



Published in final edited form as:

*Addiction*. 2014 September ; 109(9): 1518–1528. doi:10.1111/add.12619.

## Reciprocal Associations Between Cigarette Consumption and DSM-IV Nicotine Dependence Criteria in Adolescent Smokers

Mei-Chen Hu<sup>a</sup>, Pamela C. Griesler<sup>b</sup>, Melanie M. Wall<sup>a,b,c</sup>, and Denise B. Kandel<sup>a,b,d,\*</sup>

<sup>a</sup>Department of Psychiatry, Columbia University, New York, NY 10032, USA

<sup>b</sup>New York State Psychiatric Institute, New York, NY 10032, USA

<sup>c</sup>Department of Biostatistics, Mailman School of Public Health, Columbia University, New York, NY 10032, USA

<sup>d</sup>Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, New York, NY 10032, USA

### Abstract

**Aims**—To examine the interrelationships between cigarette consumption and DSM-IV nicotine dependence (ND) criteria from smoking onset in adolescence up to seven years later, adjusting for alcohol consumption and DSM-IV alcohol dependence (AD) criteria.

**Design**—A cohort drawn from grades 6-10 in an urban school system was interviewed five times at 6-month intervals (Waves 1-5) and 4.5 years later (Wave 6). A parent was interviewed three times.

**Setting**—Chicago, Illinois.

**Participants**—Recent smokers (n=409).

**Measurements**—Structured household interviews ascertained number of cigarettes smoked, DSM-IV ND symptoms, drinks consumed, DSM-IV AD symptoms, and selected covariates.

**Analysis**—Reciprocal prospective associations between number of cigarettes smoked and ND criteria, controlling for time-varying alcohol consumption and dependence criteria, were examined with cross-lagged models.

**Findings**—Reciprocal associations between number of cigarettes smoked and ND criteria were both significant. Cigarette consumption had stronger associations with later ND ( $\beta=0.25$ , 95% CI=0.17-0.32) than dependence had with later cigarette consumption ( $\beta=0.09$ , 95% CI=0.01-0.16). Alcohol and cigarette consumption influenced each other; AD scores were associated with later ND scores but not the reverse. Reports of pleasant initial experiences from smoking were positively associated with cigarette consumption and ND the first year after smoking onset; later

\*Corresponding author, 1051 Riverside Drive, Unit 20, New York, NY 10032, USA. Tel.: +1 212 304 7080; fax: +1 212 305 1933. dbk2@columbia.edu..

**Contributors** Denise B. Kandel and Mei-Chen Hu contributed to the study design and wrote the manuscript. Mei-Chen Hu undertook the statistical analysis. Pamela Griesler and Melanie Wall contributed to data analysis. All authors revised the manuscript and approved the final version for submission.

**Conflict of interest** No conflict declared.

smoking onset was negatively associated with cigarette consumption the seventh year after onset; parental ND predicted cigarette consumption and ND throughout.

**Conclusions**—In adolescent smokers, higher cigarette consumption predicts later severity of DSM-IV nicotine dependence more than the reverse. Smoking and drinking also influence each other mutually over time.

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## Introduction

The conceptualization of phenotypes reflecting problematic drug involvement has revolved around two definitions: extensiveness of use and substance use disorders. One focuses on behaviors, including the frequency with which a substance has been consumed and levels of intake. The other views drug addiction as a chronic brain disorder and assesses associated physiological, medical, psychological, and social problems<sup>[1]</sup>. Diagnostic criteria for substance use disorders are specified by the American Psychiatric Association. The recent DSM-5<sup>[2]</sup> version eliminates the prior distinction between abuse and dependence in DSM-IV<sup>[3]</sup>. This study, implemented before the DSM-5 publication, examines DSM-IV dependence.

While extensiveness of use and dependence are highly interrelated, there is not a one-to-one correspondence between these phenotypes. Thus, adolescents meet criteria for nicotine dependence (ND) at lower levels of cigarette consumption than adults, as do women compared with men<sup>[4]</sup>. The direction of influence between extensiveness of drug use and dependence remains mostly to be specified. Smoking provides a good test case in which to investigate this issue. Smoking can lead to ND through the action of nicotine on the brain. Dependence can cause more smoking because of tolerance, withdrawal and craving. Since 90% of adult smokers begin to smoke before age 20<sup>[5]</sup>, adolescence constitutes an optimal period in the lifecycle for studying the development of ND, its antecedents and consequences.

