

Comparing the validity of the Cigarette Dependence Scale and the Fagerström Test for Nicotine Dependence

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Abstract

Background: We compared the validity of the Cigarette Dependence Scale (CDS-12) and of the Fagerström Test for Nicotine Dependence (FTND) in daily cigarette smokers.

Methods: Internet survey in 2004–2007. Eight days and 6 weeks after answering these two dependence questionnaires, participants indicated their smoking status and answered the Cigarette Withdrawal Scale and the Smoking Self-Efficacy Questionnaire. We used the Mini International Neuropsychiatric Interview (MINI) to assess nicotine dependence as defined in DSM-IV.

Results: There were 13,697 participants at baseline, 1113 (8%) after 8 days and 435 (3%) after 6 weeks. CDS-12, but not FTND, predicted smoking cessation after 8 days (odds ratio = 1.20 per standard deviation unit, $p = 0.03$) and 6 weeks (odds ratio = 1.34, $p = 0.01$). In participants who had quit smoking after 8 days, CDS-12 was a better predictor of craving ($\beta = 0.30$, $p < 0.001$), than FTND ($\beta = 0.14$, $p < 0.01$). After 8 days, self-efficacy in quitters was predicted by CDS-12 ($\beta = -0.16$, $p = 0.02$), but not by FTND ($\beta = -0.05$, $p = 0.3$). CDS-12 was more strongly associated than FTND with DSM-defined dependence measured by MINI: area under the Receiver Operating Characteristic (ROC) curve = 0.72 (95% confidence interval = 0.70–0.73). For FTND, the area under ROC = 0.64 (0.63–0.66).

Conclusions: CDS-12 performed better than FTND on tests of predictive and construct validity.

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1. Introduction

Researchers and clinicians need a valid and reliable instrument to measure dependence on cigarettes. Several instruments are available, including self-administered unidimensional scales such as the Fagerström Test for Nicotine Dependence (FTND) and the Tobacco Dependence Screener (Heatherton et al., 1991; Kawakami et al., 1999), self-administered multidimensional scales such as the Nicotine Dependence Syndrome Scale (NDSS) and the WISDM-68 (Shiffman et al., 2004; Piper et al., 2004), and interviews based on the DSM-IV or ICD-10 definitions of dependence (American Psychiatric Association, 1994; Johnson et al., 1996; World Health Organization, 1992). Deciding which measure to use is made difficult by the lack of consensus about whether dependence is uni- or multidimen-

sional, and by the lack of validation studies for some of the questionnaires (Colby et al., 2000; Piper et al., 2004, 2006). In addition, all the instruments listed above have limitations, and none is generally accepted as valid. In particular, several important aspects of dependence, as defined in DSM-IV and ICD-10, are not covered by FTND (Colby et al., 2000; Piper et al., 2004; Etter et al., 1999; Etter, 2005a; Moolchan et al., 2002). NDSS has also limitations, in particular, it does not cover important aspects of dependence, as defined in DSM-IV and ICD-10, (e.g. unsuccessful efforts to quit, use despite risks, time spent smoking), and NDSS includes several elements that can hardly be considered to reflect dependence (e.g. influence of contextual factors). The WISDM-68 is still in its experimental phase, and it is too long (68 items) for most practical purposes (Piper et al., 2004, 2006). There are only scant validation data for the Tobacco Dependence Screener (Kawakami et al., 1999). Interviews based on the DSM-IV and ICD-10 definitions can be considered a gold standard (e.g. Johnson et al., 1996), but they are expensive to implement and are too long for most clinical or research purposes.

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The limitations of available questionnaires justify the development of new instruments. An ideal measure should cover the ICD-10 and DSM-IV definitions of dependence, have good psychometric properties, and it should be brief and self-administered. We recently developed the Cigarette Dependence Scale (CDS-12), a brief, self-administered, unidimensional, continuous measure that reflects DSM-IV and ICD-10 criteria of dependence (Etter et al., 2003; Etter, 2005a; Okuyemi et al., 2007). CDS-12 has a higher test–retest reliability than FTND, a higher internal consistency, is more sensitive to change over time (Etter et al., 2003; Etter, 2005a), and is more strongly related to biochemical markers of exposure to smoke (Okuyemi et al., 2007). However, there are few data on the predictive validity of CDS-12, and this scale has not been compared with DSM-based measures of dependence. The aim of this study was to further document the predictive and construct validity of CDS-12 and to compare it with the most widely used dependence scale: the FTND.

