	
Confidence to quit	Low	59.3%	67.6%	0.02	73.8%	<0.01
	High	40.7%	32.4%		26.2%	
CDS-12		4.01	4.09	0.06	3.99	0.18
CDS-5		3.75	3.88	0.03	3.71	0.08
FTND		0.78	0.80	0.34	0.73	0.04
HSI		3.31	3.42	0.08	3.23	0.07
NDSS-T		−0.11	−0.12	0.85	−0.12	0.69
Drive		0.32	0.32	0.98	0.23	0.06
Priority		0.03	0.12	0.14	0.03	0.69
Tolerance		−0.51	−0.56	0.50	−0.59	0.23
Continuity		−0.27	−0.11	0.02	−0.14	0.05
Stereotypy		−0.42	−0.43	0.86	−0.45	0.49

indicators of dependence, the number of cigarettes smoked per day and the time to the first cigarette of the day have been reliably shown to predict cessation, but several studies have shown that multi-item cigarette dependence measures predict smoking cessation only slightly or not at all (e.g., Chaiton et al., 2007; Chatkin et al., 2006; Etter, 2005, 2008; Etter et al., 2003; Sledjeski et al., 2007; Wetter et al., 2005a,b). However, many of these studies did not take into account potential confounders such as the degree of motivation to quit or the confidence of participants in their ability to quit smoking (for a study on confidence to quit as a predictor of smoking cessation, see MacKenzie et al., 2004).

In this study, we assessed the ability of the FTND, the HSI, the CDS and the NDSS to predict smoking abstinence at two later time points, controlling for intention to quit and confidence in one's ability to quit.

2. Methods

2.1. Participants

Data were collected online, in English, on the smoking cessation website Stoptabac.ch, from June 2004 to March 2007 (Courvoisier and Etter, 2008; Wang and Etter, 2004). Participants were smokers who spontaneously visited this website, or who used search engines to obtain information on smoking and were directed to this website. Visitors of this website have been described previously: compared with smokers in the general population, they are more dependent on cigarettes, more educated, and more motivated to quit smoking (Etter, 2005; Etter et al., 2003; Etter and Perneger, 2001).

The raw baseline database included 3649 records. We deleted 270 duplicate records, 147 records of never smokers (i.e., people who had smoked fewer than 100 cigarettes in their lifetime), 797 records of former smokers at baseline, and 92 records of people who did not indicate their smoking status. Analyses were based on the remaining 2343 current smokers. Participants who agreed were invited by e-mail to answer the same questionnaire again after 8 days, and to indicate their smoking status after 31 days.

2.2. Questionnaires

2.2.1. The Cigarette Dependence Scale (CDS). The CDS is a 12-item instrument, rated on a 5-point scale, covering, albeit sometimes indirectly, the main components of the DSM-IV (American Psychiatry Association, 1994) and of the ICD-10 (World Health Organization, 1992) definitions of dependence: compulsion, withdrawal, loss of control, time allocation, neglect of other activities, and persistence of use despite harm. The CDS has high test–retest reliability ($r \geq 0.83$), and a high internal consistency (Cronbach's $\alpha \geq 0.90$; Etter, 2005; Etter et al., 2003), even though the internal consistency of CDS-12 is lower among light smokers (Okuyemi et al., 2007). There is also a 5-item version of this scale (CDS-5).

2.2.2. The Fagerstrom Test of Nicotine Dependence (FTND). The FTND is a widely used 6-item scale with high test–retest validity (Stavem et al., 2008; Vink et al., 2005), but it has low internal consistency (Cronbach's α ranging from 0.60 to 0.70; Heatherton et al., 1991).

2.2.3. The Heaviness of Smoking Index (HSI). The HSI includes 2 items from FTND (cigarettes/day and time to first cigarette). This scale has adequate reliability and test–retest validity (Etter et al., 1999).

2.2.4. The Nicotine Dependence Syndrome Scale (NDSS). The NDSS is a 19-item scale covering 5 dimensions: Drive (craving, withdrawal and compulsion to smoke), Priority (preference for smoking over other reinforcers), Tolerance (reduced sensitivity to the effects of smoking), Continuity (regularity of smoking rate), and Stereotypy (invariance of behavior) (for a complete description of this instrument, see Shiffman et al., 2004). The scale as a whole, as well as its subscales, exhibits adequate psycho-

Table 2
Test–retest reliability of the CDS, FTND and NDSS.

