



A comparison of the Autonomy over Tobacco Scale and the Fagerström Test for Nicotine Dependence

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ABSTRACT

The Autonomy over Tobacco Scale (AUTOS) is a 12-item theory-based instrument used to measure tobacco dependence in smokers. It provides separate measures of three factors that make smoking cessation more difficult: withdrawal symptoms, psychological dependence, and cue-induced urges to use tobacco. We compared the internal reliability and concurrent validity of the AUTOS to those of the Fagerström Test for Nicotine Dependence (FTND). Adult current smokers ($n = 422$; 62% female; 86.8% white; mean age 33.3 years, $SD = 13.7$; 57% daily smokers) completed an anonymous web-based survey that included the AUTOS, the FTND and 11 smoking-related behavioral measures. Cronbach's α was .94 for the AUTOS and $\alpha > .75$ for each of the 3 subscales; $\alpha = .73$ for the FTND. The AUTOS and its subscales correlated with all measures of concurrent validity ($r = .70$ between AUTOS & FTND). The AUTOS correlated better than the FTND with the Hooked on Nicotine Checklist, the longest period of abstinence, latency to wanting, percentage of time a person smokes because of momentary need, pleasure from smoking, days smoked per month, and concern about deprivation. The measures showed similar correlations with the latencies to craving and needing. The FTND correlated better with the duration of smoking and cigarettes smoked per day. Based on these results and those from prior studies, we conclude that the AUTOS offers researchers a valid and highly reliable, theory-based measure that is more versatile in its applications than the FTND.

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1. Introduction

In 1978 Karl Fagerström pioneered the measurement of nicotine addiction in adult smokers with the introduction of the Fagerström Tolerance Questionnaire (FTQ; Fagerström, 1978) and for over three decades various versions of this instrument have been the primary measures used in cessation research (Colby, Tiffany, Shiffman, & Niaura, 2000; Fagerström, Heatherton, & Kozlowski, 1990). Items in the FTQ inquire about the patterns of cigarette consumption, focusing on the need to replace nicotine after an overnight abstinence (Contreras, O'Loughlin, Rodriguez, Wellman, & DiFranza, 2010). Repeated efforts to improve upon the psychometric performance of the FTQ have produced the Fagerström Test for Nicotine Dependence (FTND), and other measures (Heatherton, Kozlowski, Frecker, & Fagerström, 1991; Heatherton, Kozlowski, Frecker, Rickert, & Robinson, 1989; Heatherton et al., 1991, 1989; John et al., 2004).

The FTND was created in 1991 to counter concerns about the FTQ's psychometric deficiencies, including poor internal consistency, a factor structure that was difficult to interpret, and items that contributed little to the information in the total FTQ score (Lichtenstein & Mermelstein, 1986). Specifically, the authors of the FTND eliminated items related to (a) the nicotine yield from cigarettes smokers usually smoked, and (b) the inhalation patterns of smokers; they also altered the scoring of items to be consistent between the FTND and the short-form Heaviness of Smoking Index (Heatherton et al., 1989; Heatherton et al., 1991). These alterations yielded a single factor solution and moderate internal consistency ($\alpha = 0.61$) for the FTND. Strengths of the FTND include its relative brevity and ease of administration, and the fact that the full scale and its HSI components have been shown in some studies to predict cessation (Chaiton, Cohen, McDonald, & Bondy, 2007; Courvoisier & Etter, 2010).

However, Moolchan et al. (2002) observed poor correlations between the FTND and the Diagnostic and Statistical Manual (DSM), leading them to suggest that they do not measure the same aspects of addiction. Several authors have expressed concern regarding a lack of consensus on exactly what the Fagerström instruments measure (Haddock, Lando, Klesges, Talcott, & Renaud, 1999; Lichtenstein & Mermelstein, 1986; Pomerleau, Pomerleau, Majchrzak, Kloska, & Malakuti, 1990). Additionally, because they include measures of daily consumption, Fagerström instruments may not be optimal for

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cross-cultural comparisons where the affordability of tobacco differs markedly, or over time as tobacco prices change, or in comparisons between racial groups with different rates of nicotine metabolism (Perez-Stable, Herrera, Jacob, & Benowitz, 1998). As the Fagerström measures do not measure withdrawal (Contreras et al., 2010) or indicate what aspects of addiction are troublesome for a particular individual, patients' responses are not particularly helpful for tailoring the content of smoking cessation counseling.