2. Methods

2.1. Baseline survey

We posted CDS-12 and FTND together on the internet between May 2004 and March 2007, in French, on the smoking cessation website *Stop-tabac.ch*. A link to the questionnaire was posted on several pages of this website, which was visited by over 100,000 people per month (Wang and Etter, 2004). The survey also covered motivation to quit smoking, and whether participants smoked every day, occasionally (not daily), or never. We also computed scores for CDS-5 (a subset of five items from CDS-12), and for the Heaviness of Smoking Index, which combines two FTND items: cigarettes per day and minutes to the first cigarette of the day (Heatherton et al., 1989; Kozlowski et al., 1994).

2.2. The MINI questionnaire

From April 2005 onwards, the survey also included the nicotine dependence module of the Mini International Neuropsychiatric Interview (MINI) (Lecrubier et al., 1997; Sheehan et al., 1998). The MINI assesses DSM-IV and ICD-10 diagnoses (American Psychiatric Association, 1994; World Health Organization, 1992). The nicotine dependence module of MINI can be self-administered, and includes seven questions answered in a Yes–No response format, which reflect the elements in the DSM-IV and ICD-10 definitions of nicotine/tobacco dependence (Table 1). Respondents also indicated when the symptoms started and ended, in conformity with the DSM-IV requirement that symptoms must have occurred in the previous 12 months. The MINI scoring is dichotomous: participants are considered dependent if they experienced three or more symptoms in the previous 12 months. In contrast, CDS-12, CDS-5, FTND and HSI produce continuous scores and reflect the current state of dependence.

2.3. Follow-up surveys after 8 days and 6 weeks

Eight days and 6 weeks after answering the dependence questionnaires, participants who agreed and who indicated an e-mail address were invited by e-mail to answer follow-up surveys. The 8-day and 6-week surveys included the Cigarette Withdrawal Scale (Etter, 2005b; Etter and Hughes, 2006; West et al., 2006), the Smoking Self-Efficacy Questionnaire (Etter et al., 2000; Christie and Etter, 2005), and smoking status. To avoid misclassifying occasional (non-daily) smokers, only participants who had not smoked any tobacco in the 7 days before the follow-up surveys and who classified themselves as ex-smokers were considered abstinent at follow-up.

The Cigarette Withdrawal Scale (CWS) is a validated, 21-item, six-dimension scale that covers the DSM-IV and ICD-10 definitions of nicotine/

tobacco withdrawal: depression, anxiety, craving, irritability, impatience, appetite, weight gain, insomnia, and difficulty concentrating (Etter, 2005b; Etter and Hughes, 2006; West et al., 2006).

The Smoking Self-Efficacy Questionnaire (SEQ-12) is a validated, 12-item-scale that covers two dimensions: confidence in one's ability to refrain from smoking in front of external stimuli (six situations, e.g. when having a drink with friends) and in front of internal stimuli (six situations, e.g. when feeling nervous or depressed) (Etter et al., 2000; Christie and Etter, 2005).

2.4. Content validity

To assess content validity, we compared the content of CDS-12, FTND and MINI with DSM-IV and ICD-10 definitions of nicotine or tobacco dependence (American Psychiatric Association, 1994; World Health Organization, 1992) (Table 1).

2.5. Internal consistency and factor structure

We assessed whether internal consistency coefficients (Cronbach's alpha) of the scales exceeded 0.7, as recommended (Nunnally and Bernstein, 1994). To assess the structure of the dependence scales, we applied factor analysis. To determine the number of factors to retain, we applied Velicer's MAP test, Horn's parallel analysis, the criterion of eigenvalue > 1, and criteria of interpretability (Horn, 1965; O'Connor, 2000; Velicer, 1976).

2.6. Predictive validity

We tested the following hypotheses to assess the predictive validity of the dependence scales:

1. In baseline daily smokers, dependence ratings at baseline would predict smoking cessation after 8 days ($n = 1113$) and after 6 weeks ($n = 435$).
In the 235 baseline daily smokers who had quit smoking at the time of the 8-day survey, we hypothesized that higher dependence ratings at baseline:
 2. would predict higher withdrawal ratings after 8 days, and
 3. would predict lower self-efficacy ratings after 8 days.

