Measuring the Loss of Autonomy Over Nicotine Use in Adolescents

The DANDY (Development and Assessment of Nicotine Dependence in Youths) Study

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Context: There is no validated, theory-based tool for assessing the onset of nicotine dependence. However, the use of all addictive substances can result in a loss of autonomy. We propose that nicotine dependence begins when autonomy is lost, ie, when the sequelae of tobacco use, either physical or psychological, present a barrier to quitting.

Objectives: To test the autonomy theory of nicotine dependence, and to evaluate the Hooked on Nicotine Checklist (HONC) as a measure of the loss of autonomy over tobacco use.

Design: The psychometric performance and concept validity of the HONC were evaluated in a 30-month prospective longitudinal study of the natural history of tobacco use in a cohort of 679 seventh-grade students.

Results: As hypothesized, endorsement of a single item on the HONC was associated with a failed attempt at smoking cessation (odds ratio [OR], 29; 95% confidence interval [CI], 13-65), continued smoking until the end of follow-up (OR, 44; 95% CI, 17-114), and daily smoking (OR, 58; 95% CI, 24-142). Scores on the HONC correlated with the maximum amount smoked ($r = 0.65$; $P < .001$) and the maximum frequency of smoking ($r = 0.79$; $P < .001$). Internal reliability was 0.94. A 1-factor solution explained 66% of the total variance.

Conclusions: The data support the autonomy theory that dependence begins with the loss of autonomy. The autonomy theory represents a potentially useful alternative to current concepts of nicotine dependence for adolescents, and the HONC appears to measure lost autonomy in adolescents. Construct validity was demonstrated by its utility in predicting failed cessation and the progression of tobacco use. In addition, the psychometric properties were excellent.

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Nicotine interacts with a variety of receptors, neurotransmitter systems, and neural pathways in the central nervous system, but it has not been established how nicotine produces dependence. Many behavioral and neurobiological theories of addiction have been advanced, but none offers a complete explanation. Without an understanding of the pathophysiological mechanisms, it has not been possible to develop a “gold standard” for identifying or measuring nicotine dependence. A recent exhaustive review of dependence measures concluded that “the field lacks a widely accepted, theoretically-derived, and psychometrically-sound research tool for evaluating nicotine dependence.” This is especially true for the pediatric population.

The Fagerstrom Tolerance Questionnaire (FTQ) was developed in 1978 to predict physiological tolerance to nicotine as measured by heart rate and temperature responses. Many have found it useful, and it has been widely employed. However, poor performance on psychometric testing has led to several modifications. In addition, the FTQ and its progeny were not derived from addiction theory, and it is unclear what is being measured. In one study, the FTQ and 2 related measures explained only about 1% of the variance as to which smokers were successful at quitting. Thus, the FTQ may measure the motivation to maintain serum nicotine levels rather than dependence. This measure may not be relevant to the onset of dependence; adolescents report symptoms of dependence when nicotine intake is too low to achieve consistent blood levels. Some FTQ questions, such as those assessing smoking when too sick to get out of bed and the time between waking and smoking, may also be inappropriate for youths. Without parental permission, youths may be unable to light up within 5 minutes of rising or smoke when sick in bed.
PARTICIPANTS AND METHODS

The methods for this study have been described in detail. Briefly, this longitudinal study was conducted in 2 small cities in central Massachusetts with a cohort of 679 seventh-grade students of mixed racial and ethnic backgrounds (mean age, 13 years; age range, 12-15 years at the start of the study). Eight rounds of private individual interviews were conducted in the schools using a structured protocol between January 1998 and June 2000.

ASSEMBLING THE COHORT

The Institutional Review Board of the University of Massachusetts Medical School, Worcester, approved a passive consent process. Random number assignments were used to assemble a cohort of subjects from 2 school systems. Subjects were told the study was confidential and concerned tobacco. Prior tobacco use did not preclude participation. No subjects were added after the first set of interviews was completed. This report covers 8 rounds of interviews.