The Autonomy over Tobacco Scale (AUTOS – Table 1) (formerly the Autonomy over Smoking Scale) is based on the Autonomy Theory which states that addiction begins when symptoms appear that make quitting difficult or unpleasant (DiFranza, 2002). The Hooked on Nicotine Checklist (HONC) was the first measure of diminished autonomy over tobacco (DiFranza & Wellman, 2007). It assesses the accretion of 10 cumulative lifetime symptoms, the presence of any of which signals that autonomy has been diminished and therefore addiction has begun. Clinical observations suggested that three types of symptoms contribute to difficulty in quitting: withdrawal, psychological dependence, and cue-induced urges to use tobacco. According to the Autonomy Theory, therefore, these three types of symptoms warrant assessment when considering a smoker's autonomy over tobacco. Thus, the AUTOS represents a second-generation instrument that (a) measures both the presence and the intensity of current, presumably transitory symptoms, and (b) is unique among measures of addiction because it assesses the three symptom domains. Our hope was to provide smoking researchers with a valid and reliable instrument that shares none of the limitations of the HONC or the FTND. Because the AUTOS does not assess daily consumption, scores should not be affected by the affordability of tobacco. Because the AUTOS can be completed by individuals who have discontinued tobacco use, it can be administered after the quit date to track the persistence of symptoms.

In development, the AUTOS items were subjected to exploratory factor analyses with separate adolescent and adult samples; these yielded one factor solutions (DiFranza, Wellman, Ursprung, & Sabiston, 2009). Confirmatory factor analyses with two additional adolescent samples revealed that autonomy over tobacco is a higher-order latent factor that is represented by the three lower-order latent factors encompassing symptoms of withdrawal, psychological dependence and cue-induced cravings (DiFranza et al., 2009; Wellman et al.,

2012). Field testing with adults demonstrated that the AUTOS is reliable ($\alpha = .91$) and valid. It discriminated well between daily and nondaily smokers, scores correlated moderately with daily cigarette consumption, and greater lifetime experience with smoking was associated with a greater likelihood of endorsing each item (DiFranza et al., 2009). All 12 AUTOS items have face validity, and the total scale exhibits excellent test–retest reliability with adult smokers ($\alpha = .91$) (DiFranza, Morello, & Gershenson, 2012).

1.1. The current study

To date there has been only limited investigation of the psychometric properties of the AUTOS when used with adults (DiFranza et al., 2009; DiFranza et al., 2012). Our goal in this study was to extend our understanding of the reliability and concurrent validity of the AUTOS and to determine how the AUTOS and the FTND compare in relation to multiple indicators of tobacco addiction and smoking behavior.

2. Methods

2.1. Sampling procedures

Through electronic communications, subjects were recruited to complete a web-based survey. The study was announced (1) via postings on the internal website of a major health care organization in central Massachusetts, and on Craigslist (<http://boston.craigslist.org>); and (2) via a single blast email invitation to students, faculty and staff of a central Massachusetts university, and to students of six universities in Mississippi that participate in research conducted by the Social Science Research Center at Mississippi State University. No follow-up or reminder emails were sent. Potential participants were not individually identified prior to the general electronic communications (i.e., no sampling frame was developed).

The web postings and emails took the form of advertisements that posed two questions: “Have you smoked at least one cigarette in the past month?” and “Would you like to participate in a research study about the experiences people have when they smoke?” A link was provided that directed interested smokers to the consent page of the survey, which was hosted on a password-secured server by HostMonster, a commercial website hosting service (<http://www.hostmonster.com>). Upon reading a description of the survey, respondents attested that they were at least 18 years of age, currently smoked cigarettes, and agreed to participate. The survey could be completed in less than 10 min. All study procedures were approved by the Institutional Review Boards of the University of Massachusetts Medical School, Fitchburg State University, and Mississippi State University.