Most studies have examined the influence of one smoking phenotype upon the other but not reciprocal associations. Several longitudinal studies have established that number of cigarettes smoked leads to ND in adolescence<sup>[6-9]</sup>. Taking a more nuanced developmental approach, other studies have examined ND as a correlate of smoking trajectories. Over a two-year period, escalation in smoking level was associated with the highest level of ICD-10 ND<sup>[10]</sup>. Correlatively, we documented that heavy smoking predicted a chronic trajectory of DSM-IV ND symptoms<sup>[11]</sup>. However, in a 15-year follow-up of adolescents, smoking trajectory group membership did not differentially predict adult ND levels<sup>[12]</sup>. The reverse influence of dependence on extensiveness of smoking has rarely been investigated. In one study, the Nicotine Dependence Syndrome Scale (NDSS)<sup>[13]</sup> predicted daily smoking two years later among adolescent light smokers<sup>[14]</sup>; ND scores predicted number of days smoked, with the effect increasing over 48 months<sup>[15]</sup>.

Only Doubeni et al.<sup>[16]</sup> estimated the lagged reciprocal associations between number of cigarettes smoked and ND (Hooked on Nicotine Checklist, HONC) among 6<sup>th</sup> graders assessed seven times over 2½ years<sup>[17]</sup>. Number of cigarettes predicted number of dependence symptoms in the first three waves after smoking onset; dependence symptoms at

waves 2 to 4 predicted number of cigarettes smoked at each successive wave. Thereafter, neither factor influenced the other. The authors suggested that craving and withdrawal symptoms drive smoking, as per the sensitization-homeostasis theory of substance dependence<sup>[18]</sup>. Recently, Dierker et al.<sup>[19]</sup> documented that alcohol-related problems predicted smoking frequency 48 months later through ND symptoms at 6-24 months.

Integrating findings across studies is difficult because of differences in samples, participants' ages, smoking phenotypes and analytical strategies. Thus, Selya et al.<sup>[15]</sup> classified 15.7 years old youths into three smoking groups according to initial lifetime consumption levels and recency of smoking and estimated mixed-effects regression models on wave-specific contemporaneous correlations between dependence and smoking days. Doubeni et al.<sup>[16]</sup> estimated a cross-lagged model in a cohort aged 12 as of first cigarette puff. Each study examined different time points in adolescents' smoking histories.

The present investigation focuses on changes in smoking histories as of smoking onset. We investigate the reciprocal relationships between cigarette consumption and number of DSM-IV ND criteria over time among recent adolescent smokers followed for seven years from mean age 14.2 (SD=1.4) to age 21.2 (SD=1.4), adjusting for alcohol consumption and alcohol dependence (AD) criteria. Selected other risk factors were considered: pleasant initial sensitivity to tobacco, age of smoking onset, parental smoking and ND, sex, race/ethnicity<sup>[6,20-28]</sup>. The relative importance of these factors at different periods following smoking onset was examined.

## Methods

### Sample

Analyses were based on six waves of interviews with a multi-ethnic cohort of 6<sup>th</sup>-10<sup>th</sup> graders from the Chicago Public Schools (CPS), and three waves with one parent. A two-stage design was implemented to select the follow-up sample. In Phase I (1/03-5/03), 15,763 students from 43 schools were surveyed (completion rate 83.1%). The sample was designed to provide approximately equal numbers of non-Hispanic whites, non-Hispanic African-Americans, and Hispanics. The target sample of 1,236 youths included 1,106 tobacco users reporting having initiated use within 12 months of the school survey, and 130 non-tobacco users susceptible of starting to smoke<sup>[29]</sup>, included so as not to divulge to parents that the study focused on smokers. All whites and African-Americans who started using tobacco 0-12 months earlier, and Hispanics who started 0-6 months earlier were selected; 25% of Hispanics who started 7-12 months earlier were sampled because of the larger number of Hispanics than other racial/ethnic groups in the CPS.

In Phase II (2/03-10/05), on average 9 weeks after each school survey, 1,039 (84.1%) of 1,236 youths and one parent were interviewed at wave 1 (W1). Three annual computerized household interviews (W1, W3, W5) were conducted with youths and parents (87% biological mother, 5% biological father, 8% other parental figure), and two short bi-annual interviews (W2, W4) with youths six months after W1 and W3. Average interval between waves was 6.0-6.3 months, range=3-10. W2-W5 completion rates were 96% of W1. In Phase III (11/09-8/10), 4.5 years after W5, 934 (90.6%) of 1,031 W1 respondents were re-

interviewed (W6). The field work was conducted by the National Opinion Research Center (NORC).

The analytical sample included 409 lifetime cigarette smokers, identified at W1 as having started to smoke (even if only one or two puffs) within 12 months, or between W1 and W5, based on specific onset dates. Discrepancies between school and W1 household smoking reports resulted in the exclusion of two groups from those reporting ever smoking in the school survey (N=832): at W1, 189 stated having never smoked; 348 specified an onset before the prior 12 months (55% of 643 W1 self-acknowledged smokers). At W1, those denying having smoked had reported in school lighter use than those admitting use. Those reclassified as starting to smoke more than 12 months before W1 reported in school heavier use than those still classified as starting within the prior 12 months<sup>[20]</sup>.

**Human subjects procedures**—Passive parental consent was obtained for the school surveys, active consent for household interviews; adolescent assent or consent was obtained. Procedures were approved by Institutional Review Boards of the New York State Psychiatric Institute/Columbia University, and NORC.

