

## Nicotine dependence among African American light smokers: A comparison of three scales<sup>☆</sup>

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### Abstract

Approximately 50% of African American (AA) smokers are light smokers (smoke  $\leq 10$  cigarettes a day), yet this group is understudied despite being at-risk of smoking-related death and disease. This study is a secondary analysis of data from a clinical trial that assessed the efficacy of nicotine gum and counseling for smoking cessation among African American light smokers. The purpose of the current paper was to assess nicotine dependence among participants enrolled in the clinical trial using three measures of nicotine dependence. The Cigarette Dependence Scale (CDS), the Fagerstrom Test for Nicotine Dependence Scale (FTND), and the Nicotine Dependence Syndrome Scale (NDSS) were administered to 700 participants (67% female; mean age=45 years). Exhaled carbon monoxide (CO) and serum cotinine were assessed. The CDS showed the strongest association with biochemical markers ( $r=0.28$  for cotinine and  $0.25$  for CO). Factor analysis of the NDSS revealed five factors: drive, priority, tolerance, continuity, and stereotypy. Compared to those who smoked 1–5 CPD, smokers who averaged 6–10 CPD scored higher on all three dependence ( $p<0.001$ ) and two biochemical measures ( $p<0.001$ ),

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and on three of the five NDSS subscales (Drive,  $p < 0.001$ ; Stereotypy,  $p < 0.01$ ; and Tolerance,  $p < 0.01$ ). Given the different domains tapped by each instrument, the use of multiple measures might yield the most comprehensive assessment of nicotine dependence. Results suggest the validity of these scales for African American light smokers and point to the need for sensitivity to differential levels of nicotine dependence among subgroups of light smokers.

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## 1. Background

Despite an overall decline in smoking prevalence, the proportion of smokers who smoke few cigarettes a day — light smokers, is growing (Hassmiller, Warner, Mendez, Levy, & Romano, 2003; Okuyemi, Harris et al., 2002; Zhu, Sun, Hawkins, Pierce, & Cummins, 2003). Numerous studies have shown that smoking few cigarettes a day is associated with substantial health risks. Light smokers are at increased risk for chronic obstructive pulmonary disease (Fletcher, Peto, & Tinker, 1976) and have a relative risk of developing lung cancer 5.5 times that of nonsmokers (Garfinkel & Stellman, 1988; Jimenez-Ruiz, Kunze, & Fagerstrom, 1998). The prevalence of light smoking is high among ethnic minorities including African American and Hispanics where up to 50%–60% of smokers smoke 10 or fewer cigarettes a day (Evans et al., 1992; Okuyemi, Ahluwalia, Richter, Mayo, & Resnicow, 2001). Despite smoking fewer cigarettes a day, African Americans experience disproportionately higher rates of tobacco-related morbidity. Furthermore, African Americans are more likely to attempt to quit smoking than Caucasians in any given year (Fiore et al., 1989; Giovino et al., 1994). However, the success rate is lower for African Americans (Fiore et al., 1989; Gilpin et al., 2001; Giovino et al., 1994; Kabat & Wynder, 1987; Trinidad, Gilpin, White, & Pierce, 2005).

One possible reason for lower cessation rates among African Americans is higher levels of nicotine addiction. Some studies have suggested that African Americans have higher levels of nicotine dependence (Ahijevych & Gillespie, 1997; Royce, Hymowitz, Corbett, Hartwell, & Orlandi, 1993) but this finding is not consistent across studies (Andreski & Breslau, 1993; Kandel & Chen, 2000). Because most studies on nicotine dependence have focused on heavy smokers, relatively little is known about nicotine dependence among light smokers. Shiffman and colleagues (Shiffman, 1989; Shiffman, Kassel, Paty, Gnys, & Zettler-Segal, 1994; Shiffman, Paty, Kassel, Gnys, & Zettler-Segal, 1994) studied a sub-group of light smokers who absorb and metabolize nicotine normally, yet smoke no more than 5 CPD on at least 4 days per week (e.g., chippers). The ability of chippers to maintain consistently low levels of consumption over time without evidencing withdrawal challenges classic addiction theory and calls for a better understanding of the factors that motivate smoking by this group (Shiffman, 1989). Recent work has shown that compared to heavy smokers, chippers' smoking is under greater stimulus control and is more likely associated with indulgent activities such as relaxing, socializing, eating, and consuming alcohol. Outside of indulgent settings, chippers' consumption is more likely linked to negative affect. Chippers are as likely to smoke when alone as heavy smokers (questioning their status as social smokers) and experience urges equal to those of heavy smokers when smoking, albeit have fewer overall daily urges given a relative absence of urges when not smoking (Shiffman and Paty, 2006). This research highlights the complexity of factors motivating light smoking and supports the expansion of this work to more diverse and representative samples of smokers.