2.2. Measures

The survey was designed using the online Lime Survey tool (<http://www.limesurvey.org>). Smoking experience and behavior was assessed with questions regarding frequency (“How often do you smoke?” – 8 response options ranging from *<once/month*, *>once a month & <once a week*, ... *every day*); quantity (“On days that you smoke, how many cigarettes do you usually smoke?”—response options: *<1/day*, *1 or more/day*, (follow-up: “How many?”—open response)); lifetime duration (“How long have you been smoking?”—response options: *a month or less*, *>1 month & <1 year* (follow-up: “How many months?”), *1 year or more* (follow-up: “How many years?”)); and duration of longest abstinence (“What is the longest time during which you have stopped smoking completely?”—response options ranging from *I have never stopped smoking completely* to *more than a year*, with appropriate follow-up for details).

Response options to the 12 AUTOS items were: *describes me not at all* (scored as 0), *describes me a little* (scored as 1), *describes me pretty*

Table 1
Frequency and score data for the Autonomy over Tobacco Scale and its three subscales ($n = 422$).

	Mean (SD)	Percent endorsing ^a
AUTOS ($\alpha = .94$)	14.04 (9.54)	
Withdrawal symptoms ($\alpha = .93$)	4.10 (3.85)	
When I go too long without a cigarette I get impatient.		61.1
When I go too long without a cigarette I get strong urges to smoke that are hard to get rid of.		61.1
When I go too long without a cigarette I lose my temper more easily.		51.4
When I go too long without a cigarette I feel nervous or anxious.		54.5
Psychological dependence ($\alpha = .77$)	3.88 (3.05)	
I rely on smoking to focus my attention.		40.0
I rely on smoking to take my mind off being bored.		61.4
I rely on smoking to deal with stress.		76.7
I would go crazy if I couldn't smoke.		47.9
Cue-induced urges to use tobacco ($\alpha = .81$)	6.06 (3.43)	
When I feel stressed I want a cigarette.		86.7
When I see other people smoking I want a cigarette.		83.9
When I smell cigarette smoke I want a cigarette.		61.6
After eating I want a cigarette.		69.4

^a The numbers indicate the percent of individuals who endorsed the item when scored dichotomously as *describes me not at all* versus all other responses (*describes me a little*, *describes me pretty well*, *describes me very well*).

well (scored as 2), and *describes me very well* (scored as 3). The AUTOS score is computed by summing the responses to the 12 items (range 0–36). Subscale scores are computed by summing the four items that comprise each subscale (range 0–12). The AUTOS and its subscales can also be scored dichotomously, with 0 indicating “not at all” and 1 indicating “at least a little,” and with corresponding changes in the score ranges (i.e., 0–12 for the AUTOS and 0–4 for each subscale). In addition to the AUTOS, the survey contained items related to demographics as well as smoking behavior, including information about current and lifetime cigarette consumption, lifetime duration of smoking, and the duration of the longest period of complete abstinence. Also included were the FTND and the HONC, which is valid and reliable with adult smokers (Wellman, McMillen, & DiFranza, 2008; Wellman et al., 2005, 2006). In addition, subjects were asked “How much pleasure do you get from smoking a cigarette?” Responses were recorded on a 10-point Likert scale with zero anchored at “none” and 9 at “a great deal.” This item has demonstrated excellent retest reliability (DiFranza et al., 2012).

Three questions assessed the desire to smoke that subjects experience during tobacco withdrawal, which we believe are indicators of physical addiction (DiFranza, Sweet, Savageau, & Ursprung, in press; DiFranza, Ursprung, & Carlson, 2010; DiFranza, Wellman, & Savageau, 2011; DiFranza et al., 2011). “Wanting” was assessed with “If I go too long without smoking the first thing I will notice is a mild desire to smoke that I can ignore.” “Craving” was assessed with “If I go too long without smoking, the desire for a cigarette becomes so strong that it is hard to ignore and it interrupts my thinking,” and “needing” was assessed with “If I go too long without smoking I just can’t function right, and I know I will have to smoke just to feel normal again.” Response options for each of these statements were the same as for the AUTOS.