## Measurement

### Time-varying variables

**Observation period:** A detailed monthly drug history ascertained number of cigarettes smoked and DSM-IV ND criteria, but no other drug, for five intervals (12 months preceding W1, six months preceding W2 to W5). Cigarette consumption and ND for the prior 12 months were ascertained at W6. Time-varying variables were defined for seven time periods after smoking onset: 6 consecutive six-month intervals (1-6, ..., 31-36 months) and the 12-month interval 3.5 years later (79-90 months). Depending on the timing of smoking onset, periods of observation could cover 60-90 months. Alcohol phenotypes were ascertained for the last 12 months preceding W1, W3, W5, W6.

**Cigarette consumption:** Product of number of days smoked per month (frequency) and cigarettes per day on days smoked (quantity), recoded to mid-point values, transformed into logarithms and standardized across the sample. *Frequency:* 0 days=0; 1-2 days=1.5; 3-5 days=4; 6-9 days=7.5; 10-19 days=15; 20-29 days=25; 30 days=30. *Quantity:* one or two puffs=0.5; 1=1; 2-5=3; 6-15=10; 16-25=20; 26-35=30; 35=40 cigarettes. Variables indexed the highest monthly frequency/quantity of cigarettes smoked during each interval at W1-W5, and the most recent month smoked the prior 12 months at W6.

**Nicotine dependence criteria:** Measured per DSM-IV<sup>[3]</sup>, with an instrument for adolescents and young adults<sup>[7]</sup>. The 11-item scale defines the seven DSM-IV dependence criteria: tolerance, withdrawal, impaired control, unsuccessful quit attempts, time spent using tobacco, neglect important activities, use despite physical or psychological problems. The scale has high internal reliability ( $\alpha=.85$ )<sup>[20,30]</sup>, and concurrent and predictive validity<sup>[31]</sup>. The number of unique ND criteria experienced in each interval was treated as a continuous variable and standardized across the sample. The DSM-IV ND measure was selected because it does not include number of cigarettes smoked.

**Alcohol consumption:** Product of number of days drank the most recent month at each assessment (frequency) and drinks per day on days drank (quantity), recoded to mid-point values, transformed into logarithms and standardized across the sample. *Frequency:* 0 days=0; 1-2 days=1.5; 3-5 days=4; 6-9 days=7.5; 10-19 days=15; 20-29 days=25; 30 days=30. *Quantity:* less than 1 drink=0.5; 1=1...5=5; 6-8=7; 9-11=10; 12=12 drinks. Timed in relationship to smoking onset.

**Alcohol dependence criteria:** Same criteria as for ND covered the prior 12 months at W1,W3,W5,W6. The measure was treated as a continuous variable standardized across the sample. Timed in relationship to smoking onset.

### Time-constant variables

**Onset age of smoking:** Month/year first smoked, even a puff, minus birth date. Ages 14-18 versus 10-13.

**Pleasant initial sensitivity to tobacco<sup>[32]</sup>:** Average score of four items: pleasant sensations, relaxation, pleasurable dizziness, pleasurable rush or buzz experienced upon first tobacco use ( $\alpha=.77$ ), coded 4=intense experience to 1=none.

**Parental lifetime smoking and DSM-IV ND (same measure as for youth):** Self-reported by interviewed parent at W1, W3 or W5. Full dependence defined as 3+ criteria within a 12-month period. A trichotomous variable was defined: never smoked; ever smoked, never dependent; lifetime ND.

**Race/ethnicity:** non-Hispanic white; non-Hispanic African-American; Hispanic.

**Sex:** male; female.

**Statistical analysis:** The reciprocal associations between cigarette consumption and ND criteria from smoking onset up to 90 months later were estimated in two autoregressive cross-lagged models among recent smokers using Mplus 7.11<sup>[33]</sup>. Model 1 included cross-lagged effects of alcohol consumption on cigarette consumption and ND; Model 2 cross-lagged effects of AD on smoking and ND. Five time-constant covariates were entered as predictors of the two smoking phenotypes across time. Sex and race/ethnicity predicted the alcohol phenotypes. Zero values for the time-varying outcomes included youths who did not smoke or drink in a particular period. A model in which all parameters were freely estimated was fitted first. Nested models then tested equality constraints of (1) autoregressive parameters, (2) cross-lagged parameters, and (3) effects of covariates on cigarette consumption, ND, and each alcohol variable across six time points using chi-square tests<sup>[34]</sup>. Model fit was determined by the Bayesian information criterion (BIC), comparative fit index (CFI), and root-mean-square error of approximation (RMSEA). A smaller BIC, CFI .90 or larger, and RMSEA smaller than .08 provide an acceptable fit<sup>[35]</sup>. Because of the number of parameters to be estimated and sample size, both alcohol phenotypes could not be entered in the models simultaneously. The 31-36 months period after smoking onset was excluded to enable convergence of the model.