2.7. Construct validity

We tested whether dependence ratings reflected dependence as defined in DSM-IV and ICD-10, using MINI as the reference. We used the area under the Receiver Operating Characteristic (ROC) curve as a criterion to compare the ability of dependence scales to identify dependent individuals, with MINI as the reference. The ROC curve plots 1-specificity against sensitivity, and the area under this curve quantifies the predictive ability of a test (Hanley and McNeil, 1982). We computed the sum of sensitivity and specificity to establish the CDS-12, CDS-5, FTND and HSI thresholds that optimally discriminated dependent from non-dependent smokers, using MINI as the reference.

2.8. Statistical analyses

We used linear regression models to assess associations between continuous variables, and logistic regression models to assess associations between dependence ratings and dichotomous outcome variables. Because CDS-12, CDS-5, FTND, HSI and MINI have different numbers of items and use different response options, linear regression coefficients or odds ratios cannot be compared. Thus, we used R -square statistics from linear regression models to compare the extent to which dependence ratings predicted withdrawal and self-efficacy at follow-up, and we used the area under the ROC curve as a criterion to compare the extent to which the scales predicted smoking cessation at follow-up. We reported 95% confidence intervals for areas under the ROC curves, which enable the reader to compare the performances of the scales. We used standardized dependence scores (mean = 0, standard deviation = 1) for CDS-12, CDS-5, FTND and HSI in all regression analyses.

Table 1
Dependence scales classified along DSM-IV and ICD-10 criteria of dependence

DSM-IV criteria for substance dependence	ICD-10 Tobacco dependence syndrome	Abbreviated items in FTND	Abbreviated items in CDS-12	Abbreviated items in MINI
	1. A strong desire or sense of compulsion to take tobacco.	- Difficult to refrain - Smoke if ill - Minutes to first cigarette	- Prisoner of cigarette - Smoke all the time - Before going out - Minutes to first cigarette	Not covered
1. Tolerance	4. Tolerance	Not covered, but tolerance can be assessed by repeated measures of FTND	Not covered, but tolerance can be assessed by repeated measures of CDS-12	Used more to get same effect
2. Withdrawal	3. Withdrawal when tobacco use has ceased or been reduced. Use of the substance with the intention of relieving withdrawal	- Minutes to first cigarette (possibly) - Otherwise not covered	- Minutes to first cigarette (possibly) - Urge to smoke - Idea of not having cigarettes causes stress	Withdrawal symptoms when reduced or stopped. Smoked to avoid these symptoms
(a) Characteristic withdrawal syndrome (b) The substance is taken to relieve withdrawal				
3. The substance is often taken in larger amounts or over a longer period than was intended	2. Difficulties in controlling tobacco-taking in terms of its onset, termination, or levels of use	Not covered	- Smoke too much - Prisoner of cig.	Ended up smoking more than you thought you would
4. Persistent desire or unsuccessful efforts to cut down or control substance use		Not covered	- Smoke too much - Quitting difficult	Have you tried to reduce or stop smoking?
5. A great deal of time is spent in activities necessary to obtain the substance, or use the substance		Not covered	- Smoke all the time	Did you spend substantial time (>2 h) smoking?
6. Important social, occupational, or recreational activities are given up or reduced because of substance use	5. Neglect of alternative interests because of substance use, increased amount of time necessary to obtain or take the substance	Not covered	- Drop everything	Did you reduce some of your activities because of smoking or smoking restrictions?
7. Substance use is continued despite knowledge of having a physical or psychological problem caused by substance	6. Persisting with substance use despite clear evidence of overtly harmful consequences Narrowing of the repertoire of patterns of substance use	- Smoke if ill (possibly) Not covered	- Smoke despite risks - Smoke all the time	Continued to smoke, even though it caused you health problems Not covered

3. Results

3.1. Participation

There were 13,697 daily smokers at baseline, of whom 5314 (39%) agreed to take part in the follow-up and indicated an e-mail address. Of these, 1113 (21% of 5314) answered the 8-day survey and 435 (8% of 5314) the 6-week survey. Baseline participants were on average 29 years old, 42% were men, they smoked on average 15 cigarettes per day and 86% had a DSM-IV diagnosis of nicotine dependence (presence of three or more criteria in the past year, based on MINI). Participation in the 8-day survey was predicted by CDS-12 ratings (odds ratio = 1.43 per standard deviation (S.D.) unit, $p < 0.001$), by FTND ratings (odds ratio = 1.14 per S.D. unit, $p < 0.001$) and by a MINI diagnosis of dependence (odds ratio = 1.58, $p < 0.001$).