The duration of abstinence that precedes the onset of a withdrawal symptom is termed the latency. Using a valid and reliable measure of latency, we have established that latencies shorten over time as addiction progresses (DiFranza & Ursprung, 2008; DiFranza et al., 2012; Fernando, Wellman, & DiFranza, 2006; Ursprung, Morello, Gershenson, & DiFranza, 2010). Each item assessing wanting, craving and needing was followed by a question assessing the latency (how long the smoker could go without smoking before experiencing the symptom). We assessed the latency to wanting, the latency to craving, and the latency to needing, with response options ranging from *more than four weeks* to *less than one hour*. Respondents who indicated they could go less than one day specified the number of hours, while those who indicated they could go less than one hour specified the number of minutes. Responses were converted to common units of hours.

On a theme similar to the FTND, we asked several questions that get at the psychological and behavioral symptoms related to feeling a need to smoke when deprived of nicotine: (1) “Sometimes I feel as if something inside my head is telling me I should smoke;” (2) “If I know I am going to be in a situation where I can’t smoke, I will smoke extra to prepare myself;” (3) “To some degree I have to plan my schedule around when I will be able to smoke;” and (4) “I am careful not to run out. I make sure I have enough cigarettes for the next morning.” Response options for statements 1 and 2 were the same as for the AUTOS, while statements 3 and 4 were answered “yes” or “no.” Preliminary data analysis revealed highly skewed responses to items 1 and 2, with 75% and 84% of respondents respectively choosing the lowest two response categories. We therefore scored those items dichotomously (*not at all* vs. *at least a little*) and summed all four items to produce a ‘concern about deprivation’ scale.

2.3. Data analysis

PASW/SPSS V17.0 was used for data analysis. The standard scoring was used for the AUTOS (DiFranza et al., 2009), HONC, and FTND (Wellman et al., 2006), except that item 2 on the FTND (“Do you find

it difficult to refrain from smoking in places where it is forbidden?”) was reworded as “Have you ever found it hard to keep from smoking in places where you are not supposed to?” The potential range for the FTND and HONC is 0–10. Internal reliability was calculated using Cronbach’s alpha. Pearson’s correlations were used to compare the FTND and AUTOS scores to continuous variables and these correlations were converted to *z* scores using the Meng, Rosenthal, and Rubin (1992) extension of Fisher’s *r* to *z*’ transformations for correlated correlations (CBU Statistics, 2011) to test for significant differences between the FTND and the AUTOS as they related to each of the other variables of interest. Finally, to ascertain the extent to which sex, lifetime duration of smoking, or number of cigarettes smoked per day affected scores on the AUTOS or FTND, we conducted four 2 (sex) × 4 (duration of smoking or daily consumption) analyses of variance (ANOVAs) with either the AUTOS or the FTND as dependent variables. Smoking duration and daily consumption were divided into quartiles for these analyses. A *p* value of <0.05 was used as a test of statistical significance, and a Bonferroni adjustment for multiple comparisons was applied to the ANOVA results.

3. Results

3.1. Participant characteristics

The survey was completed by 422 current smokers (61.9% female), of whom 86.8% were white, 4.3% Hispanic, 3.6% black, 2.4% Asian, 2.4% of mixed race, and 0.5% Native American or Pacific Islander. The mean age was 33.3 years (*SD* = 13.7; range: 18–78). The frequency of smoking ranged from an average of less than once per month to daily smoking; 57% were daily smokers. Average cigarette consumption ranged from <1 to 50 per day (Mean (*M*) = 8.25, *SD* = 7.76). Women’s daily cigarette consumption (*M* = 8.8 cigarettes/day, *SD* = 7.4) was equivalent to men’s (*M* = 7.4 cigarettes/day, *SD* = 8.2; *t*(415) = 1.88, *p* = .06). The duration of smoking ranged from <1 month to 64 years (*M* = 13.3 years, *SD* = 13.3). Women had smoked for a longer time (*M* = 14.6 years, *SD* = 13.1) than men (*M* = 10.9 years, *SD* = 13.0; *t*(415) = 2.81, *p* = .005). Because incomplete responses were not saved, no data are available on the number of persons who began but did not complete the survey.