To handle missingness on outcomes, the full information maximum likelihood method in Mplus assuming missing-at-random was used. A sandwich estimator accounted for the cluster sampling of schools. Sample weights corrected for undersampling of Hispanics, who started using tobacco 7-12 months before the school survey, and the higher nonresponse rates at W1 of youths reporting in the school survey having smoked the last year and being heavy smokers<sup>[20,36]</sup>.

## Results

### Analytical sample

Of the 409 youths, 35.9% were white, 23.5% African-American, 40.6% Hispanic; 56.6% were female. 189 youths started smoking within 7-12 months before W1, 149 1-6 months before W1, 28 at W2, 18 at W3, 14 at W4, 11 at W5. Because monthly data were not collected after W5, individuals had structurally missing data for months 31-36 (started 1-6 months before W1) to 7-36 months after onset (started at W5). Seventeen percent started smoking before age 13; 23% at 13; 30% at 14; 30% at age 15 or older. Only 47 youths were not re-interviewed at W6. Baseline covariates were not significantly different between the re-interviewed and not re-interviewed (Table 1).

### Patterns of smoking and ND

Smoking patterns over time were characterized by many changes (Table 2). Only 20% of adolescents smoked continuously for up to seven years after onset; the majority stopped smoking at some time. Only 37.1% continued to smoke after the first six months (Table 2, column a); 22.7% never smoked again (data not presented). Fifty percent of smokers had multiple nonsmoking and smoking periods (Table 2, columns b,e). The percentages who stopped and resumed increased each year, reaching 39.6% in the seventh year. Of those who smoked the seventh year, 66.2% [=39.6%/(39.6%+20.2%)] had previously stopped smoking for at least one 6-month period. By the seventh year after onset, 59.8% were currently smoking.

Number of cigarettes smoked and ND criteria increased over time and differed by quitting history (Table 3). Mean number of cigarettes smoked monthly increased from 22.6 during the first six months following onset to 127.5 seven years later; mean number of DSM-IV ND criteria increased from 0.6 to 2.0 (Panel 1). In any period, those who resumed smoking had smoked fewer cigarettes than persistent smokers (Panel 2). Similarly, those who stopped smoking had previously reported smoking fewer cigarettes and experiencing fewer ND symptoms than those who continued smoking (Panel 3). For instance, in months 13-18, the mean number of cigarettes smoked monthly was 91.4 (SD=128.5) among those who would continue to smoke versus 18.2 (SD=59.7) among those who would stop smoking the next period; the mean number of ND criteria was 1.7 (SD=1.7) versus 1.0 (SD=1.5).

### Reciprocal relationships between cigarette consumption and ND over time

Models included time-varying alcohol measures – number of drinks in Model 1, number of AD criteria in Model 2. The best-fitting models included equality constraints for autoregressive effects of ND and AD criteria; the cross-lagged effects of the two smoking



phenotypes and of each alcohol phenotype on the two smoking phenotypes; effects of sex, race/ethnicity, parental ND on cigarette consumption and ND; age at smoking onset on ND; sex on AD; race/ethnicity on alcohol use and AD. Coefficients for Model 1 appear in Figure 1 and Table 4, for Model 2 in Figure 2 and Table 4. Appendix Table S1 presents the correlations. Model fit indicators for Model 1 were:

CFI=0.93, RMSEA=0.05, BIC=10866.79; for Model 2:

CFI=0.81, RMSEA=0.09, BIC=11584.87.

Autoregressive associations between levels of smoking and drinking between two successive periods within three years after onset were significantly higher ( $\beta=0.62-0.70$ ;  $0.77-0.91$ ) than those between the third and seventh years ( $\beta=0.47$ ;  $0.33$ ) ( $p<.0001$ ). This probably results from the 4.5-year lag in measurement between W5 and W6. Reciprocal associations between cigarette consumption and ND criteria were both significant, although the effect of number of cigarettes smoked on number of dependence criteria was significantly stronger than the reverse ( $t=2.64$ ,  $p<.01$ ). A one-standard deviation ( $=2.43$ ) increase in (logarithmic) number of cigarettes smoked led to a 0.25 standard deviation ( $=1.72$ ) increase in number of dependence criteria, controlling for other variables. Specifically, an increase of 20 cigarettes/month was associated with an increase of 0.53 dependence criteria [ $0.25 \times (\log(20)/2.43) \times 1.72$ ]. By contrast, a one-standard deviation increase in number of dependence criteria led only to a 0.09 standard deviation increase in (logarithmic) number of cigarettes smoked. An increase of one ND criterion was associated with a 14.0% increase in number of cigarettes smoked per month [ $\exp(0.09/1.72 \times 2.43) - 1$ ]. Number of drinks and cigarettes smoked had significant bi-directional effects equal in magnitude; amount drunk did not predict ND. Alcohol dependence predicted ND, but not levels of smoking. ND did not predict either alcohol phenotype. However, the reciprocal paths between AD and ND were not statistically different (Path ND to AD:  $\beta=0.05$ , 95% CI =  $-0.01-0.12$ ,  $p=.11$ ).