SURVEY INSTRUMENT

The survey instrument collected detailed information about prior and current tobacco use, including the duration of use, the frequency of use, the amount used, the pattern of use, the types of tobacco used, periods of abstinence, and attempts to quit smoking. Students were asked to provide exact dates for the first puff, the first inhalation, the first monthly use, the first daily use, and the first occurrence of 10 indicators of lost autonomy (Figure 1). These indicators were identified by a review of the literature conducted to locate validated survey items used as indicators of dependence in previous studies.

MAIN OUTCOME MEASURES

Data were collected concerning the date of birth, sex, and race/ethnicity of participants. Subjects were asked about the smoking status of both parents (never smokers, ex-smokers, or current smokers). Subjects were considered to be tobacco users if they had ever used any form of tobacco, and those who had ever smoked 2 cigarettes within a period of less than 2 months were termed “monthly smokers.” The category would include subjects who were daily smokers from their first cigarette, as well as subjects who smoked on 2 consecutive days and then stopped. The onset of monthly smoking was defined as the point in time when the subject first smoked with a frequency of at least once per month.

DATA ANALYSIS

An unsuccessful attempt to quit was defined as a conscious decision to discontinue tobacco use followed by a relapse. The reason the subject resumed smoking was ascertained, and the interviewer determined whether it would count as a relapse (eg, resumed smoking at the end of a sports season would not be a relapse). The current smoking status was recorded at each interview. This included information on the amount smoked (converted to cigarettes per year); the frequency of smoking (converted to days per year); and the maximum intensity of smoking in terms of cigarettes per year and days per year.

Although they are often used as guidelines for treatment, the definitions of nicotine dependence developed by official committees are not immutable, mutually consistent, applicable to all populations, or universally accepted. Specifically, the Diagnostic and Statistical Manual of Mental Disorders (DSM) definition of nicotine dependence has not been validated with adolescents, and it offers no description or explanation of how nicotine dependence develops in youths. It presumes how dependence begins with its requirements for daily, prolonged, and heavy use, and, therefore, may not be applicable to the onset of dependence in adolescence, when symptoms of dependence can appear with occasional use. The DSM definition originated in Edwards’ and Gross atheoretical empirical description of the behavior of advanced alcoholics, which was later adapted based on clinical observations of heavy adult smokers. Edwards himself later warned that “those who study dependence and argue for the clinical utility of the dependence concept should make sure that an idea does not become an over-valued idea, or themselves the victims of an idée fixe.” Appealing to this spirit of remaining receptive to new concepts of

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dependence, we offer an alternative to the DSM approach for evaluating the onset of nicotine dependence.

The World Health Organization holds that the cardinal feature of substance abuse is impaired control over substance use.22 The DSM describes loss of control in terms of the amount or duration of use, but we believe that this concept can be usefully expanded to encompass the loss of autonomy over tobacco use. In our autonomy theory, we propose that the onset of dependence can be defined as the moment when an individual loses full autonomy over the use of tobacco. In philosophical terms, the loss of autonomy begins when discontinuing the use of tobacco is no longer an effortless exercise of free will. Operationalizing this concept, a person has lost autonomy when the sequelae of tobacco use, either physical or psychological, present a barrier to quitting.

Autonomy can be lost through different mechanisms. The autonomy theory does not assume that all symptoms of dependence are a result of the pharmacological effects of nicotine. In some individuals, the loss of autonomy may be caused by neuropharmacological mechanisms. In others, psychological or behavioral processes may predominate. The assumption that dependence entails a single clinical entity has left addiction theorists unable to provide a theory that explains all of the clinical manifestations of the hypothesized dependence syndrome. The autonomy model assumes that what appears to be a single clinical syndrome actually represents a mixture of overlapping conditions that result from multiple independent mechanisms. Therefore, a single mechanistic theory cannot explain all of the manifestations of the clinical syndrome of dependence. The autonomy model allows for the reconciliation of competing theories of addiction into a single model; several existing theories of addiction may be valid.2-4