Scale	Reliability (this study)	Reliability (previous studies)	Source
CDS-12	.83	.83	Etter et al. (2003)
CDS-5	.87	.83	Etter et al. (2003)
FTND	.70	.78	Pomerleau et al. (1994)
NDSS-T	.87	.81	Shiffman et al. (2004)
Drive	.80	.83	Shiffman et al. (2004)
Priority	.75	.73	Shiffman et al. (2004)
Tolerance	.72	.71	Shiffman et al. (2004)
Continuity	.70	.77	Shiffman et al. (2004)
Stereotypy	.61	.73	Shiffman et al. (2004)

Table 3
Regression coefficients for the logistic regression of abstinence on dependence, adjusting for intention to quit and confidence in ability to quit among all respondents. Effect sizes (R^2) are only for the dependence variable.

Dependence scale	Abstinence at 8-day follow-up (N = 437; 16 quitters)				Abstinence at 31-day follow-up (N = 489; 105 quitters)			
	OR	95% CI low	95% CI high	R^2	OR	95% CI low	95% CI high	R^2
CDS-12	3.98	2.19	7.22	.15	1.11	0.81	1.52	.00
CDS-5	3.27	1.90	5.63	.14	1.36	1.02	1.80	.00
FTND	9.42	2.54	34.88	.10	2.61	1.43	4.77	.01
HSI	2.03	1.28	3.21	.08	1.40	1.12	1.74	.01
NDSS-T	2.81	1.60	4.98	.12	0.99	0.78	1.24	.00
Drive	2.07	1.32	3.25	.08	0.86	0.69	1.06	.01
Priority	1.27	0.75	2.17	.01	0.90	0.70	1.16	.00
Tolerance	1.25	0.82	1.91	.01	1.11	0.91	1.36	.01
Continuity	1.29	0.81	2.06	.01	1.56	1.24	1.96	.02
Stereotypy	1.75	1.01	3.04	.04	1.30	1.04	1.64	.00

metric properties (Cronbach's α = 0.71–0.83; Shiffman et al., 2004). Items overlap and are weighted to compute five standardized scores (mean = 0, SD = 1). A single overall score composed of 14 items, the NDSS-T, is based on the first principal factor. We computed the NDSS overall score and subscales according to the directions given in Shiffman et al. (2004).

2.3. Procedure

We posted on the Internet a questionnaire comprised of the CDS, NDSS and FTND, as well as several questions on smoking behavior, intention to quit and confidence in ability to quit. To avoid halo effects, participants were randomly allocated to one of two survey forms, counterbalancing the order of scales. In the first form, the scale order was FTND–CDS–NDSS, and in the second form, the scale order was NDSS–FTND–CDS. Responses differed significantly between forms for three questions only. Since testing these differences represented 37 tests (one test for each question), these differences can be attributed to chance. Participants were also asked to provide their email address for the follow-up surveys. Independently of their decision to participate in the follow-up, they received a feedback report assessing their dependence level.

Intention to quit in the next 30 days was measured by the following question: "Which of the following statements best describes your current situation?": "I am a smoker, and I: A. Have no intention to quit in the next 6 months; B. Seriously consider quitting in the next 6 months; C. Decided to quit in the next 30 days; I am an EX-smoker and stopped D. less than 6 months ago; E. more than 6 months ago". Ex-smokers were discarded and answers A and B were recoded to 0 and answer C to 1. Confidence in ability to quit was assessed by the question: "Is it likely that in one month from now, you will be an EX-smoker?", answered on a 6-point scale: 1, unlikely; 2 ,more or less likely; 3, rather likely; 4, very likely; 5, extremely likely; 6, absolutely sure.

Smoking abstinence was assessed by a single question at the 8-day (respectively 31-day) follow-up: "Have you smoked any tobacco (even one puff of cigarette, cigar, pipe, etc.) in the past 24 h (respectively past 7 days)?".

2.4. Analyses

We estimated the test–retest reliability of the scales among smokers who did not make a quit attempt between baseline and the 8-day survey. For each dependence scale, we used binary logistic regression models to predict the occurrence of smoking abstinence, and we report odds ratios with 95% confidence intervals. The logistic regressions of smoking abstinence on confidence to quit and level of dependence were ran separately on all respondents and on respondents who intended to quit. Each analysis included only one addiction scale as the independent variable. Effect sizes were computed using pseudo R-square (computed with the Stata 10 software). Effect sizes are bounded by zero and one: zero indicating no prediction of the independent variables on the dependent variable and 1 indicating a perfect prediction. We did not apply a correction for the number of tests since our goal was to compare the scales, and p-values were not the main interest.

We used the Area under the receiver operating characteristic (ROC) curves (AUCs) as criteria to compare the ability of dependence scales to predict abstinence at follow-up. The ROC curve plots 1-specificity against sensitivity, and the area under this curve quantifies the predictive ability of a test (Hanley and Mac Neil, 1982). We first tested differences between AUC for the general scales (CDS-12, CDS-5, FTND, NDSS-T, HSI), and for all 10 scales (DeLong et al., 1988).

It is important to note that odds ratio's values cannot be compared across dependence measures since the different scales had different number of points. However, AUC and pseudo R^2 can be compared across measures.