3.2. Scale reliabilities

Table 1 displays the frequency of endorsement of each of the 12 AUTOS items and the mean and standard deviation for the AUTOS and each of its subscales. Cronbach’s α = .94 for the AUTOS, .93 for the Withdrawal subscale, .77 for the Psychological Dependence subscale, and .81 for the Cue-Induced Urges to use Tobacco subscale. For the FTND α = .73, α = .92 for the HONC and .78 for the Concern about Deprivation scale.

3.3. Concurrent validity of the AUTOS

Correlations with the FTND were *r* = .70 for the total AUTOS score, .70 for Withdrawal Symptoms, .62 for Psychological Dependence, and .60 for Cue-Induced Urges (*p* < .001 for all comparisons). Table 2 presents results for the AUTOS and FTND for comparison purposes. When compared to the FTND, the AUTOS demonstrated a stronger correlation with the HONC. The HONC contains only two items that might be considered to overlap conceptually with the AUTOS; both items refer to withdrawal symptoms, specifically feeling nervous or anxious and having strong urges to smoke when abstinent. However, the wording of the AUTOS stresses the persistence of the urges. The AUTOS also correlated more strongly than the FTND with the longest period of abstinence, the latency to wanting, the latency to needing, the percentage of time a person smokes because of momentary need, the pleasure from using tobacco, days smoked per month and

Table 2

Correlations between the Fagerström Test for Nicotine Dependence and the Autonomy over Tobacco Scale and other measures ($n = 422$ unless otherwise specified).

	AUTOS	FTND	p difference ^a
Hooked on Nicotine Checklist	.84	.71	<.001
Longest period of abstinence	-.24	-.11	.001
Latency to wanting ($n = 303$)	-.56	-.45	.004
Latency to craving ($n = 235$)	-.26	-.34	ns
Latency to needing ($n = 169$)	-.40	-.27	.02
Smoking because of momentary need	.58	.50	.01
Pleasure from using tobacco	.44	.25	<.001
Duration of smoking	.35	.52	<.001
Smoking days per month	.68	.59	.002
Cigarettes smoked on smoking days	.59	.75	<.001
Concern about deprivation ($n = 420$)	.79	.71	<.001

^a p difference based on Meng's extension of Fisher's r to z transformation.

concern about deprivation. The FTND had a stronger correlation with the duration of smoking. Although the FTND also correlated more strongly with cigarettes smoked per day, this association is confounded because the cigarettes/day variable is the same as that used in the calculation of the FTND score. The AUTOS and FTND were comparable in relation to latency to craving. The time to first cigarette item on the FTND correlated inversely with the latency to craving ($r = -.34$, $p < .001$) such that a shorter latency related to smoking sooner after awakening.

Table 3 displays the correlations between the AUTOS subscales and the FTND and smoking-related variables. The subscales correlated in the low to moderate range with all measures ($r = -.17$ to $.76$; all p values $< .001$). As expected, because a higher AUTOS score indicates more diminished autonomy, negative correlations were observed for those variables for which smaller numbers indicate stronger addiction (the longest abstinence and the latencies).

In the ANOVAs examining sex and duration of smoking, sex was not significantly related to either AUTOS scores ($F(1/409) = 2.82$, $p = .09$) or FTND scores ($F(1/409) = 1.31$, $p > .10$). The interaction between sex and duration of smoking was also not significant in both instances (AUTOS: $F(3/409) = 0.22$, $p > .10$; FTND: $F(3/409) = 0.58$, $p > .10$). Similarly, in the ANOVAs examining sex and cigarette consumption, sex was not significantly related to either AUTOS scores ($F(1/409) = 2.02$, $p > .10$) or FTND scores ($F(1/409) = 1.15$, $p > .10$).