Youths with higher levels of pleasant initial sensitivity at first tobacco use consumed more cigarettes and experienced higher numbers of ND criteria the first twelve months after smoking onset than those with lower levels (Table 4). Age at smoking onset predicted only cigarette consumption and differentially at different intervals after onset. Compared with onset below age 14, later onset age predicted a higher number of cigarettes smoked at months 25-30 but a lower number 79-90 months after onset. At all periods, adolescents with a nicotine dependent parent smoked more extensively and experienced higher levels of ND criteria than adolescents whose parent never smoked. Females smoked less than males, as did Hispanics compared with whites and African-Americans. Males drank more than females months 25-30 ( $\beta=0.17$ , 95% CI =  $0.04-0.29$ ,  $p<.05$ ) and 79-90 ( $\beta=0.57$ , 95% CI =  $0.38-0.76$ ,  $p<.001$ ); whites drank more than African-Americans at all periods ( $\beta=0.10$ , 95% CI =  $0.05-0.16$ ,  $p<.001$ ). Controlling for other covariates, sex and race/ethnicity did not predict either ND or AD.

## Discussion

For the majority of adolescents, smoking was intermittent. One-fifth of smokers smoked continuously for at least five years after smoking onset; most stopped smoking for at least

one 6-month period during the first three years after onset. Half these youths smoked again at least once within the next five years.

There were reciprocal and invariant associations over time between cigarette consumption and DSM-IV ND criteria. However, smoking level had a stronger effect on subsequent dependence than dependence had on smoking level. At all periods after onset, youths who smoked heavily subsequently experienced higher levels of ND than lighter smokers. A reduction in number of cigarettes smoked decreased ND level. By contrast, Doubeni et al.<sup>[16]</sup> concluded that number of cigarettes smoked influenced levels of HONC dependence only in the first 12 months after smoking onset, while the influence of ND on smoking level emerged later; no association between either phenotype was observed at months 21 to 28. However, the statistical significance of differences in the reciprocal effects of smoking levels and dependence at various intervals following smoking onset was not tested. Having tested for equality constraints in this study, we found no significant differences over time. Different findings between the two studies may also result from the use of different dependence measures (HONC, DSM-IV).

Smoking and alcohol had similar reciprocal associations with each other. The finding that AD increased ND but not levels of smoking is consistent with Dierker et al. (2013)<sup>[19]</sup>, who found that alcohol problems predicted smoking frequency four years later through ND symptoms. This consistency is notable in view of differences between the two studies in analytical strategy (path analysis versus cross-lagged models) and measurement (alcohol problems versus DSM-IV AD, NDSS versus DSM-IV ND).

To the extent that parental ND, sex and race/ethnicity predicted cigarette consumption or dependence, these effects were constant over time. By contrast, the positive effects of pleasant experiences at initial tobacco use on both smoking phenotypes occurred only in the first 12 months after onset. Similarly, age of smoking onset had different consequences at different ages and different intervals after onset. At 2½ years after onset, late onset was associated with higher levels of smoking. But by the end of the observation period (seven years after onset), older onset age of smoking was associated with lower smoking levels. Reduced access to cigarettes may contribute to the slower progression of consumption among youths who initiate smoking early. These youths may have to obtain cigarettes from parents, while youths who begin smoking at age 14 or older probably have greater access to cigarettes from peers. Late smoking onset appears to be associated with shorter latency but with progression to lower levels of smoking than early onset. Thus, results from several studies converge in documenting that youths who start smoking or using other drugs at an early age are more likely ultimately to become dependent or daily users, although they take longer to do so than those who initiate drug use at an older age<sup>[37-40]</sup>. In the last decade, 14-15 appear to be the ages at which the developmental patterns reverse and the lifetime risk of problematic drug use declines<sup>[37-39]</sup>. With recent secular trends exhibiting later ages of smoking onset, it remains to be seen whether later onset age of smoking will continue to be protective. Additional longitudinal research with young adults may address this question.

Limitations of the study need to be highlighted. Since the sample excluded smokers who started smoking more than one year prior to Wave 1 (at average age 12.2, SD=1.8), the



current findings may not apply to youths with an earlier age of smoking onset than those we studied. Because of small sample size, several important factors related to smoking and ND, e.g., peer smoking, depression, conduct disorder, were not controlled. Reflecting the standard psychiatric definition available when the study was implemented, dependence was measured as per DSM-IV. The DSM definition of ND has limitations, especially as a diagnostic tool that requires that a specified number of criteria have been experienced<sup>[41]</sup>. However, the use of ND criteria for research purposes to assess ND severity is accepted as a valid strategy, among adolescents and adults<sup>[41-44]</sup>.

