EXECUTIVE SUMMARY: Examining Gambling and Substance Use: Applications of Advanced Latent Class Modeling Techniques for Cross-sectional and Longitudinal Data

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Abstract

The purpose of this project was to present three empirical studies that illustrate the application of advanced latent class modeling techniques to research questions about gambling and substance use. Latent class models and their longitudinal extensions are statistical methods that: identify types of individuals characterized by similar multidimensional patterns of behavior, describe change over time in behavior, and model relations among multiple behaviors. The first study identified and predicted types of college-student gamblers. Four types of gamblers were identified: non-gamblers, cards and lotto players, cards and games of skill players, and multi-game players. There were gender differences in type prevalence; for example, men were more likely than women to be cards and games of skill and multi-game players. Significant predictors of gambling type included: year in school, living in off-campus housing, Greek membership, and past-year alcohol use. The second study linked gambling type to longitudinal patterns of drinking among adolescents and young adults. Gambling and drinking were strongly related; for example, frequent/heavy drinkers at any time were most likely to engage in all types of gambling activities. Overall, drinking frequency compared to quantity was more predictive of gambling. The third study modeled the development of smoking and drinking simultaneously, which showed, in part, that transitioning from non-drinking to heavy drinking was progressively more likely for more serious types of smokers. Results from advanced latent class models of gambling provide important information for the design of prevention and treatment programs addressing gambling and related problem behaviors.

Executive Summary

During the last two decades, many substance use researchers have been using a variety of advanced person-centered statistical methodologies, which have helped to understand developmental transitions and trajectories of substance use. The field of gambling research is poised to begin using these same methodologies, especially as longitudinal data become widely available. To date, the majority of gambling studies have used variable-centered approaches such as analysis of variance, chi-squared tests, and linear and logistic regression to describe the correlational relation between gambling and other characteristics and behaviors. These methods are well-suited for describing associations between variables, but they are unable to address questions about types of individuals characterized by similar patterns of behavior or about within-individual development over time. Gambling researchers have already begun to use some person-centered methodologies, like growth trajectory modeling, to begin addressing these kinds of questions, but other potentially useful methodologies, like latent class models, have not been used.

The purpose of the current project was to present three empirical studies that illustrate the application of advanced latent class modeling techniques to research questions about gambling and substance use. Latent class models and their longitudinal extensions are statistical methods that: identify types of individuals characterized by similar multidimensional patterns of behavior, describe change over time in behavior, and model relations among multiple behaviors. These methods may be used to identify types of individuals who may be at high risk for developing problems in multiple domains, and thereby suggest how prevention programs may be targeted to individuals undergoing different etiological processes. ***By clarifying and disseminating the practical application of these methods, a goal of this project as a whole was to inspire new applications of these methods to gambling research.***

The first two empirical studies addressed questions directly from the field of gambling research. In the first study, types of college-student gamblers were identified and gambling type was predicted from a variety of demographic characteristics and substance use behaviors. In the second study, types of adolescent and young adult gamblers were identified, as were longitudinal patterns of drinking. Then, the relation between gambling and longitudinal patterns of drinking was described. The third empirical study addressed a question about the relation between smoking and drinking development over time in order to illustrate how advanced latent class modeling techniques can be used in the future to study the relation between gambling and other problem behaviors. First, adolescent smoking and drinking development were modeled as separate processes. Then, the behaviors were modeled simultaneously over time to explore the extent to which developmental transitions in drinking varied by smoking behavior. Each of the three studies is discussed in detail below.

Empirical Study #1: Identifying and Predicting Types of College-Student Gamblers

As prevention and treatment efforts for problem and pathological gambling become priorities for public health agencies, it is essential that researchers are able to identify individuals who are at increased risk for developing gambling problems. Historically, the identification of individuals who may benefit from prevention and treatment programs has been conducted using diagnostic criteria to categorize individuals as being non-problem, problem, or pathological gamblers. This approach is based on the number of diagnostic criteria met, rather than which criteria are met. Using this approach, individuals endorsing criteria about gambling-related intra- and interpersonal problems, and individuals endorsing criteria about gambling-related financial problems are identified as the same type of gambler if their total number of endorsed criteria is the same. However, as discussed by Shaffer et. al. (2004) this

> "unidimensional additive scoring ... is inadequate to represent a multidimensional latent state. The method of summing endorsed characteristics assumes that all dimensions exist on the same additive continuum, and that all dimensions equally predict gambling disorders ... This equivalence is highly unlikely and misleading."[1]

[1]Shaffer, H. J., LaBrie, R. A., LaPlante, D. A., Nelson, S. E., & Stanton, M. V.(2004). The road less traveled: Moving from distribution to determinants in the study of gambling epidemiology. *Canadian Journal of Psychiatry, 49*(8), 504-516. [pg. 513]

It is likely that there are types of individuals who are at lower or higher risk for developing gambling problems, and that these individuals may be identified long before they are at the point of meeting diagnostic criteria. (For example, substance use researchers identify youth at high risk for developing substance abuse and dependence long before youth are likely to meet diagnostic criteria.) Furthermore, it is likely that types of gamblers may be identified using information about gambling behavior that is not included in the diagnostic criteria.