Table 3

Correlations between the subscales of the Autonomy over Tobacco Scale and other smoking-related variables.

	n	Mean (SD)	Withdrawal symptoms	Psychological dependence	Cue induced urges
FTND	422	2.5 (2.5)	.70 ^a	.62	.60
Longest period of abstinence (weeks)	422	101.3 (260)	-.17	-.21	-.29
Latency to wanting (hours)	303	143.7 (240)	-.52	-.45	-.53
Latency to craving (hours)	235	48.6 (120)	-.29	-.16	-.20
Latency to needing (hours)	169	51.2 (122)	-.39	-.26	-.37
Smoking because of momentary need	422	33.2 (29.8)	.56	.53	.51
Pleasure from using tobacco	422	5.3 (2.6)	.34	.39	.49
Duration of smoking (years)	422	13.3 (13.3)	.35	.32	.29
Smoking days per month	422	20.0 (12.7)	.63	.59	.66
Cigarettes smoked on smoking days	422	8.3 (7.8)	.59	.54	.51
Concern about deprivation	420	1.6 (1.5)	.76	.72	.69

^a All p values $< .001$.

and the interaction between sex and consumption was nonsignificant as well (AUTOS: $F(3/409) = 0.57$, $p > .10$; FTND: $F(3/409) = 0.18$, $p > .10$). Therefore, for the sake of simplicity, **Table 4** displays the results based only on the univariate effects of duration and consumption. As can be seen, both longer lifetime duration of smoking and higher consumption were associated with higher scores on both the AUTOS and the FTND. AUTOS scores discriminated among all four quartiles of consumption, while FTND scores discriminated only among the higher levels.

4. Discussion

The AUTOS demonstrated concurrent validity as a measure of addiction in relation to the FTND, the HONC and additional indicators, and correlated with the pleasure obtained from smoking, and the duration, frequency and amount of cigarette consumption. The AUTOS and each of the subscales showed very good to excellent internal reliability, as in prior studies (DiFranza et al., 2009; DiFranza et al., 2012). Comparisons between the AUTOS and FTND in relation to multiple indicators (**Table 2**) suggest that both instruments are tapping related aspects of dependence. The AUTOS was designed for tobacco cessation research. The utility of the AUTOS as a predictor of cessation outcomes must be established by prospective studies.

Sober alcoholics are called “recovering alcoholics” in recognition of the fact that alcoholism is not cured the day a person stops drinking. Neither are smokers cured of their addiction immediately upon quitting; craving may recur for an extended period of time (Hughes, 2010). In regard to the dimensions measured by the AUTOS, it is not known how long recovering smokers remain psychologically dependent on smoking after their quit date. Nor do we know how long recovering smokers continue to experience urges to smoke in response to cues. Research is needed to examine the natural history of the resolution of these aspects of addiction. With excellent test–retest reliability (DiFranza et al., 2012), the AUTOS provides a valid and reliable instrument for such studies.

The AUTOS fills an important gap in the field of tobacco addiction research and treatment. The ability of the AUTOS to simultaneously track the persistence of withdrawal symptoms, psychological dependence and cue-induced urges to smoke provides smoking researchers with a new tool that can be used to determine the independent

Table 4

Means, (standard deviations) and Analysis of Variance (ANOVA) results for AUTOS and FTND scores as a function of duration of smoking and cigarettes smoked per day.

	AUTOS			FTND		
	M (SD)	F (df)	η^2	M (SD)	F (df)	η^2
<i>Duration of smoking</i>						
Q1: ≤ 1.9 years (n = 75)	7.30 ^a (7.73)	25.71 (3/409) [*]	0.16	0.93 ^a (1.44)	40.64 (3/409) [*]	0.23
Q2: 2–5.9 years (n = 133)	12.00 ^b (9.20)			1.48 ^a (1.96)		
Q3: 6–22.9 years (n = 106)	17.07 ^c (9.07)			2.97 ^b (2.52)		
Q4: ≥ 23 years (n = 108)	18.28 ^c (8.17)			4.27 ^c (2.24)		
<i>Cigarettes smoked per day</i>						
Q1: fewer than 2 (n = 84)	4.10 ^a (5.65)	122.67 (3/409) [*]	0.47	0.48 ^a (0.98)	174.4 (3/409) [*]	0.56
Q2: 2–5 (n = 121)	9.94 ^b (6.70)			0.95 ^a (1.43)		
Q3: 6–11 (n = 102)	18.14 ^c (7.11)			2.77 ^b (1.88)		
Q4: 12 or more (n = 115)	21.81 ^d (7.43)			5.23 ^c (1.81)		

Means that do not share a superscript differ from each other at $p \leq .002$; η^2 = effect size.