The study suggests that, among adolescents, interventions that reduce cigarette consumption will have a greater impact in reducing ND than interventions targeted toward ND will have in reducing smoking, although both phenotypes need to be targeted. Cognitive-behavioral and social influence approaches are efficacious strategies for reducing cigarette consumption among adolescents<sup>[45]</sup>. Complementary approaches that alleviate ND withdrawal symptoms, such as nicotine-replacement or other pharmacological therapies, may help youths remain abstinent, although the efficacy of these interventions has not been established among adolescents<sup>[46]</sup>. Parental smoking cessation, delaying smoking onset, reducing drinking, and raising adolescents' awareness of the physiological reactions to tobacco that increase risk for chronic smoking and ND<sup>[16]</sup> may be additional important prevention and intervention targets. Adolescent tobacco use is to be addressed in a broader context which takes into account that smoking and drinking reinforce each other.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

**Role of funding source** This research was partially supported by DA12697, DA026305 and K-5 DA0081 from the National Institute on Drug Abuse; and ALFCU51672301 and ALF6814 from Legacy to Denise Kandel.

We wish to thank the reviewers for their comments, and, in particular, the suggestion to include alcohol phenotypes in the models.

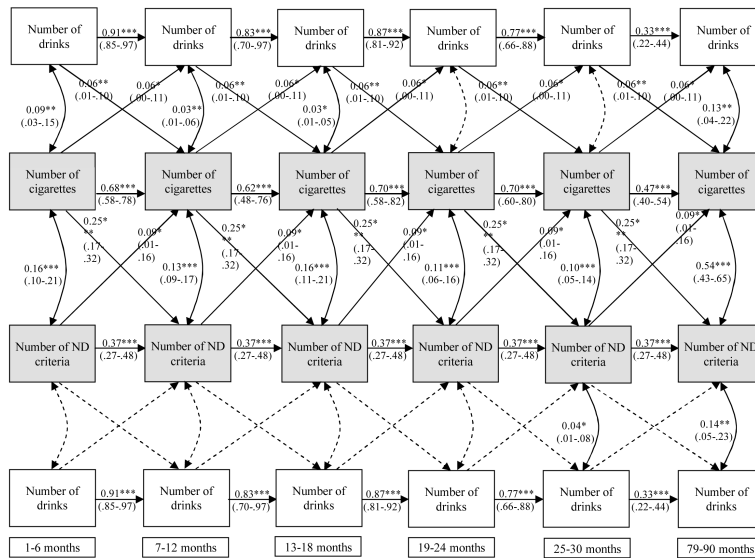
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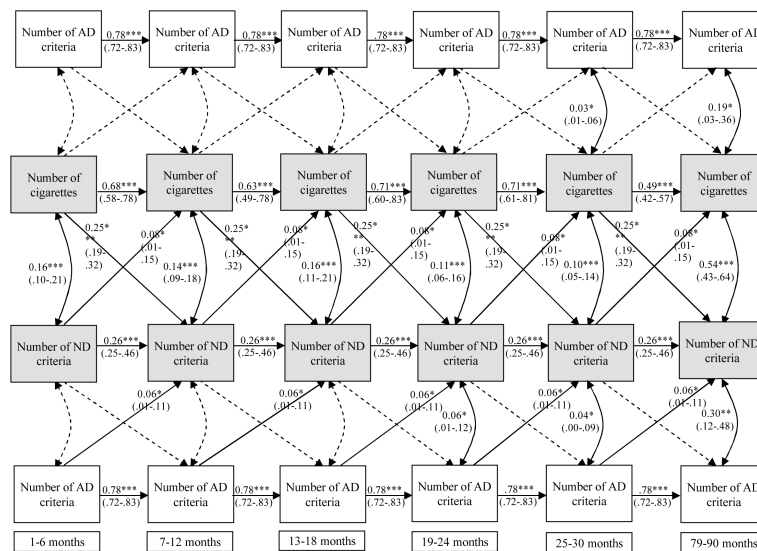


**Figure 1.** Autoregressive cross-lagged model of cigarette consumption, DSM-IV nicotine dependence (ND) criteria and alcohol consumption over a seven-year period after smoking onset (N=409)

**Note.** Model controls for five time-constant variables (sex, race/ethnicity, onset age of smoking, pleasant initial sensitivity to tobacco, parent smoking/nicotine dependence) on the two smoking phenotypes and two time-constant variables (sex, race/ethnicity) on the alcohol phenotype. The alcohol phenotype was included as a time-varying cross-lagged bi-directional predictor of the two smoking phenotypes simultaneously and is presented twice in the figure to avoid cluttering of arrows. Unstandardized coefficients and 95% confidence intervals are shown. Dotted paths are not significant.