Nicotine dependence is classified as a destructive pattern of nicotine use that leads to significant social, occupational, or medical impairment (American Psychiatric Association, 1994). Clinical diagnostic criteria for nicotine dependence include: 1) tolerance to the effects of nicotine; 2) withdrawal symptoms when nicotine use is abated; 3) greater use of nicotine than intended; 4) unsuccessful efforts to cut down or control use; 5) great deal of time spent using nicotine; 6) sacrifice of other activities in order to use nicotine; and 7) continued use of nicotine despite known health problems associated with use. Existing measures of nicotine dependence cover various aspects of this syndrome (see Table 1).

Given the multi-faceted nature of nicotine dependence, multiple means of assessment have been developed. Some measures, such as the Cigarette Dependence Scale (CDS) (Etter, Le Houezec, & Perneger, 2003), combine criteria from formal diagnostic systems such as the DSM-IV (American Psychiatric Association, 1994) and the ICD-10. Such tools offer the benefits of brevity and ease of administration; however, they have the drawback of masking heterogeneity, such that the same dependence score might not convey important individual differences, which might map onto different outcomes (Shiffman, Dresler, & Rohay, 2004). The Fagerstrom Tolerance Questionnaire (FTQ)

Table 1  
Dependence scales classified according to DSM-IV criteria

DSM-IV criteria for substance dependence	FTND	CDS-5	NDSS
1. Tolerance: (a) need increased amounts to get an effect (b) diminished effect with continued use of the same amount of the substance	Not covered	Not covered	Smoke more to get an effect Smoke more than when first started
2. Withdrawal: (a) development of substance-specific syndrome due to cessation of substance and substance causes impairment in everyday functioning (b) substance is taken to relieve withdrawal	Indirectly covered: Cigarette after waking	Urge to smoke after period of abstinence	Experience craving after period of abstinence Smoke to relieve feelings of restlessness and irritability Smoke to prevent discomfort Feels out of control after period of not smoking Not covered
3. The substance is taken in larger amounts over a longer period of time than intended	Not covered	Not covered	
4. There is a persistent desire or unsuccessful effort to cut down or control substance abuse	Not covered	Difficulty quitting	Controllability over smoking behavior
5. A great deal of time is spent in activities necessary to obtain the substance, use the substance, or recover from its effects.	Not covered	Not covered (But covered in CDS-12 by item "I smoke all the time")	Not covered
6. Important social, occupational, or recreational activities are given up or reduced because of substance use	Not covered	Not covered (But covered in CDS-12 by item "Sometimes I drop everything to go out and buy cigarettes")	Avoid non-smoking restaurants Avoid non-smoking friends Avoid airplanes because cannot smoke
7. Substance use is continued despite knowledge of having a persistent or recurrent physical or psychological problem caused or exacerbated by the substance.	Smoking when ill	Not covered (But covered in CDS-12 "I smoke despite the risks to my health")	Not covered

(Fagerstrom, 1978) and its revision, the Fagerstrom Test for Nicotine Dependence (FTND) (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991) are the most widely-used measures of nicotine dependence. The Fagerstrom scales are unidimensional measures of physical tolerance, the component of dependence that is believed to motivate compulsive smoking (Fagerstrom & Schneider, 1989). The Fagerstrom scales offer numerous advantages, including brevity, ease of administration, adequate test–retest reliability (Pomerleau, Carton, Lutzke, Flessland, & Pomerleau, 1994) and acceptable predictive validity (Pinto, Abrams, Monti, & Jacobus, 1987).