The validity of the autonomy model can be tested by determining if a measure of lost autonomy is predictive of continued smoking or failed cessation. To assess autonomy in youths, an instrument was developed based on 3 mechanistic theories of addiction.2-4 According to the self-medication theory, people become addicted through the use of a drug to medicate unpleasant affective states.2 Nicotine is a mood-modulating drug that is used by adolescents primarily to reduce excessive arousal (anxiety), but also to boost low arousal (boredom).31-37 Stress provokes urges to smoke in 70% of adolescent smokers, and relapse is most commonly blamed on “being upset.”36,37 When youths depend on tobacco as a “psychological crutch” it becomes an obstacle to cessation.38 Under the self-medication theory, a loss of autonomy occurs when one depends on nicotine to cope.

The negative reinforcement theory holds that addictive behavior is motivated primarily by the desire to avoid unpleasant emotional states, including nicotine withdrawal.4 Withdrawal symptoms predict relapse, and adults titrate nicotine intake to avoid them.4,39,40 They are common prior to daily smoking and accompany the first attempt to quit for most youths.17,24,25,41,42 A single symptom can make quitting unpleasant, representing a price to be paid for cessation and, therefore, a loss of autonomy.

The incentive-sensitization theory proposes that separate neuropathways mediate “pleasure” and “wanting.”3 With ordinary stimuli, such as food, sensory receptors stimulate the pleasure pathway, which in turn stimulates the pathway responsible for wanting. With their direct effect on brain neuroreceptors, addictive drugs appear to be capable of bypassing the pleasure pathways to stimulate the wanting pathways directly. According to this theory, addictive drugs produce persistent neuronal sensitization, resulting in “craving,” a pathologically intense “wanting.” It is important to distinguish between cravings for food and those that result from nicotine-induced alterations in the sensitization of neural pathways. There is a good deal of experimental evidence supporting the sensitization model.3,43-47 Cravings in adolescents correlate with measures of nicotine intake, suggesting a physiological mechanism.25,42 Cravings also predict relapse and dependence.39,42,48,49 In youths, craving is the most common, and often, the most severe, withdrawal symptom.17,23-25,30,42,49 As the primary mechanism of addiction in this model, craving indicates a loss of autonomy.

Drawing from these 3 theories of addiction, the Hooked on Nicotine Checklist (HONC) was constructed to screen for symptoms that signify a loss of autonomy in youths (Figure 1). Based on the philosophical concept that an individual either has autonomy or does not, we hypothesized that the endorsement of a single item on the HONC would indicate a loss of autonomy. We also considered that the HONC could be scored to measure the degree of lost autonomy. The psychometric properties of the HONC and the validity of the autonomy concept as an indicator of dependence were evaluated in a prospective study.

RESULTS

Of the 679 subjects, 332 had used tobacco, and 145 had progressed to monthly smoking. Throughout each section of the “Results,” data will be presented first for the population of all tobacco users and then for the subpopulation of monthly smokers.

The Table shows the mean HONC scores for all tobacco users and monthly smokers broken down by sex and according to whether the subject had quit smoking or had continued smoking until his or her last interview. The mean HONC scores were significantly higher for subjects who had inhaled, for those who had progressed to monthly smoking, for girls, and for those who were still smoking at their last interview. The HONC symptoms were much more prevalent among the 237 sub-

Figure 1. The Hooked on Nicotine Checklist.