3.2. Content validity

FTND omits some key components of dependence, as defined in DSM-IV and ICD-10, in particular substance use in larger amounts than initially intended, tolerance, unsuccessful efforts to quit, smoking despite health problems, withdrawal symptoms and time spent to obtain and use tobacco (Table 1). Except for tolerance, each element in the DSM-IV and ICD-10 definitions of dependence is reflected by at least one item in CDS-12, even though the match between CDS-12 and these definitions is sometimes partial and indirect (Table 1). The questions in MINI match the DSM-IV and ICD-10 definitions, except for the ICD-10 criterion of compulsion that is not covered by MINI.

3.3. Factor structure

For CDS-12, factor analysis produced two components with eigenvalues > 1 (eigenvalues = 5.58 and 1.08), which accounted respectively for 47% and 9% of the total variance, Horn's parallel analysis suggested to retain either one or two factors, and Velicer's MAP test one factor. No meaningful or interpretable second factor emerged from CDS-12. Velicer's MAP test, Horn's parallel analysis and the rule of eigenvalue > 1 all indicated that there was a single factor in FTND (eigenvalue = 2.35). For MINI, factor analysis produced two components with eigenvalues > 1 (eigenvalues = 1.75 and 1.06), Horn's parallel analysis suggested to retain either one or two factors, and Velicer's MAP test identified no factor in MINI.

3.4. Internal consistency

Internal consistency coefficients were higher for CDS-12 (Cronbach's $\alpha = 0.89$) and CDS-5 ($\alpha = 0.76$) than for FTND ($\alpha = 0.68$), HSI ($\alpha = 0.65$) and MINI ($\alpha = 0.49$). For CDS-12, corrected item-scale correlations were all > 0.50 , except for the items on smoking despite risks ($r = 0.45$) and minutes to the first cigarette ($r = 0.49$). For CDS-5, corrected item-scale correlations were all > 0.50 . For FTND, corrected item-scale correlations ranged from 0.29 to 0.57. For MINI, the corrected item-scale correlations were all < 0.3 .

3.5. Tests of predictive validity

3.5.1. Hypothesis 1: Dependence ratings would predict smoking cessation after 8 days and 6 weeks. Among baseline daily smokers, 30% had quit smoking at the time of the 8-day survey (330 of 1113 participants) and 60% had quit at the time of the 6-week survey (262 of 435). A higher CDS-12 score at baseline predicted smoking abstinence after 8 days (odds ratio = 1.20 per S.D. unit on CDS-12, 95% confidence interval: 1.01–1.41, $p = 0.03$), and after 6 weeks (odds ratio = 1.34, 1.07–1.67, $p = 0.01$). CDS-5, FTND and HSI ratings did not predict smoking cessation. A MINI diagnosis of dependence predicted abstinence after 6 weeks (odds ratio = 2.48, 1.12–5.48, $p = 0.03$), but not after 8 days (Table 2).

3.5.2. Hypothesis 2: Dependence level would predict withdrawal intensity in quitters at follow-up. This analysis was conducted in the 235 baseline daily smokers who had quit smoking at the 8-day survey and provided complete data on all relevant variables. In these participants, higher CDS-12, CDS-5 and FTND ratings in the first survey predicted higher withdrawal ratings, for all withdrawal symptoms except appetite and insomnia (Table 2). A MINI diagnosis of dependence predicted only higher insomnia ratings at follow-up. *R*-square statistics and beta coefficients indicated that CDS-12 was a slightly stronger predictor of withdrawal than the other scales, in particular for craving and for the total withdrawal score. However, the associations between dependence and withdrawal were weak, as dependence ratings explained no more than 6–7% of the variance in craving and withdrawal (Table 3).

3.5.3. Hypothesis 3: Higher dependence would predict lower self-efficacy in quitters at follow-up. In the 235 baseline daily smokers who had quit smoking after 8 days, a higher CDS-12 score predicted lower “internal stimuli” self-efficacy ratings at follow-up (linear regression coefficient: $\beta = -0.16$ per standard deviation unit on CDS-12, 95% confidence interval: -0.30 to -0.03 , $p = 0.02$). The strongest associations were observed for items reflecting a low confidence in ability to abstain from smoking: “When I feel depressed” ($\beta = -0.22$, $p = 0.02$), and: “When I feel nervous” ($\beta = -0.21$, $p = 0.02$). The other scales did not predict self-efficacy in quitters at the 8-day survey.