Despite the strengths of the Fagerstrom scales, they were designed to measure a single dimension of dependence (physical tolerance), and do not assess other salient dimensions of dependence such as craving, compulsion to smoke, or withdrawal (Shiffman, Dresler et al., 2004). In fact, there is a low concordance between the Fagerstrom (Fagerstrom, 1978) and the DSM (American Psychiatric Association, 1994) diagnostic systems given the different domains of nicotine dependence tapped by the respective measures (Etter, 2005; Moolchan et al., 2002). In order to more comprehensively assess nicotine dependence, therefore, multi-dimensional measures such as the Nicotine Dependence Syndrome Scale (Shiffman, Dresler et al., 2004) and the Wisconsin Inventory of Smoking Dependence Motives (Piper et al., 2004) have been developed. Although lengthier, these scales offer the advantage of assessing multiple aspects of nicotine dependence in a continuous manner.

A complementary assessment approach, utilizing multiple measures of nicotine dependence, might yield insight into various aspects of nicotine dependence among those populations at greatest risk for smoking-related morbidity and mortality (Moolchan et al., 2002). These populations include African American smokers who, despite having a high prevalence of light smoking ( $\leq 10$  cigarettes per day, CPD) (Kandel & Chen, 2000; Okuyemi, Harris et al., 2002), experience a disproportionately high rate of tobacco-related illness and death (Harris, Zang, & Anderson, 1993). African American smokers tend to display different patterns of nicotine consumption than other ethnic groups, such as preferring high tar/nicotine and mentholated cigarettes (Kabat & Hebert, 1991; Okuyemi, Ebersole-Robinson, Nazir, & Ahluwalia, 2004), inhaling more deeply (Clark, Gautam, & Gerson, 1996; Okuyemi, Richter et al., 2002), having a slow rate of nicotine metabolism (Perez-Stable, Herrera, Jacob, & Benowitz, 1998), high serum cotinine levels (Benowitz, 1996; Caraballo et al., 1998), and greater difficulty quitting smoking (Royce et al., 1993). These characteristics may contribute to the excess smoking-related morbidity experienced by this group.

Despite a large proportion of African American smokers being light smokers, (Caraballo et al., 1998; Okuyemi, Harris et al., 2002) nicotine dependence among light smokers is not well understood. We therefore conducted a secondary analysis of data from a clinical trial that assessed the efficacy of nicotine gum and counseling for smoking cessation among African American light smokers. The aim of the current study is to evaluate the validity of three nicotine dependence scales in a sample of *African American light smokers as a first step toward better understanding nicotine dependence among this understudied and at-risk population. Specifically, we examined the internal consistency of each scale and the factor structure of those scales that are multi-dimensional* (Nunnally & Bernstein, 1994). *Given the rigorous development of the nicotine dependence scales under investigation and/or their proven track record in clinical research* (Etter et al., 2003; Heatherton et al., 1991; Kozlowski, Porter, Orleans, Pope, & Heatherton, 1994; Pinto et al., 1987; Pomerleau, Pomerleau, Majchrzak, Kioska, & Malakuti, 1990; Kozlowski et al., 1994), *we hypothesize that the measures will demonstrate similar psychometric performance as observed in previous studies among heavier smokers.*

## 2. Methods

### 2.1. Study design

The parent study was a placebo-controlled randomized trial of African American light smokers ( $\leq 10$  CPD) evaluating the efficacy of nicotine gum and counseling for smoking cessation (Okuyemi et al., 2007). The study used a factorial design ( $2 \times 2$ ) in which 755 participants were randomly assigned to one of 4 study arms: placebo gum plus health education (HE); placebo gum plus motivational interviewing (MI); 2 mg nicotine gum plus HE; and 2 mg nicotine gum plus MI. Eligibility was determined by a phone screening and those who were eligible were scheduled for a randomization appointment. Eligible persons described themselves as “African American or black,” were at least 18 years of age, smoked  $\leq 10$  cigarettes per day, were interested in quitting in the next 14 days, spoke English, and had a home address and working telephone. Participants were excluded if they had a contraindication for nicotine gum, were pregnant, or used other forms of tobacco or nicotine replacement in the past 30 days. Participants provided written informed consent during the randomization visit and study procedures were approved and monitored by the human subjects committee at investigators’ institution.