1. Have you ever tried to quit but couldn’t?
2. Do you smoke now because it is really hard to quit?
3. Have you ever felt like you were addicted to tobacco?
4. Do you ever have strong cravings to smoke?
5. Have you ever felt like you really needed a cigarette?
6. Is it hard to keep from smoking in places where you are not supposed to, like school?
7. Did you find it hard to concentrate because you couldn’t smoke?
8. Did you feel more irritable because you couldn’t smoke?
9. Did you feel a strong need or urge to smoke?
10. Did you feel nervous, restless, or anxious because you couldn’t smoke?
Among all subjects who had ever tried tobacco, subjects who had at any time responded positively to 1 of the 10 HONC items had an OR of 44 (95% CI, 17-114) for continuing to smoke until their last interview (P < .001; sensitivity, 93%; specificity, 76%). When adjusted for sex and the age at the first cigarette, the OR was 48 (95% CI, 18-126). Age of initiation and sex were not independent predictors of continued smoking. The endorsement of 1 or more HONC items accounted for 35% of the variance in predicting continued smoking.

Subjects reporting 1 or more HONC symptoms had an OR of 58 for having progressed to daily smoking by their last interview (95% CI, 24-142). The HONC symptoms preceded daily smoking in 70% of cases. Among 200 subjects with HONC scores of 0, only 3% had progressed to daily smoking, compared with 64% of 132 subjects with HONC scores greater than 0. None of the 200 subjects with HONC scores of 0 had progressed to smoking one half pack per day, compared with 40% of 132 subjects with HONC scores greater than 0 (P < .001; OR, incalculable).

Among all subjects who had tried smoking, those endorsing at least 1 of the HONC-9 items were 29 times more likely to report a failed attempt to quit than subjects with HONC-9 scores of 0 (95% CI, 13-65). When adjusted for sex and the age at the first cigarette, the OR remained significant at 30 (95% CI, 13-68). Sex and age of initiation were not independent predictors of a failed attempt to quit. The HONC-9 accounted for 34% of the variance predicting a failed attempt at cessation.

Among subjects who had progressed to monthly smoking, those endorsing 1 or more HONC symptoms had an OR of 11 for continued smoking until their last interview (95% CI, 3.2-40). When adjusted for sex and the age of the onset of monthly smoking, the OR remained significant at 12 (95% CI, 3.3-43). Age of onset and sex were not independent predictors of continued smoking. Among monthly smokers, those endorsing 1 or more of the HONC-9 symptoms had an OR of 5.1 (95% CI, 2.1-12.2) for a failed attempt to quit. Monthly smokers who had a failed attempt to quit had a mean (SD) of 5.7 (3.1) HONC symptoms in addition to the symptom of a failed attempt to quit, compared with a mean (SD)

CORRELATES OF THE HONC

Among all 332 tobacco users, the HONC score showed a Pearson correlation coefficient of 0.65 with the maximum amount smoked (P < .001), 0.79 for the maximum frequency of smoking (P < .001), 0.18 for duration of tobacco use (P < .05), and −0.11 for age at first use (P < .05). Among monthly smokers, correlations were 0.53 for maximum amount smoked (P < .001), 0.57 for maximum frequency of smoking (P < .001), 0.18 for duration of tobacco use (P < .05), and −0.10 for age at first use (P = .3).

Figure 2. Sex differences in the distribution of scores on the Hooked on Nicotine Checklist (HONC) among 332 adolescents who had ever used tobacco.

Figure 3. Sex differences in the distribution of scores on the Hooked on Nicotine Checklist (HONC) among 145 adolescents who had ever used tobacco monthly.
of 2.5 (2.7) HONC symptoms among monthly smokers who had not failed an attempt to quit (P<.001).

**FACTOR ANALYSIS**

The factor analysis included all 332 subjects who had used tobacco, revealing one domain that included all 10 items and explained 66% of the total variance. This factor had an eigenvalue of 6.6. All items had factor loadings of 0.70 or higher. The internal consistency analysis produced a Cronbach α of .94 for both the HONC and the HONC-9.

Some drugs of dependence produce tolerance, whereas others cause the reverse.39,40 Some have life-threatening withdrawal syndromes, whereas others have none.20 Some are intoxicating, whereas nicotine is not generally considered to be an intoxicating drug.20,33 The ability to cause a loss of autonomy is the common denominator among drugs of dependence.22 Our autonomy theory offers several advantages over other conceptualizations of dependence. The validity of any definition of dependence as a disease will be in doubt until the pathophysiological mechanism of dependence is better understood. In contrast, the loss of autonomy, as a philosophical concept, has face validity. It can be defined precisely without an understanding of the pathophysiological mechanism of dependence.