The identification of types of gamblers based on similarities in behavioral characteristics should be considered and investigated as an important part of understanding gambling and the development of gambling problems. ***By using advanced statistical methods that allow the multidimensional nature of behavior to be examined, it may be possible to identify types of gamblers in ways that are more helpful for prevention and treatment.*** In addition, once types of gamblers have been identified, it is possible to explore how individual and contextual characteristics are related to type in order to reach a more nuanced understanding of the etiological processes underlying gambling for different types of individuals.

College students may be a particularly interesting population in which to study gambling and to try out new ways of identifying types of gamblers. Rates of gambling problems appear to be somewhere in between rates for adolescents and adults. In addition, college appears to be a time when many individuals are willing to take risks in a variety of domains; during this time individuals may initiate or expand their gambling behavior as they approach an age at which gambling activities become legal. It may also be a time when some individuals are first beginning to develop problems with gambling.

Purpose

The purpose of the first empirical study was to:

1. Explore whether types of college-student gamblers were identifiable based on similar multidimensional patterns of gambling activity participation.
2. Explore whether demographic characteristics and substance use behaviors were predictive of gambling type for college students.

It was hypothesized, in part, that identified types would differ for men and women, as would type prevalence such than men would be less likely to be non-gamblers and more likely to be players of multiple activities. Types of gamblers were identified using latent class analysis (LCA) with gender as a grouping variable; to predict latent class membership (i.e., gambling type), demographic characteristics and substance use behaviors were added to the latent class model as covariates.

Participants

Data were from a study conducted at a large northeastern university designed to collect information about risk-taking behaviors and motivations from undergraduate college students. The original sample was drawn from introductory psychology and communications courses; data were collected in Spring 2005, Winter 2005, and Spring 2006. The sample for the current study consisted of 507 students (63% female) who reported their gender and who responded to at least one question about gambling activity participation.

Measures

Gambling activity participation was measured using 13 binary indicators corresponding to 13 types of gambling activities (e.g., played cards or board games for money with family or friends; bet on games of personal skill; bought lottery tickets). Participants were considered to be "players" of an activity if they reported having engaged in the activity at least once during the past 12 months; participants were considered to be "non-players" of an activity if they reported not having engaged in the activity during the past 12 months.

Six demographic characteristics shown to be associated with gambling in previous research were examined to determine whether they were predictive of gambling type: gender (male, female), year in school (1st,

2nd, 3rd, 4th, 5th or above), ethnic background (White, Black or Hispanic, other), current-semester living arrangement (dorm, off-campus, other), membership in a Greek organization (i.e., fraternity or sorority; yes, no), and grade point average. Four types of substance use shown to be associated with gambling in previous research were examined to determine whether they were predictive of gambling type: past-semester cigarette use (yes, no), past-year alcohol use (none/low, moderate, heavy), past-year binge drinking (yes, no), and past-year marijuana use (none, moderate, heavy).

Modeling Approach

First, LCA with gender as a grouping variable was used to develop and select a model identifying types of gamblers for men and women based on the indicators of gambling activity participation. Latent class models divide a population into a set of mutually exclusive and exhaustive discrete latent classes characterized by similar multidimensional patterns of behaviors. In this study, LCA was used to identify different types of gamblers based on observed patterns of responses to questions about gambling activity participation. Identified classes may be interpreted as "types" of individuals, as the classes represent groups of individuals who responded to the questions in a similar way. (Technical details about latent class models and their extensions are presented in Chapter 1, pp. 12-22.)

After identifying the latent classes (i.e., gambling types), demographic characteristics and substance use behaviors were added to the latent class model as covariates to predict gambling type. The effect of a covariate was quantified by multinomial logistic regression coefficients. For example, in a latent class model including grade point average as a covariate, the effect of grade point average on gambling latent class membership was expressed by a set of odds ratios of membership in a target latent class relative to membership in a reference latent class. When gender was simultaneously included in the model as a grouping variable, the logistic regression coefficients were conditional on group membership and were different for men and women.

Results and Discussion

Four latent classes were identified for men and women: (1) a class characterized by very low endorsement of all activities, (2) a class characterized by high endorsement of playing cards and playing the lotto, and very low endorsement of other activities, (3) a class characterized by high endorsement of playing cards and games of skill, with variable endorsement of other activities, and (4) a class characterized by high endorsement of playing cards, table games at a casino, games of skill, lotto, slots, and other. The first latent class was labeled "non-gamblers," the second labeled "cards and lotto" players, the third labeled "cards and skill" players, and the fourth labeled "multi-game" players. ***Based on the probabilities of playing each of the gambling activities, the order of severity of lowest risk to highest risk for developing gambling problems was: non-gamblers, cards and lotto, cards and games of skill, and multi-game players.*** (Additional information about determining the order of risk-severity is presented in Chapter 2, pp. 46-47.)