### 2.2. Measures

The baseline assessment included measures of demographic and health information, and smoking behaviors (set in Table 2). The principal source for these items was the COMMIT Smoking Prevalence

Table 2  
Description of participants in the study

Characteristic	All (N=700)
Age, mean (SD), y	45.0 (10.7)
Women, No. (%)	467 (66.7%)
Monthly family income <\$1800, N (%)	403 (59.2%)
<High school graduate, N (%)	114 (16.3%)
FTND Score, mean (SD)	2.8 (1.74)
NDSS Score, mean (SD)	−1.00 (1)
Drive subscale, mean (SD)	−0.79 (1.19)
Stereotypy subscale, mean (SD)	−0.15 (0.95)
Continuity subscale, mean (SD)	−0.01 (0.96)
Priority subscale, mean (SD)	−0.20 (0.94)
Tolerance subscale, mean (SD)	−1.09 (0.94)
CDS score, mean (SD)	14.8 (3.6)
Number of cigarettes smoked per day, mean (SD)	7.08 (2.53)
CO level, mean (SD), ppm	13.7 (8.7)
Serum cotinine, mean (SD), ng/mL	243.7 (152.8)
First cigarette within 30 min, N (%)	447 (64.0%)
Smoke mentholated cigarettes, N (%)	567 (81.2%)
Number quit attempts in past year, mean (SD)	3.3 (6.8)
Duration of smoking in years, mean (SD)	23.7 (12.0)
Smoke high nicotine/tar cigarettes, N (%)	428 (61.3)
Inhale deeply, N (%)	383 (54.9)



Survey. This instrument has established validity and reliability, and has been used in a sample comparable to the one in the current study (Royce et al., 1993).

### 2.2.1. Cigarette Dependence Scale (CDS)

The CDS (Etter et al., 2003) is a 12-item instrument that covers the main components of DSM-IV (American Psychiatric Association, 1994) and ICD-10 definitions of dependence: compulsion, withdrawal symptoms, loss of control, time allocation, neglect of other activities, and persistence despite harm. From the original scale (CDS-12, score range 0–60), a 5-item version of this scale (CDS-5, score range 0–25) was also developed and has similar measurement properties but less comprehensive content. Items in the CDS-5, the version used in the present study, include a self-rating of addiction, number of cigarettes smoked per day, time to first cigarettes of the day, difficulty to quit smoking, and urge to smoke. The CDS-5 has high test–retest reliability ( $r \geq 0.83$ ), and a high internal consistency (Cronbach's  $\alpha \geq 0.84$ ).

### 2.2.2. Fagerstrom Test of Nicotine Dependence (FTND)

The FTND is a 6-item scale (score range 0–10) widely-used as a measure of nicotine dependence. The FTND has adequate internal consistency and reliability (Cronbach's  $\alpha = 0.61$ ) (Heatherton et al., 1991). Prior studies have found the Fagerstrom scales to correlate with biochemical measures of nicotine dependence including exhaled air carbon monoxide ( $r = 0.24$ ) (Pinto et al., 1987) and plasma cotinine ( $r = 0.33$ – $0.46$ ) (Pomerleau et al., 1990). The FTND has also been found to predict smoking cessation, although the predictive value may account for little variance (Kozłowski et al., 1994).

### 2.2.3. Nicotine Dependence Syndrome Scale (NDSS)

The NDSS (Shiffman, Waters, & Hickcox, 2004) is a 19-item, 5-dimension measure of nicotine dependence. The scale exhibits good psychometric properties (Cronbach's  $\alpha = 0.71$ – $0.83$ ) (Shiffman, Waters et al., 2004). Factor analysis of the NDSS revealed five factors: *Drive* (craving and withdrawal, and subjective 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 smoking). The NDSS yield a single overall score NDSS-T (mean = 0, SD = 1), based on the first principal component, and sub scores for the 5 factors previously described.