The autonomy theory proposes that the loss of autonomy marks the onset of dependence and defines the loss of autonomy as when the physiological or psychological sequelae of tobacco use present a barrier to quitting. If the loss of autonomy marks the onset of dependence, a measure of lost autonomy should be related to the subsequent course of tobacco use and the outcome of cessation attempts. To test the autonomy theory, a measure of lost autonomy, the HONC, was constructed from 3 competing mechanistic theories of addiction. As hypothesized, endorsement of a single item on the HONC was associated with marked increases in the likelihood of having a failed attempt at cessation (OR, 29), continuing to smoke until the end of follow-up (OR, 44), and established daily smoking (OR, 58).

The HONC was developed and tested on adolescents. Focus group testing demonstrated content validity, in that youths understand the HONC items in the same way adults do.54 The test-retest reliability of individual HONC items was high, ranging from 0.61 to 0.93.55 The test-retest reliability of the HONC as a whole was κ=0.61 (95% CI, 0.35-0.87).55 The high internal consistency of 0.94 measured in the current study agrees closely with that of 0.91 reported by O’Loughlin et al.55 Because each of the items listed in the HONC can be the first symptom to appear, the inclusion of all 10 items contributes to the measure’s ability to detect the onset of the loss of autonomy.16

Our data, and that reported by O’Loughlin et al,55 show a strong correlation between HONC scores and measures of tobacco use. In the current study, the HONC correlated with the maximum amount smoked (r=0.65) and the maximum frequency of smoking (r=0.78). The weak correlation with duration of smoking (r=0.18) was expected based on our previous report of wide individual variability in the latency to the onset of symptoms.10 Although the HONC correlates well with measures of cigarette use, we question the practice of validating instruments by using consumption as a measure of dependence.

The HONC is the only tool for diagnosing nicotine dependence that has been validated with outcome measures in adolescents. None of the FTQ-related measures has face validity as a measure of dependence, nor has any measure been validated for the purpose of establishing the presence or absence of dependence.5,9 The original FTQ has poor internal consistency (average Cronbach α=.51).22,23,30,31 The modified FTQ of Prokhorov et al12-14 for adolescents has adequate internal consistency (α=0.72) and good test-retest reliability (correlation of 0.71), but it was validated against the amount and duration of smoking, not against outcome measures, such as cessation. Correlations with the amount smoked were much lower for the modified FTQ (0.4) than those reported here for the HONC (0.65-0.78).32 Although this might be because of population selection, the superior performance of the HONC is surprising because the FTQ records the amount smoked, whereas the HONC does not.12

There is no “true rate” of dependence against which the validity of the DSM definition can be tested.30 The lack of standardized questionnaire items makes it impossible to assess the DSM definition for internal reliability, and its predictive value in adolescents has not been assessed.6 The prevalence of a DSM diagnosis in adolescent smokers has been determined, but there are no studies of the validity of the DSM or World Health Organization definitions in this population.18,23,30 Moreover, a DSM diagnosis did not correlate with cotinine levels in 18 year olds.23

Most of the evaluations of the FTQ and the DSM have been performed on homogeneous populations, such as adult daily smokers, heavy smokers, military recruits, or participants in cessation programs.5,12,28,57,58 The HONC was developed and tested with unselected, culturally diverse populations of adolescents.16,33 Additional strengths of the HONC include its derivation from addiction theory, its face validity, its reliability, its predictive properties, and the fact that it does not preclude the nature of dependence by placing prerequisites on the duration or frequency of smoking. The HONC has been more thoroughly evaluated with adolescents and performs better than any of the clinical definitions of dependence or FTQ-related measures.38,20