3. Results

3.1. Study population

At baseline, the sample included 2206 daily smokers (91%) and 137 occasional (non-daily) smokers (6%). The mean number of cigarettes per day was 19.6 (SD: 11.8). Participants who indicated a country of residence (91%) lived in the USA (54%), the UK (10%), Denmark (9%), Canada (8%) and other countries (19%). Participants were on average 37.5 years old and most (62%) were women. Half (52%) had decided to quit smoking in the next 30 days, and half (53%) had made a serious attempt to quit in the previous year. Table 1 presents the baseline characteristics of the participants who answered only the first survey, answered the first and second survey (N = 456), or answered the first and third survey (N = 486). Respondents who participated in the second or third follow-up were slightly older and more of them were females. Moreover, they were less likely to have decided to quit and have less confidence that, if they did try to quit, they would succeed. However, they were not different in their smoking habits (cigarettes/day, depen-

Table 4
Regression coefficients and effect sizes (R^2) for the regression of abstinence on dependence, adjusting for confidence in ability to quit among respondents intending to quit within 30 days at baseline.

Dependence scale	Abstinence at 8-day follow-up (N = 171; 6 quitters)				Abstinence at 31-day follow-up (N = 222; 82 quitters)			
	OR	95% CI low	95% CI high	R^2	OR	95% CI low	95% CI high	R^2
CDS-12	6.68	2.28	19.53	.26	1.10	0.75	1.62	.00
CDS-5	4.88	1.87	12.75	.23	1.27	0.90	1.78	.00
FTND	23.24	2.03	266.30	.17	2.54	1.24	5.20	.01
HSI	2.59	1.18	5.66	.13	1.43	1.09	1.88	.01
NDSS-T	4.46	1.53	13.04	.19	1.02	0.77	1.34	.00
Drive	2.87	1.33	6.17	.15	0.88	0.69	1.14	.00
Priority	0.89	0.40	2.01	.00	0.91	0.67	1.23	.00
Tolerance	1.50	0.77	2.90	.02	1.14	0.91	1.43	.01
Continuity	1.06	0.52	2.15	.00	1.51	1.15	1.98	.03
Stereotypy	1.86	0.74	4.68	.04	1.23	0.94	1.60	.01

Table 5
Area under the ROC curve for the regression of abstinence on dependence, adjusting for confidence in ability to quit.

Dependence scale	Abstinence at 8-day follow-up						Abstinence at 31-day follow-up					
	All respondents			Respondents intending to quit			All respondents			Respondents intending to quit		
	AUC	p^a	p^b	AUC	p^a	p^b	AUC	p^a	p^b	AUC	p^a	p^b
CDS-12	0.76	0.50	<0.01	0.85	0.50	<0.01	0.51	<0.01	<0.01	0.52	0.15	0.06
CDS-5	0.70			0.73			0.56			0.56		
FTND	0.72			0.79			0.58			0.59		
HSI	0.67			0.72			0.58			0.58		
NDSS-T	0.76			0.84			0.50			0.52		
Drive	0.75			0.83			0.45			0.47		
Priority	0.50			0.43			0.52			0.48		
Tolerance	0.54			0.61			0.56			0.57		
Continuity	0.56			0.55			0.59			0.61		
Stereotypy	0.64			0.70			0.53			0.56		

[a] Tests whether all general scales have equal AUC.
[b] Tests whether all 10 scales have equal AUC.

dence level, and daily vs. occasional smoker). The 31-day follow-up sample included 328 daily smokers (67%), 38 occasional smokers (8%) and 120 recent quitters (25%), defined as people who had not smoked even a puff in the past 7 days.

3.2. Test–retest reliability

The test–retest reliability of each scale or subscale between baseline and the 8-day follow-up, among smokers who did not make a quit attempt in this interval (Table 2) are very close to those obtained in previous studies (Etter et al., 2003; Pomerleau et al., 1994; Shiffman et al., 2004) except for the Stereotypy subscale of the NDSS ($r = 0.61$), which test–retest reliability was lower than the usually recommended threshold of 0.7.

3.3. Prediction of smoking abstinence

At the 8-day follow-up, all general scales and the NDSS Drive subscale significantly predicted 24 h smoking abstinence for all respondents (Table 3), and also when only respondents intending to quit within 30 days at baseline were included (Table 4). The Stereotypy subscale was a significant predictor only when all respondents were considered. For both groups, the comparison of AUC of all general scales was non-significant but the comparison of AUC of all 10 scales was significantly different ($ps < 0.01$ for both groups – see Table 5). AUCs were close to 0.70 (acceptable threshold; Hosmer and Lemeshow, 2000) for all general scales and the NDSS Drive but not for the other NDSS subscales. Effect sizes indicated that the CDS was slightly more predictive than the other scales, either among all respondents or among respondents who intended to quit. Among all respondents, an increase of one standard deviation in CDS multiplied by almost four the risk to continue smoking. Among respondents intending to quit, the odds ratio rose to 6.68.