### 2.2.4. Biochemical measurements

Expired carbon monoxide (CO) and serum cotinine were assessed at randomization. The CO was measured using a hand held portable CO monitor (Bedfont Micro Smokerlyzer, Kent, England) and is measured in parts per million (ppm). Serum cotinine analysis (measured in ng/mL) was performed by the Clinical Pharmacology Laboratory at the University of California, San Francisco.

## 2.3. Statistical analysis

Surveys were double-data entered in Access and exported into SAS v9.1 for analysis. Categorical baseline variables were summarized by frequencies and percentages while quantitative baseline variables were summarized by means and standard deviations. Pearson correlations were calculated between each of the dependence scales and subscales. Of the three scales examined, only the NDSS is multi-dimensional (Etter, 2005) (Shiffman, Waters et al., 2004). Cronbach's  $\alpha$  was calculated for each scale and subscale. We conducted a confirmatory factor analysis using the 19 items of the NDSS. We compared

Table 3

NDSS factor scores among African American light smokers ( $N=700$ )

Questionnaire item	Drive	Continuity	Priority	Stereotypy	Tolerance
Whenever I go without a smoke for a few hours, I experience craving.	0.66	0.22	0.19	0.22	−0.05
After not smoking for a while, I need to smoke to relieve feelings of restlessness and irritability.	0.61	0.34	0.17	0.25	0.02
When I'm really craving a cigarette, it feels like I'm in the grip of some unknown force that I cannot control.	0.54	0.32	0.19	0.09	0.11
After not smoking for a while, I need to smoke in order to keep myself from experiencing any discomfort.	0.54	0.18	0.15	0.18	0.26
I feel a sense of control over my smoking. I can "take it or leave it" at any time.	−0.32	0.11	0.06	−0.04	−0.08
The number of cigarettes I smoke per day is often influenced by other factors — how I'm feeling, what I'm doing, etc.	0.15	0.77	0.08	0.07	0.05
I smoke at different rates in different situations.	0.12	0.61	−0.00	0.11	0.14
It's hard to estimate how many cigarettes I smoke per day because the number often changes.	0.11	0.42	0.07	0.01	0.20
My smoking pattern is very irregular throughout the day. It is not unusual for me to smoke many cigarettes in an hour, then not have another one until hours later.	0.06	0.25	0.04	−0.04	0.04
I tend to avoid restaurants that don't allow smoking, even if I would otherwise enjoy the food.	0.13	0.13	0.69	0.11	0.01
Sometimes I decline offers to visit with my non-smoking friends because I know I'll feel uncomfortable if I smoke.	0.03	0.06	0.65	0.15	0.03
Even if traveling a long distance, I'd rather not travel by airplane because I wouldn't be allowed to smoke.	0.12	0.07	0.57	0.19	−0.02
My cigarette smoking is fairly regular throughout the day.	0.28	0.10	0.06	0.75	0.07
I smoke consistently and regularly throughout the day.	0.24	0.12	0.15	0.59	0.15
I smoke about the same amount on weekends as on weekdays.	0.13	0.02	0.13	0.38	−0.00
My smoking is not much affected by other things. I smoke about the same amount whether I'm relaxed or working, happy or sad, alone or with others, etc.	−0.06	−0.11	0.18	0.29	0.01
Compared to when I first started smoking, I can smoke much, much more now before I start to feel nauseated or ill.	0.10	0.23	0.12	0.09	0.64
Compared to when I first started smoking, I need to smoke a lot more now in order to get what I really want out of it.	0.24	0.27	0.12	0.19	0.51
Since the time when I became a regular smoker, the amount I smoke has either stayed the same or has decreased somewhat.	−0.01	−0.02	0.06	0.01	−0.23

demographics and dependence scales between those who smoked 1–5 cigarettes per day versus 6–10 cigarettes per day. The two-sample *t*-test was used to compare quantitative variables and the chi-square test was used to compare categorical variables between these two groups.