N free parameters = 108; Log likelihood = -5108.65; BIC = 10866.79; CFI = 0.93; RMSEA = 0.05

\*p<.05; \*\*p<.01; \*\*\*p<.001



**Figure 2.**

Autoregressive cross-lagged model of cigarette consumption, DSM-IV nicotine dependence (ND) criteria and alcohol dependence (AD) criteria over a seven-year period after smoking onset (N=409)

**Note.** Model controls for five time-constant variables (sex race/ethnicity, onset age of smoking, pleasant initial sensitivity to tobacco, parent smoking/nicotine dependence) on the two smoking phenotypes and two time-constant variables (sex, race/ethnicity) on the alcohol phenotype. The alcohol phenotype was included as a time-varying cross-lagged bi-directional predictor of the two smoking phenotypes simultaneously and is presented twice in the figure to avoid cluttering of arrows. Unstandardized coefficients and 95% confidence intervals are shown. Dotted paths are not significant.

N free parameters = 99; Log likelihood = -5494.76; BIC = 11584.87; CFI = 0.81; RMSEA = 0.09

\* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$



**Table 1**

Distribution of respondents' characteristics at baseline (W1) or onset of smoking (N=409)

<b>Characteristics</b>	<b>Total Sample (N=409) Mean (SD), %</b>	<b>Re-interviewed at W6 (N=362) Mean (SD), %</b>	<b>Not Re-interviewed at W6 (N=47) Mean (SD), %</b>
Pleasant initial sensitivity	1.42 (0.59)	1.44 (0.59)	1.30 (0.53)
Onset age of smoking 14	59.5%	58.6%	66.0%
Parental nicotine dependence			
Never smoked	26.4%	27.1%	21.4%
Smoked, not dependent	44.1%	44.8%	38.6%
Dependent	29.5%	28.1%	40.0%
Female	56.6%	56.8%	55.2%
Race/ethnicity			
White	35.9%	36.0%	35.4%
African-American	23.5%	24.1%	18.9%
Hispanic	40.6%	39.9%	45.7%

Table 2

Current smoking status and smoking history at successive monthly periods after smoking onset (N=409)

Number of months after smoking onset	Current Smoker			Current Nonsmoker			Total %	Total N
	(a) Never stopped %	(b) Stopped, resumed %	(c) Stopped in current period %	(d) Stopped did not resume %	(e) Stopped/resumed/ stopped in current period %			
1-6 months	100.0	--	--	--	--	--	100.0	(409)
7-12 months	37.1	--	62.9	--	--	--	100.0	(391)
13-18 months	26.0	13.3	12.0	48.7	--	--	100.0	(375)
19-24 months	21.6	18.3	4.2	49.9	6.0	6.0	100.0	(353)
25-30 months	18.4	22.6	2.2	46.9	9.9	9.9	100.0	(322)
31-36 months	12.7	23.3	4.3	44.1	15.6	15.6	100.0	(189)
79-90 months	20.2	39.6	3.3	26.4	10.5	10.5	100.0	(362)

Table 3

Distributions of number of cigarettes smoked and DSM-IV nicotine dependence criteria by number of months after smoking onset among all current smokers and by prior and subsequent smoking status (N=409)

Number of months after smoking onset	1. All current smokers			2. Smokers by smoking in prior period			3. Smokers by smoking in next period							
	Mean	SD	N	Mean	SD	N	Smoked	Had stopped	Continued to smoke	Stopped smoking	Mean	SD	N	
Maximum monthly cigarettes smoked in each period														
1-6 months	22.6	87.3	(398)	---	---	---	---	---	56.9	140.3	(136)	3.1	17.3	(244)***
7-12 months	70.7	168.6	(139)	70.7	168.6	(139)	---	---	75.0	124.0	(94)	36.6	197.1	(39)
13-18 months	69.3	117.0	(144)	90.6	126.5	(97)	77.3	(47)***	91.4	128.5	(97)	18.2	59.7	(36)***
19-24 months	84.7	185.7	(140)	127.3	234.7	(74)	34.4	81.9	97.6	201.2	(94)	35.4	75.1	(30)***
25-30 months	85.1	171.4	(127)	144.7	225.7	(57)	36.5	78.0	103.2	162.4	(50)	14.9	36.3	(22)***
31-36 months	85.1	165.4	(67)	190.5	234.8	(23)	27.6	56.7	95.3	170.2	(43)	65.4	161.5	(23)
79-90 months	127.5	225.7	(213)	183.2	295.8	(69)	99.1	177.8	---	---	---	---	---	---
DSM-IV dependence criteria in each period														
1-6 months	0.6	1.3	(409)	---	---	---	---	---	1.3	1.7	(139)	0.2	1.8	(245)***
7-12 months	1.5	1.7	(139)	1.5	1.7	(139)	---	---	1.8	1.6	(94)	0.8	1.5	(39)***
13-18 months	1.5	1.6	(143)	1.7	1.6	(97)	1.2	1.6	1.7	1.7	(96)	1.0	1.5	(36)*
19-24 months	1.5	1.7	(135)	1.8	1.7	(71)	1.3	1.6	1.6	1.7	(92)	1.2	1.3	(29)
25-30 months	1.3	1.6	(127)	1.5	1.5	(57)	1.1	1.7	1.6	1.7	(50)	0.9	1.0	(22)*
31-36 months	1.1	1.5	(63)	1.3	1.9	(20)	1.0	1.4	1.2	1.7	(40)	1.0	1.4	(22)
79-90 months	2.0	1.9	(213)	2.2	2.0	(69)	1.9	1.9	---	---	---	---	---	---

\* p&lt;.05,

\*\* p&lt;.01,

\*\*\* p&lt;.001.

