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Repeated measures latent class analysis of daily smoking in three smoking cessation studies

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ABSTRACT

Background: Person-centered approaches to the study of behavior change, such as repeated measures latent class analysis (RMLCA), can be used to identify patterns of change and link these to later behavior change outcomes.
Methods: Daily smoking status data from three smoking cessation studies (N = 287, N = 334, and N = 403) were submitted to RMLCA to identify latent classes of smokers based on patterns of abstinence across the first 27 days of a quit attempt. Three-month biochemically verified abstinence rates were compared among latent classes with particular patterns of smoking across days. Pharmacotherapy variables and baseline individual differences were added as covariates of latent class membership.
Results: Results of separate and pooled analyses supported a five-class solution that replicated across studies. Latent classes included a large class that achieved immediate stable abstinence, a smaller class of cessation failures, and three classes with partial abstinence that increased, decreased, or remained stable over time. Three-month point-prevalence abstinence rates varied among the latent classes, with 38–55% abstinent among early quitters, 3–20% abstinent among those who smoked intermittently throughout the first 27 days, and fewer than 5% abstinent in the classes marked by little or delayed change in smoking. High-dose nicotine patch and bupropion promoted membership in abstinent classes. Demographics, nicotine dependence, and craving were related to latent class in multiple studies and pooled analyses.
Conclusions: We identified five patterns of smoking behavior in the first weeks of a smoking cessation attempt. These patterns are robust across multiple studies and are related to later point-prevalence abstinence rates.

1. Introduction

1.1. Person-centered approaches to the study of relapse

As with many drugs of abuse, relapse remains the most common outcome of attempts to quit smoking (Fiore et al., 2008). Success in quitting is typically measured in binary terms and at discrete time-points (Hughes et al., 2003). This approach is useful in assessing the health impact of smoking cessation treatments, but masks the pathways by which individuals change. Person-centered analysis of abstinence in the first weeks of quitting may reveal meaningful heterogeneity in responses to treatment and aid in identifying risk and protective factors associated with different paths to abstinence or relapse to smoking.

1.2. Modeling change

Relapse has long been recognized as a nonlinear process (Brandon et al., 2007; Shiffman, 1989) requiring nonlinear analytical approaches. In a recent effort to describe patterns of abstinence during a smoking cessation attempt, a repeated measures latent class analysis (RMLCA) of daily smoking in 1433 adult smokers from a trial of five active pharmacotherapies and placebo medication (Piper et al., 2009) yielded five latent classes (McCarthy et al., 2015). The most common patterns were stable success or failure in quitting. Less common patterns indicated unstable patterns of

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behavior during the first 27-days post-quit, with some establishing initially high probabilities of abstinence and then relapsing, others reducing the frequency of smoking early in the quit attempt, and others reporting initial smoking but then markedly increasing abstinence. The latent classes differed in six-month abstinence rates, suggesting that monitoring early smoking patterns may help identify individuals at high risk of longer-term smoking.

1.2.1. Treatment effects on change processes. Modeling change patterns may facilitate treatment evaluation and refinement. Comparing treatments based on their ability to promote early change patterns may tell us more than will the evaluation of distal outcomes. This process approach may also suggest ways to identify individuals who do not initially respond to treatment and who may benefit from adaptive interventions (Rose and Behm, 2014).

1.2.1. Risk and protective factors. Although most smokers who attempt to quit smoking will ultimately relapse, this homogeneity of the distal outcome (relapse) masks considerable heterogeneity of the smoking relapse process (McCarthy et al., 2006). Identifying stable risk and protective factors associated with particular change processes may foster development of treatment-matching protocols to boost cessation success (Witkiewitz et al., 2010). An RMLCA (McCarthy et al., 2015) showed that latent classes of smokers differed in nicotine dependence, smoking history, initial quitting confidence, sleep problems, and ethnic identification. It is important to replicate such findings to identify candidate variables for inclusion in treatment algorithms.

1.3. Study aims

The current study aims to replicate our previous analysis (McCarthy et al., 2015) in three independent smoking cessation studies (Shiffman et al., 1996, 1997; McCarthy et al., 2008a,b) and extend it to new treatment conditions. All studies offered treatment (counseling, patch, and/or bupropion) to smokers motivated to quit and assessed smoking status both in real time using ecological momentary assessment (EMA; Stone and Shiffman, 1994) *via* palmtop computer, and frequent time-line follow-back (TLFB) assessments. Daily abstinence status in the first 27 days of a quit attempt was analyzed using RMLCA to identify the latent classes of abstinence patterns in each study. Analyses addressed relations between 3-month outcomes, treatments, and relapse-relevant covariates and latent class.

Based on results from the six-arm pharmacotherapy trial (McCarthy et al., 2015), we hypothesized that high-dose nicotine patch treatment would facilitate early quitting, whereas bupropion would support recovery from early smoking. Based on an earlier study of counseling effects on lapse reactions (McCarthy et al., 2010), we expected counseling to promote recovery pattern. We also hypothesized that known relapse risk factors including gender, racial minority status, nicotine dependence, quitting confidence, and baseline craving and affective distress would be associated with membership in latent abstinence classes across studies, but did not make *a priori* hypotheses about cross-study variation in these relations.

2. Methods

The design and sample characteristics of each of the three studies are summarized in Tables 1 and 2. Each of these studies has been

Table 1
Summary of study design, sample sizes, and inclusion and exclusion criteria by study.

Study design	Study 1 ($N = 287$) Prospective longitudinal study	Study 2 ($N = 334$) Randomized, double-blind nicotine patch	Study 3 ($N = 407$) Randomized, crossed factorial
Treatments	Group CBT[a]	Patch[b], Group CBT[c]	Bupropion[d], Counseling[e]
Days of EMA: pre-quit/post-quit	16/26	14/56	14/28
Number of clinic visits	8	11	11
Number of counseling sessions	8	7	8
Payment ($)	50	150	200
Distal 7-day abstinence outcome(weeks post-quit)	6–16	11	12
Biochemical validation: CO ppm/cotinine ng/ml	≤8/ < 15	≤8/ < 15	≤10/ < 15
Inclusion Criteria			
Age (years)	≥18	≥21 and ≤65	≥18
Years of smoking	≥2	≥5	
Cigarettes/day	≥10	≥15	≥10
Baseline CO (ppm)			≥10
Exclusion Criteria	Study 1	Study 2	Study 3
Use of other tobacco		X	X
Other drug or alcohol abuse		X	X
Contraindications to nicotine patch		X	
Recent bupropion treatment		X	
Body weight <110 lbs.		X	
Using mood-altering/sedating meds		X	
Reversed/shifted wake-sleep cycle		X	
Serious lung disease		X	
Participation in another study		X	X
Pregnancy or breast feeding		X	X
Living with an enrolled participant		X	X
History of bipolar or psychosis		X	X
Current depression			X
Contraindications to bupropion use			X

[a] 8 60-min group sessions of cognitive behavior therapy for smoking cessation.
[b] Participants were randomly assigned to wear either 35 mg for 3 weeks, 21 mg for 2 weeks, and placebo for 1 week or placebo patches daily for six weeks post-quit.
[c] All participants were encouraged to attend 7 60-min group sessions of cognitive behavior therapy for smoking cessation.
[d] Participants were randomly assigned to take active bupropion SR (150 mg for 4 days then 300 mg for 59 days) or placebo pills (63 days) beginning one week pre-quit.
[e] Participants were randomly assigned to receive 8 individual, face-to-face 10-min smoking cessation counseling sessions or no counseling.