### 3. Results

#### 3.1. Participants

Of the 755 AA light smokers who participated in the parent study, a total of 700 participants (mean age=45) reported smoking 1–10 CPD at randomization and were therefore included in analyses





(see Table 2). A total of 55 participants reported already quitting or smoking >10 CPD at randomization and were excluded from current analyses. In our study sample, 25% smoked 1–5 CPD and 75% smoked 6–10 CPD. A majority of the participants were female (67%) with at least a high school education (84%) and a monthly family income of less than \$1800 (59%). Participants predominantly smoked mentholated cigarettes (81%).

### 3.2. Examination of three nicotine dependence measures

#### 3.2.1. Internal consistency

Cronbach's alpha for each of the three nicotine dependence measures was 0.64 for the CDS, 0.63 for the FTND, and 0.80 for the NDSS. Alphas for the NDSS subscales were: Drive=0.75; Continuity=0.60; Priority=0.70; Stereotypy=0.62; and Tolerance=0.48.

#### 3.2.2. Factor structure

Of the three scales examined, only the NDSS is multi-dimensional (Etter, 2005; Shiffman & Sayette, 2005). Therefore, we conducted a confirmatory factor analysis using the 19 items of the NDSS. The five factor structure proposed by Shiffman, Waters et al. (2004) was replicated as can be seen from Table 3. To confirm the 5 factor structure, we utilized the maximum likelihood method specifying the number of factors equal to 5 with a varimax rotation. The questions that make up the five subscales and the total score are identical and the corresponding factor loadings are similar to those seen in Shiffman et al.

Table 5  
Comparison of smokers who consume 1–5 CPD vs. 6–10 CPD

	1–5 CPD (N=204)	6–10 CPD (N=496)	p-value
Age, mean (SD), y	44.3 (11.8)	45.2 (10.2)	0.35
Women, No. (%)	130 (63.7%)	337 (67.9%)	0.28
Monthly family income <\$1800, N (%)	115 (57.8%)	288 (59.8%)	0.64
<High school graduate, N (%)	36 (17.7%)	78 (15.8%)	0.54
FTND Score, mean (SD)	2.2 (1.7)	2.99 (1.7)	<0.0001
NDSS Score, mean (SD)	−1.32 (0.99)	−0.87 (0.97)	<0.0001
Drive subscale, mean (SD)	−1.11 (1.1)	−0.65 (1.2)	<0.0001
Stereotypy subscale, mean (SD)	−0.30 (0.89)	−0.08 (0.95)	0.005
Continuity subscale, mean (SD)	−0.02 (0.96)	−0.01 (0.96)	0.84
Priority subscale, mean (SD)	−0.10 (0.90)	−0.23 (0.94)	0.11
Tolerance subscale, mean (SD)	−1.28 (0.91)	−1.01 (0.94)	0.0006
CDS score, mean (SD)	12.5 (3.5)	15.7 (3.2)	<0.0001
Number of cigarettes smoked per day, mean (SD)	4.10 (1.12)	8.43 (1.52)	<0.0001
CO level, mean (SD), ppm	11.1 (7.6)	14.79 (8.9)	<0.0001
Serum cotinine, mean (SD), ng/mL	176.4 (127.7)	271.4 (153.8)	<0.0001
First cigarette within 30 min, N (%)	102 (50.3%)	345 (69.70%)	<0.0001
Smoke mentholated cigarettes, N (%)	171 (83.8%)	396 (80.2%)	0.26
Number quit attempts in past year, mean (SD)	3.7 (6.7)	3.2 (6.9)	0.39
Duration of smoking in years, mean (SD)	23.0 (13.2)	24.0 (11.4)	0.35
Smoke high nicotine/tar cigarettes, N (%)	126 (18.1)	302 (43.3)	0.26
Inhale deeply, N (%)	103 (14.8)	280 (40.1)	0.14

### 3.2.3. Criterion validity

Significant positive correlations were observed among the three nicotine dependence measures (see Table 4). Relatively stronger correlations emerged between the CDS-5 and the FTND ( $r=0.67$ ), and CDS-5 and NDSS ( $r=0.62$ ) than between the FTND and the NDSS ( $r=0.47$ ). Of the five NDSS subscales, the Drive subscale showed the strongest association with both the CDS-5 ( $r=0.60$ ) and the FTND ( $r=0.39$ ), followed by the Stereotypy subscale ( $r=0.21$  for both the CDS-5 and the FTND).