With craving being reported by 88% of youths who smoke regularly, the HONC criteria indicate that a very high proportion of young smokers have suffered a loss of autonomy.30 This is supported by data from 6 surveys that indicate that 71% to 83% of adolescent smokers had tried unsuccessfully to quit.17,14,19,36,41,59,60

The HONC may be useful to practicing clinicians as a self-administered office tool (Figure 1; complete copies are also available on the Web at http://www.umassmed.edu/fmch/research/publications/). It identifies youths for whom help and encouragement with cessation would be appropriate. As a self-assessment tool, the HONC might promote progression to a more advanced stage of change,
stimulating youths to attempt cessation earlier when success is more likely.1,6,10–13 The HONC could be used in mass media campaigns to educate youths to recognize the first signs of dependence. In research applications, a HONC score of 1 or higher would be more appropriate for defining the transition from “experimental” to “established” smoking than either “lifetime use of 100 cigarettes” or “daily smoking,” as these measures do not assess dependence. The HONC is being adopted as a measure of dependence and a predictor of relapse in ongoing smoking cessation trials. The performance of the HONC in adult populations should be evaluated, as it may provide a better basis than existing measures for a comparison of dependence between adults and adolescents.

Limitations of this study include the narrow age range of the subjects. As with any diagnostic test, the performance of the HONC will depend on the population studied, and different results might be obtained if the population were much older than the one studied here. We considered whether youths might have reported HONC symptoms because of performance expectations or sociocultural influences. Random false reporting is inconsistent with the observed reliability and internal consistency of the HONC, with its strong correlations with several measures of tobacco use and its predictive powers in terms of failed cessation and continued smoking until the end of follow-up.

In the current study, data were collected by an interviewer, but in the study by O’Loughlin et al,13 the HONC was self-administered. We are conducting additional research to evaluate the reliability and performance of the HONC as a self-administered survey. Additional research is needed to confirm the results of this study, especially in regard to sex differences. While our factor analysis produced a single-factor solution, O’Loughlin et al13 found a 2-factor solution with one factor representing the withdrawal symptoms included in the HONC and a second factor representing the remaining HONC items. Because the autonomy theory holds that the loss of autonomy can occur through multiple mechanisms, a multifactor solution is not inconsistent with the theory. Additional factor analyses will be performed with different populations to further explore this issue.

Youths’ expectations about dependence may be important. If youths believe they are invulnerable to dependence, it may cause them to initially deny their symptoms. On the other hand, Bandura’s concept of self-efficacy64 would predict that if youths expect to be dependent, this might hamper their ability to quit. Expectations, rather than representing a source of bias, might contribute to a loss of autonomy through a self-fulfilling and self-defeating process. We plan to conduct focus groups with smoking and nonsmoking youths to learn more about what their expectations might be.

The autonomy theory provides for the possibility that there may be multiple independent and overlapping mechanisms underlying the clinical syndrome of dependence. Our data suggest that the initial loss of autonomy occurs through physiological processes in some youths and through psychological processes in others.10 With time, many youths develop symptoms involving both mechanisms. In conclusion, the autonomy theory appears to be a useful new approach to evaluating nicotine dependence in adolescents. It provides an overarching function that integrates competing mechanistic theories of dependence into a unified theory.

What This Study Adds

A recent review concluded that there is no widely accepted, theoretically derived, and psychometrically sound research tool for evaluating tobacco dependence. This assessment is particularly true for the problem of identifying the onset of dependence in the pediatric population because all currently available measures were initially developed for adult smokers.

This article presents a new theory of dependence, the autonomy theory, which represents a marked departure from traditional thinking. The autonomy theory postulates that tobacco dependence begins when the sequelae of tobacco use, either psychological or physiological, present a barrier to quitting. The HONC represents the first validated, theory-derived tool for measuring tobacco dependence. The HONC is an easy-to-use measure that demonstrates psychometric properties superior to those of previously available measures.

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