* $p < .001$.

contribution of each of these factors to relapse. The AUTOS is currently undergoing evaluation of predictive validity in longitudinal adolescent and adult population studies.

This study provides new insights into the characteristics of the FTND. The FTND demonstrated concurrent validity against all indicators. The FTND demonstrated better reliability in this study ($\alpha = .73$) than reported by its creators ($\alpha = .61$; Heatherton et al., 1991) or in a comparison of the HONC and the FTND (Wellman et al., 2006). This may be because our community sample included a large proportion of nondaily smokers, improving response variability. It is important to recognize that the internal reliability of an instrument sets an upper limit on how strongly it can correlate with other measures. Given that the internal reliability of the FTND was only .73, the correlation of the AUTOS with the FTND ($r = .70$) was as strong as could be expected. This suggests that the AUTOS is tapping the same construct of dependence as the FTND. Among the AUTOS subscales, withdrawal showed the strongest correlation with the FTND ($r = .70$). This makes sense since so many of the FTND items assess whether smokers feel compelled to smoke during or after a period of abstinence.

4.1. Strengths and limitations

Study strengths include the use of a relatively large, non-treatment based sample of adults that covered the full range on all dependence measures, and a wide range in relation to age, duration of smoking and frequency of current use. The psychometric properties of addiction measures cannot be optimally evaluated in treatment seeking samples which suffer from a selection bias which excludes individuals with lower levels of addiction and motivation to quit (Colby et al., 2000; Fortmann & Killen, 1994).

Many prior evaluations of addiction instruments employed the cotinine level as a proxy for dependence (e.g., Heatherton et al., 1989). However, cotinine does not measure addiction; it measures nicotine dosing and metabolism (Perez-Stable et al., 1998). A strength of the current study is the inclusion of indicators of addiction and additional measures to provide a broad evaluation of the AUTOS and FTND. Readers can exercise their own judgment as to which of these indicators best reflect dependence. Another strength is the head-to-head comparison of the AUTOS and FTND in the same sample, as the psychometric properties of instruments will vary somewhat from one population to the next. It would be desirable, for the same reason, to repeat these comparisons in other populations.

A study limitation was that the population was primarily white. As the survey was conducted on the web through postings at multiple institutions, we cannot define the population from which the sample was drawn, and can draw no conclusions regarding the sample's representativeness. However, we do not think that the web-based sample is anomalous, as the AUTOS has demonstrated nearly identical properties with another web-based sample of adults and a community-based sample of adolescents (DiFranza et al., 2009). Furthermore, comparisons of web-based studies with more typical laboratory or field-based methods have demonstrated both a high degree of consistency in the data collected and relative diversity in sample composition (Gosling, Vazire, Srivastava, & John, 2004; Reips, 2002). Online methods of assessing smoking behavior and related constructs were recently found to be highly reliable and valid in a nationally representative sample of young adults in the U.S. (Ramo, Hall, & Prochaska, 2011).

5. Conclusion

The AUTOS demonstrated concurrent validity against all other measures including the FTND. Based on these results and those from prior studies, we conclude that the AUTOS offers researchers a valid and highly reliable, theory-based instrument. It can be used in cessation counseling to evaluate three factors that make smoking cessation

more difficult: withdrawal symptoms, psychological dependence, and cue-induced urges to use tobacco. The AUTOS correlates highly with the FTND, but has better internal reliability, is more sensitive at lower levels of cigarette consumption and among smokers who have been smoking for shorter periods of time, and is more versatile in its applications.

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Contributors

All authors participated in the study design and preparation of the manuscript, and all approved the final draft. JRD & RJW created the AUTOS. RJW created and posted the survey and downloaded the data from the website. JAS performed the data analysis and all authors participated in interpretation of the data.

Conflict of interest

The authors have no competing interests to report.

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