### 3.2.4. Concurrent validity

Associations between the three dependence measures and biochemical markers ranged from weak to modest, with the strongest association observed with the CDS-5 ( $r=0.28$  for cotinine and  $0.25$  for CO); the weakest was with the NDSS ( $r=0.13$  for cotinine and  $0.15$  for CO).

### 3.2.5. Construct validity

As shown in Table 5, light smokers with higher daily use (6–10 CPD) displayed greater nicotine dependence than those who smoked 1–5 CPD. Specifically, those who smoked 6–10 CPD scored significantly higher on all three dependence measures ( $p<0.001$ ), both biochemical measures ( $p<0.001$ ), and smoked sooner after awakening ( $p<0.001$ ). In addition, compared to those who smoked 1–5 CPD, those who smoked 6–10 CPD scored significantly higher on three of the five NDSS subscales: Drive ( $p<0.001$ ), Stereotypy ( $p<0.01$ ), and Tolerance ( $p<0.01$ ). No differences were seen between those who smoked 1–5 CPD and 6–10 CPD on smoking mentholated cigarettes ( $p=0.26$ ), number of quit attempts in the past year ( $p=0.39$ ), or duration of smoking ( $p=0.35$ ).

## 4. Discussion

The purpose of this study was to *examine the validity of three nicotine dependence measures as a first step toward better understanding light smoking among African Americans*. Advances in the understanding of nicotine dependence have been limited by the complexity of the phenomenon itself and the associated difficulty measuring it (Shiffman, Waters et al., 2004).

Examination of the internal consistency of the scales revealed that the FTND, CDS, and NDSS subscales performed similarly in our population compared to those in previous studies (Etter, 2005; Etter et al., 2003) (Shiffman, Waters et al., 2004). Cronbach's alpha for the CDS-5 in our study was slightly lower than reported in previous work (Etter, 2005; Etter et al., 2003).

Investigation of the factor structure of the NDSS showed that items loaded on the same factors proposed by Shiffman, Waters et al. (2004) and that a five factor solution provided the best model fit in our sample. This contrasts with a factor analysis of the 27-item NDSS among adolescents which revealed a four-factor model in which the Drive and Tolerance subscales were collapsed (Clark et al., 2005). Given that the 19-item version of the NDSS was used in the present study, it is difficult to draw direct comparisons between our results and those of Clark et al. (Clark et al., 2005).

Turning to an examination of the concurrent validity of the scales, we note that previous attempts to validate nicotine dependence measures have found modest relationships between dependence measures and outcomes such as smoking cessation (Breslau, Johnson, Hiripi, & Kessler, 2001) and biochemical markers (Pomerleau et al., 1990). Findings from the current investigation paralleled previous literature with regard to the magnitude of correlations observed between our three dependence measures and biochemical markers. The CDS-5 showed the strongest of otherwise weak correlations with CO and

cotinine, suggesting that the CDS-5 may be most valid among the three instruments examined for capturing the biological features of nicotine dependence among African American light smokers.

Regarding the construct validity of the scales, comparison of light smoker subgroups revealed numerous significant differences between those who smoked 1–5 vs. 6–10 CPD. Those with higher daily use (6–10 CPD) had significantly higher scores on each of the three nicotine dependence measures, displayed greater levels of carbon monoxide and serum cotinine, and reported a shorter time to the first cigarette of the day. These differences suggest that light smokers, defined broadly as those who smoke  $\leq 10$  CPD (Okuyemi, Harris et al., 2002), should not be treated as a homogeneous group in clinical research, nor in outreach programming and cessation interventions.