At the 31-day follow-up, for both populations, the FTND, the HSI, and the Continuity subscales of the NDSS were the only significant predictors of 7 days abstinence, but these predictions were very weak, as only up to 3% of the variance in abstinence was explained by the dependence scales. Again, the Stereotypy subscale was a statistically significant predictor only when all respondents were considered. The AUCs of all general scales and the AUCs of all 10 scales together differed significantly (p's < 0.01) among all respondents but not among respondents intending to quit. However, all AUCs were very low (<0.60). The odds ratios were very similar for both populations with an increase of one standard deviation in Continuity multiplying by around 1.5 the risk to continue smoking.

4. Discussion

We assessed and compared the test–retest reliability and the predictive validity of the Cigarette Dependence Scale (CDS), the Fagerström Test for Nicotine Dependence (FTND), the Heaviness of Smoking Index (HSI), and the Nicotine Dependence Syndrome Scale (NDSS), adjusting for intention to quit and confidence in ability to quit.

4.1. Test–retest reliability

Test–retest reliability was adequate to good for all scales and subscales except for the Stereotypy subscale of the NDSS. The difference in the test–retest reliability of the Stereotypy subscale between this and previous studies may be due to the fact that the participants in Shiffman et al. (2004) were highly dependent and were required to quit smoking for 3 days starting just after the second testing. Knowing that the 14-day retest was to be followed by 3 days of abstinence may have made their smoking behavior more invariant, since they were sure that they would not try to quit during the 14 days. This may have increased the test–retest reliability of the Stereotypy scale. On the contrary, the participants of this study were more motivated to quit than smokers in general (Etter and Perneger, 2001) and may have been trying to change their smoking behavior, leading to an underestimation of the test–retest reliability of Stereotypy.

4.2. Predictive validity

All dependence scales (but not all NDSS subscales) were significant predictors of smoking abstinence at the 8-day follow-up, either when considering the whole sample or only respondents who intended to quit. In both cases, the best predictor (i.e., the one that explained the most variance and whose AUC was highest) was the CDS.

At the 31-day follow-up, only the FTND, HSI, and Continuity subscale were significant predictors of smoking abstinence, but this prediction was very weak (1–3% of variance explained and AUC < 0.60) and probably not clinically significant. Interestingly, all general scales were stronger predictors of abstinence at the 8-day follow-up when only respondents intending to quit were considered. However, this increase in predictive power was not found for the abstinence at the 31-day follow-up outcome. Thus, intending to quit seems to have an impact on the short-term but not on the longer-term, either because intentions are temporary states of mind or because longer-term outcomes depend on relapse risk factors rather than on dependence levels.

The literature contains mixed results about the prediction of smoking abstinence by strength of dependence, with studies showing that dependence predicts abstinence (Baker et al., 2007; Hyland et al., 2006, 2004; Hymowitz et al., 1997), and other finding no evidence of a relation between some scales measuring dependence and subsequent quitting (Chaiton et al., 2007; Etter, 2005, 2008; Etter et al., 2003; Sledjeski et al., 2007). These contradictory results may be explained in part by differences in the interval between baseline and follow-up, or by the different composition of the samples (e.g., volunteers in clinical trials who received smoking cessation treatments, population surveys, visitors of a website).

4.3. Study limitations

The present study was conducted in a self-selected sample of Internet users, who differ from smokers in the general population (Etter and Perneger, 2001). In addition, the response rates at follow-up were relatively low, but this is a problem inherent to all e-mail surveys (Cook et al., 2000). The self-selection of participants and the low response rates may limit the generalizability of these results, but this should not be a problem for the comparison of scales, which was the main goal in this study, because the scales should appropriately predict smoking behaviors for all types of cigarette smokers.

There were only 16 baseline smokers who were abstinent at the 8-day follow-up. This low sample size may have caused important parameters to be estimated as non-significant. However, this limitation applies to all scales and thus does not bias the comparison between scales.

5. Conclusion

This is one of very few studies comparing the predictive validity of widely cited scales such as FTND and NDSS. The five dependence scales showed similar patterns of predictive validity: significant prediction of quitting at 8-day but not at 31-day follow-up. The Cigarette Dependence Scale was the best predictor of smoking cessation at the 8-day follow-up and the Continuity scale and HSI were the best, albeit weak, predictors at the 31-day follow-up.

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This study received no funding.

Contributors

Etter designed the study and wrote the protocol. Courvoisier and Etter managed the literature searches and summaries of previous related work. Courvoisier undertook the statistical analysis, and wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

None of the authors have any conflict of interest in this study.

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