3.6. Assessment of dependence as defined in DSM-IV and ICD-10

Using MINI as the reference, the area under the ROC curve was higher for CDS-12 (0.72) and for CDS-5 (0.68) than for FTND (0.64) and HSI (0.61), and the confidence intervals of the areas under the ROC curves for CDS-12 and FTND did not overlap (Table 3). Using MINI as the reference, the sum of sensitivity (0.64) and specificity (0.68) was maximized with a CDS-12 value of 43, a CDS-5 value of 16 (sensitivity = 0.63, specificity = 0.63), a FTND value of 4 (sensitivity = 0.50, specificity = 0.72), and a HSI value of 3 (sensitivity = 0.58, specificity = 0.59). From a logistic regression model, each additional standard deviation unit on CDS-12

Table 2
Assessment of predictive and construct validity for five dependence scales

	Cessation after 8 days ^a	Cessation after 6 weeks ^a	OR MINI DSM-based dependence ^b	Self- efficacy, external ^c	Self- efficacy, internal ^c	Depression– anxiety ^c	Craving ^c	Irritability– impatience ^c	Appetite– weight ^c	Insomnia ^c	Difficulty concentrating ^c	CWS total ^c
<i>N</i> in analysis	1113	435	9278	235	235	235	235	235	235	235	235	235
CDS-12	1.20*	1.34**	1.94***	−0.10 ns	−0.16*	0.28***	0.30***	0.26**	0.10 ns	0.10 ns	0.29**	0.23***
CDS-5	1.07 ns	1.19 ns	1.89***	−0.09 ns	−0.11 ns	0.22**	0.25***	0.19**	0.13 ns	0.12 ns	0.23**	0.19***
FTND	1.06 ns	1.16 ns	1.69***	−0.04 ns	−0.05 ns	0.17**	0.13*	0.18*	0.08 ns	0.09 ns	0.20**	0.14**
HSI	1.05 ns	1.11 ns	1.51***	−0.05 ns	−0.06 ns	0.12 ns	0.14*	0.12 ns	0.12 ns	0.05 ns	0.13 ns	0.11*
MINI	1.68 ns	2.48*	–	−0.08 ns	−0.02 ns	0.57 ns	0.10 ns	0.60 ns	0.60 ns	0.76*	0.68 ns	0.54*

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$; ns, not statistically significant.

^a Odds ratio from logistic regression models predicting cessation after 8 days and 6 weeks in baseline daily smokers, from standardized scores of cigarette dependence scales, or dichotomous MINI ratings.

^b Odds ratio from logistic regression models describing associations with the dichotomous MINI diagnosis of dependence in daily smokers, from standardized scores of cigarette dependence scales.

^c Coefficients from linear regression models, associations between standardized dependence ratings or dichotomous MINI ratings, and self-efficacy of withdrawal ratings 8 days later in daily smokers in the first survey who had quit smoking at the time of the 8-day follow-up.

Table 3
Test statistics for the assessment of predictive and construct validity, comparison of five cigarette dependence scales

	Cessation after 8 days ^a	Cessation after 6 weeks ^a	MINI, DSM-based dependence ^a	Self- efficacy, external ^b	Self- efficacy, internal ^b	Depression– anxiety ^b	Craving ^b	Irritability– impatience ^b	Appetite– weight gain ^b	Insomnia ^b	Difficulty concentrating ^b	CWS total ^b
<i>N</i> in analysis	1113	435	9278	235	235	235	235	235	235	235	235	235
CDS-12	0.53 (0.50–0.57)	0.57 (0.51–0.62)	0.72 (0.70–0.73)	0.01	0.02	0.04	0.07	0.03	0.01	0.00	0.04	0.06
CDS-5	0.51 (0.48–0.55)	0.54 (0.49–0.60)	0.68 (0.66–0.70)	0.01	0.02	0.04	0.07	0.03	0.01	0.01	0.04	0.06
FTND	0.51 (0.48–0.55)	0.54 (0.49–0.60)	0.64 (0.63–0.66)	0.00	0.00	0.03	0.02	0.03	0.00	0.00	0.03	0.04
HSI	0.52 (0.48–0.55)	0.53 (0.48–0.59)	0.61 (0.60–0.63)	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.01	0.02
MINI	0.52 (0.48–0.57)	0.54 (0.47–0.61)	–	0.00	0.00	0.02	0.00	0.02	0.02	0.03	0.02	0.04

^a Areas under the Receiver Operating Characteristic (ROC) curve with 95% confidence intervals, for the prediction of abstinence after 8 days and 6 weeks, and for the association with MINI ratings of dependence.