Although the NDSS was a less robust measure of global nicotine dependence in the present sample, the NDSS nonetheless provided interesting information about multiple dimensions of nicotine dependence. Compared to the lightest smokers (1–5 CPD), those who reported using 6–10 CPD at baseline had higher scores on three of the five NDSS subscales: Tolerance, Drive, and Stereotypy. Light smokers with higher daily use (6–10 CPD) reported reduced sensitivity to the effects of smoking and/or the escalation of cigarette use to achieve desired effects (Tolerance), greater craving, withdrawal-avoidance, and subjective compulsion to smoke (Drive), and a more rigid or consistent pattern of smoking behavior (Stereotypy). Characteristics of the Drive and Tolerance subscales are central to DSM-IV diagnostic criteria for nicotine dependence (American Psychiatric Association, 1994), and may be anticipated to be higher among smokers who have greater daily exposure to nicotine. Similarly, smokers with greater repetition of cigarette use (e.g., those with greater daily rates of smoking) have developed automaticity of smoking behavior (Tiffany, 1990) and thus may display increased Stereotypy, a consistent, invariable pattern of tobacco use.

Both groups of light smokers (1–5 CPD and 6–10 CPD) had similar scores for Continuity and Priority, suggesting these smokers did not report regularity of smoking rate (Continuity) or a clear preference for smoking compared to competing reinforcers (Priority). We would not necessarily expect to see differences in Continuity, as all of these smokers report use of 10 or fewer cigarettes per day, and therefore would not be expected to have continuous, uninterrupted smoking patterns as might otherwise be seen in heavier smokers. Furthermore, differences in Priority scores might be expected between light and heavier smokers, demonstrating greater behavioral priority given to cigarettes as reflected in increased use throughout the course of a day. Indeed, Shiffman, Waters et al. (2004) reported higher NDSS Priority scores among a sample of African Americans who reported smoking 11–40 CPD.

Shiffman and Sayette (2005) reported that Tolerance, Drive, and Stereotypy best discriminated between chippers ( $\leq 5$  CPD) and regular ( $> 20$  CPD) adult smokers. Our results in using the NDSS among light smokers are consistent with their findings. In previous work (Shiffman & Sayette, 2005), these three subscales were each independently associated with differences in smoking rates among chippers, such that light smokers who smoked more cigarettes daily had greater scores on these subscales. Similarly, the Continuity and Priority subscales scores were not significantly associated with smoking rate and did not help discriminate level of dependence within the group of chippers (Shiffman & Sayette, 2005).

Our findings are also consistent with Shiffman and Sayette (2005) with regard to the utility of the NDSS as a tool for evaluating and differentiating specific characteristics of nicotine dependence among smokers with varying rates of smoking. Although the NDSS showed relatively lower correlations with biochemical measures in the current study, 3 of 5 subscales retained discriminant validity within subgroups of light smokers. Such characterization may be particularly useful in trying to better understand potential biological, behavioral, and cognitive distinctions between smokers with different rates and patterns of drug use.

Because the NDSS and the CDS are relatively new scales, more studies are needed to examine the validity of these scales in a variety of populations, and to develop abbreviated scales specifically for intended population samples. Studies should also assess the potential impact of ethnicity, language, level of acculturation, and socioeconomic status on the performance of these measures. In the current study, these variables were not evaluated for their individual contribution to our findings given the relative homogeneity of the sample and restricted range with respect to ethnicity and socioeconomic status.

The current study has limitations. First, participants were enrolled in a clinical trial implying they were seeking treatment. Indeed, participants in this study were highly motivated to quit (Okuyemi et al., 2007). The sample may therefore not be representative of light smokers in general. Second, because our sample only included African American light smokers who have different smoking patterns compared to other racial/ethnic groups (Kabat, Morabia, & Wynder, 1991), findings could be different among smokers of other backgrounds. Some studies have also reported differences in nicotine dependence among various racial/ethnic groups (Kandel & Chen, 2000). Nevertheless, the measurement of nicotine dependence among light smokers is an important step in developing interventions designed to address cessation in this unique subset of smokers. As a first step toward this important goal, the current study examined the validity of several existing measures of nicotine dependence including an assessment of internal consistency, factor structure, concurrent, construct, and criterion group validity. Future scale development could be enhanced through an analysis of the ability of individual items and total score to predict smoking abstinence, the intensity of withdrawal symptoms, and progression in motivation to quit in the smoker. Thus, further attempts to describe the diversity of dependence-related symptoms for light smokers are encouraged.

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