Difference between (a) &amp; (b) or (c) &amp; (d).

Table 4

Coefficients for time-constant covariates in multiple regressions predicting cigarette consumption and DSM-IV nicotine dependence criteria at different monthly periods after smoking onset (N=409)

Predictors	Number of months after smoking onset					
	1-6 β (95% CI)	7-12 β (95% CI)	13-18 β (95% CI)	19-24 β (95% CI)	25-30 β (95% CI)	79-90 β (95% CI)
<b>Model 1 – Includes alcohol consumption</b>						
<b>Maximum number of cigarettes smoked monthly in the interval <sup>a</sup></b>						
Pleasant initial sensitivity	.44 (.28, .60) ***	.16 (.07, .24) ***	.06(-.10, .22)	-.05(-.14, .05)	.07(-.03, .17)	.07(-.09, .22)
Onset age of smoking	.01(-.08, .11)	.04(-.04, .13)	.00(-.10, .11)	.00(-.10, .10)	.11(-.01, .22)	-.22(-.35, -.09) **
Parental nicotine dependence (vs. never smoked)						
Smoked, not dependent	.00(-.06, .07)	.00(-.06, .07)	.00(-.06, .07)	.00(-.06, .07)	.00(-.06, .07)	.00(-.06, .07)
Dependent	.09(.03, .15) ***	.09(.03, .15) **	.09(.03, .15) **	.09(.03, .15) **	.09(.03, .15) **	.09(.03, .15) **
Female	-.08(-.13, -.03) **	-.08(-.13, -.03) **	-.08(-.13, -.03) **	-.08(-.13, -.03) **	-.08(-.13, -.03) **	-.08(-.13, -.03) **
Race/ethnicity (vs. white)						
African-American	-.03(-.09, .03)	-.03(-.09, .03)	-.03(-.09, .03)	-.03(-.09, .03)	-.03(-.09, .03)	-.03(-.09, .03)
Hispanic	-.11(-.16, -.05) ***	-.11(-.16, -.05) ***	-.11(-.16, -.05) ***	-.11(-.16, -.05) ***	-.11(-.16, -.05) ***	-.11(-.16, -.05) ***
<b>Number of DSM-IV nicotine dependence criteria in the interval <sup>a</sup></b>						
Pleasant initial sensitivity	.52(.31, .74) ***	.15(-.02, .31)	-.03(-.21, .16)	-.07(-.17, .03)	.04(-.06, .13)	.08(-.11, .27)
Onset age of smoking	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)
Parental nicotine dependence (vs. never smoked)						
Smoked, not dependent	.03(-.05, .11)	.03(-.05, .11)	.03(-.05, .11)	.03(-.05, .11)	.03(-.05, .11)	.03(-.05, .11)
Dependent	.09(.03, .15) **	.09(.03, .15) **	.09(.03, .15) **	.09(.03, .15) **	.09(.03, .15) **	.09(.03, .15) **
Female	.01(-.05, .06)	.01(-.05, .06)	.01(-.05, .06)	.01(-.05, .06)	.01(-.05, .06)	.01(-.05, .06)
Race/ethnicity (vs. white)						
African-American	.01(-.06, .07)	.01(-.06, .07)	.01(-.06, .07)	.01(-.06, .07)	.01(-.06, .07)	.01(-.06, .07)
Hispanic	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)	-.03(-.11, .05)
<b>Model 2 – Includes number of alcohol dependence criteria</b>						
<b>Maximum number of cigarettes smoked monthly in the interval <sup>a</sup></b>						

Predictors	Number of months after smoking onset					
	1-6 $\beta$ (95% CI)	7-12 $\beta$ (95% CI)	13-18 $\beta$ (95% CI)	19-24 $\beta$ (95% CI)	25-30 $\beta$ (95% CI)	79-90 $\beta$ (95% CI)
Onset age of smoking	14 .08 (-.01, .17)	.07(-.03, .16)	.02(-.08, .13)	.01(-.09, .12)	.12 (.01, .24)*	-.21(-.34, -.08)**

Note. Coefficients for time-varying covariates appear in Figures 1 and 2. All coefficients, except for onset age of smoking, were almost identical in both models. Only the coefficients for smoking onset age are shown for Model 2.

<sup>a</sup>The prior 6 months for months 1-6 to 25-30 after smoking onset; the prior 12 months for months 79-90.

\* p<.05,

\*\* p<.01,

\*\*\* p<.001