^b *R*-square statistics from linear regression models, for tests of predictive validity (outcome variables measured after 8 days).

increased by a factor of 1.94 the odds of being dependent, as defined by MINI, and each standard deviation unit on FTND increased these odds by a factor of 1.69 (Table 2).

3.7. Associations between dependence and motivation to quit

To elucidate the unexpected fact that higher rather than lower CDS-12 ratings predicted smoking abstinence at follow-up, we assessed associations between motivation to quit and dependence ratings. Baseline daily smokers who had decided to quit in the next 30 days had higher CDS-12 ratings (mean = 44.8) than those who had no intention to quit in the next 6 months (mean 40.7, difference = 0.40 S.D. units, $p < 0.001$). In a multivariate model, adjusting for motivation to quit, CDS-12 ratings did not predict smoking cessation after 8 days (OR = 1.14, $p = 0.19$), nor after 6 weeks (OR = 1.24, $p = 0.14$). The CDS-12 items most strongly associated with motivation to quit were: “I smoke too much” (eta squared = 0.04) and “I am a prisoner of cigarettes” (eta squared = 0.04).

4. Discussion

We compared the predictive and construct validity of the Cigarette Dependence Scale and the Fagerström Test for Nicotine Dependence.

4.1. Assessment of dependence as defined in DSM-IV and ICD-10

Except for tolerance, all the main elements in the DSM-IV and ICD-10 definitions of nicotine or tobacco dependence are reflected by at least one item in CDS-12, even though the match between CDS-12 and these definitions is sometimes only indirect (Table 1). Tolerance is probably better detected by repeated assessments in young smokers who are in the process of acquiring dependence, rather than in adult smokers. Incidentally, the utility of tolerance as a criterion for defining dependence has been questioned (Perkins et al., 2001; Perkins, 2002). The fact that CDS-12 covers DSM-defined dependence is reflected by the relatively high area under the ROC curve (0.72), using a MINI diagnosis of dependence as the reference.

In contrast, important elements of the DSM-IV and ICD-10 definitions are not covered by FTND, in particular, substance use in larger amounts than initially intended, tolerance, unsuccessful efforts to quit, use despite health problems, withdrawal symptoms and time spent to obtain or use tobacco. The original Fagerström Tolerance Questionnaire was published many years before DSM-IV and ICD-10 (Fagerstrom, 1978). As a consequence, FTQ and its shorter version, FTND, do not reflect dependence as defined in DSM-IV and ICD-10 (Table 1). This is probably why there is little agreement between FTND and DSM-based measures of dependence, as indicated by our data and several previous reports (Breslau and Johnson, 2000; Hughes et al., 2004; Moolchan et al., 2002). Incidentally, it is inaccurate to name a test that in fact measures dependence on cigarettes “test for nicotine dependence”.

The MINI was designed to match the DSM-IV and ICD-10 definitions of dependence, but it does not cover compulsion to smoke, which is listed first in the ICD-10 definition, even though compulsion or craving is not included in the DSM-IV definition. Otherwise, the psychometric characteristics of MINI did not stand out. In addition, some questions in MINI include several ideas, and it is not clear with which idea respondents agree.

4.2. Optimal thresholds to identify dependent smokers

ROC analyses indicated the optimal thresholds of CDS-12, CDS-5, FTND and HSI to distinguish dependent from non-dependent daily smokers. However, because smokers recruited on the internet may be more dependent than smokers in population-based samples (An et al., 2007; Etter and Perneger, 2001), these thresholds may not reflect the situation in the general population.

4.3. Factor structure

Factor analyses indicated that a single dimension was present in CDS-12, which confirms previous reports (Etter et al., 2003; Etter, 2005a). FTND also included a single factor. This result contrasts with some previous studies that found two factors in FTND (Payne et al., 1994; Lichtenstein and Mermelstein, 1986). However, these previous reports used the rule of eigenvalue > 1 , which is known to produce too many factors, or did not indicate which method was used to identify the number of factors.

Cronbach's alpha coefficients were higher for CDS-12 and CDS-5 than for FTND, HSI and MINI. Low internal consistency of FTND has been previously reported, with Cronbach's alpha coefficients ranging from 0.56 to 0.68 (Etter, 2005a; Heatherton et al., 1991; Payne et al., 1994; Pomerleau et al., 1994). This may indicate that FTND covers several elements, such as morning smoking, tobacco liking or smoking pattern (Haddock et al., 1999; Moolchan et al., 2002; Payne et al., 1994; Radzius et al., 2001, 2003).

4.4. Predictive validity

As in a previous report, higher, rather than lower CDS-12 ratings predicted smoking cessation at follow-up (Etter, 2005a). Endorsement of some CDS-12 items was associated with higher motivation to quit smoking, which explains why higher CDS-12 scores predicted abstinence.

Confirming previous reports, FTND did not predict smoking cessation (Etter, 2005a; Piper et al., 2004). Even though FTND predicted smoking cessation in some previous studies, this association was weak (Farkas et al., 1996; Kozlowski et al., 1994; Piper et al., 2006). The absence of an association between FTND and subsequent abstinence suggests that smoking cessation relies on psychological and social processes that are fairly independent of the level of dependence as assessed by FTND. MINI predicted smoking cessation after 6 weeks, but this association was weaker than for CDS-12 (Table 3).

Confirming previous reports, CDS-12 was a slightly better predictor of withdrawal symptoms than FTND (Etter et al., 2003; Etter, 2005a), even though the association between CDS-12 and withdrawal ratings was relatively low (6–7% of explained variance). This is nevertheless an additional element in favor of the validity of CDS-12, as the withdrawal syndrome is a key element in definitions of dependence (American Psychiatric Association, 1994; World Health Organization, 1992). Choosing the criterion of 7 days of abstinence before follow-up may have resulted in the selection of the quitters who experienced relatively few withdrawal symptoms. This may explain why dependence ratings were only weakly associated with withdrawal ratings.

CDS-12, but not the other dependence measures, predicted self-efficacy after smoking cessation. In former smokers, self-efficacy is a strong predictor of relapse (Etter et al., 2000). The ability of CDS-12 to predict self-efficacy is an additional element in favor of its validity.

We showed previously that CDS-12 had higher test–retest reliability than FTND, that it was more sensitive than FTND to change over time in dependence levels (Etter et al., 2003; Etter, 2005a), and that it was more strongly associated than FTND with biochemical measures of exposure to smoke (Okuyemi et al., 2007). Additional tests could compare NDSS, WISDM-68, FTND and CDS-12, and could include the long-term prediction of smoking cessation and relapse, an assessment of whether these scales predict response to treatments, studies of genetic linkages to measures of dependence, and clinical studies of whether the choice of a dependence measure has an impact on treatment outcome.

4.5. Study strengths and limitations

Collecting follow-up data after 8 days ensured that we captured quitters during the first week of abstinence, when withdrawal symptoms were peaking, this design optimized the test of withdrawal prediction. On the other hand, the fact that this study was conducted in a self-selected sample of internet users may limit the generalizability of our results. Previous research showed that visitors of *Stop-tabac.ch* were more dependent on tobacco and more motivated to quit smoking than smokers in the general population (Etter and Perneger, 2001). The high attrition rate and the high quit rates at follow-up suggest that the follow-up procedure resulted in a selection of those who were able to quit. In addition, the most addicted smokers were also the most likely to answer the follow-up surveys, which may further limit the generalizability of our results. Validation studies of dependence scales in representative samples are therefore warranted. We did not verify abstinence at follow-up, because in online surveys, it is impractical to obtain samples for biochemical verification of smoking abstinence. However, reviews do not recommend biochemical validation of self-reported abstinence in low-intensity intervention trials (Glasgow et al., 1993; Velicer et al., 1992).

We conclude that CDS-12 performed better than FTND on tests of predictive and construct validity. CDS-12 is therefore a valid alternative to FTND. Given the current lack of consensus about the definition and measurement of dependence, the best

approach is probably to combine different tests, in order to obtain a comprehensive assessment (Hughes et al., 2004).

Conflict of interest statement

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