There were substantial gender differences in the proportions of men and women who were members of the different latent classes. Women were most likely to be non-gamblers whereas men were most likely to be cards and lotto players. In addition, women were more likely than men to be non-gamblers; men were more likely than women to be cards and games of skill players, and multi-game players. ***Interestingly, gambling on the internet did not appear to be common among participants engaging in only one or two types of gambling activities; both men and women who gambled on the internet appeared to also be engaging in a variety of other gambling activities.***

Year in school, living in off-campus housing, Greek membership, and moderate and heavy past-year alcohol use were significant predictors of gambling latent class membership at the $\alpha = 0.05$ level. Gender differences in the effects of Greek membership and alcohol use were particularly interesting. For men, Greek membership was related to increased odds of lighter types of gambling (cards and lotto; cards and games of skill) relative to no gambling, but decreased odds of multi-game gambling. Comparatively, for women, Greek membership was related to decreased odds of all types of gambling relative to no gambling. ***It appears, then, that Greek membership may be a risk factor for lighter types of gambling for men, but***

a protective factor for women and for heavier types of gambling for men.

The strongest effects of moderate and heavy past-year alcohol use were on the odds of membership as a multi-game player relative to membership as a non-gambler. Although this was true for both men and women, the effects were especially strong for women. For men, the odds of membership as a multi-game player relative to membership as a non-gambler were 7.5 times higher for moderate drinkers relative to non-drinkers; for women they were 48.7 times higher. For heavy drinkers the effect was even stronger; for men the odds of membership as a multi-game player relative to membership as a non-gambler were 9.7 times higher for heavy drinkers relative to non-drinkers, for women they were 85.6 times higher.

The strong effects of moderate and heavy alcohol use on membership as a multi-game player have important implications for prevention and treatment research. Individually, problems with gambling and drinking result in a variety of intra- and interpersonal problems, and financial difficulties. The combination of gambling and drinking, however, has the potential to exponentially increase the likelihood of severe, long-term negative consequences. It is easily imagined that individuals who drink heavily when gambling may have irresponsible gambling behavior, which leads to intra- or interpersonal problems and/or financial stress. This stress may then lead to heavier drinking to escape depressive feelings, or it may lead to heavier gambling to recover financial losses, or both. ***It may be that prevention and treatment programs for college students need to target both gambling and drinking simultaneously in order to be effective for individuals at highest risk of developing gambling problems. The ways in which gambling and drinking behaviors may interact to increase the likelihood of negative outcomes in a variety of domains needs to be explored in order to develop prevention and treatment programs that are effective at reducing both behaviors.***

Empirical Study #2: Examining the Relation Between Gambling and Drinking Trajectories Among Adolescents and Young Adults

Research has begun to show that the initiation of gambling may take place during late childhood and early adolescence for a majority of individuals. In addition, one of the most important correlates of gambling and gambling problems is the use of alcohol and other substances, behaviors also common during adolescence. It is particularly important, then, to understand the nature of the relation between gambling and alcohol use long before individuals enter college.

In general, research on the relation between gambling and drinking during adolescence has shown that: drinking tends to co-occur with gambling, problems with drinking tend to co-occur with problems with gambling, and gamblers drink at higher rates and more regularly than non-gamblers. A deeper understanding of how specific gambling behaviors are linked to specific alcohol use behaviors is needed. For example, it is not known how participation in certain types of gambling is linked to longitudinal patterns of frequent or heavy drinking.

Purpose

The purpose of the second empirical study was to:

1. Explore whether types of adolescent and young adult gamblers were identifiable based on similar multidimensional patterns of gambling activity participation.
2. Identify longitudinal patterns of adolescent and young adult drinking frequency, quantity, and intensity.
3. Explore the extent to which gambling is related to longitudinal patterns of drinking among adolescents and young adults.

It was hypothesized, in part, that participants who had longitudinal patterns of consistent frequent or heavy drinking over time would be most likely to be players of multiple activities whereas participants who had longitudinal patterns of consistent infrequent or light drinking over time would be most likely to be

non-gamblers. Types of gamblers were identified using latent class analysis (LCA); longitudinal patterns of drinking over time were identified using LCA for repeated measures; the relation between gambling and drinking was described by modeling the behaviors simultaneously with advanced latent class modeling techniques.

Participants

Data were from the National Longitudinal Study of Adolescent Health (Add Health), a nationally representative study that was designed to collect data about the causes of health-related behaviors of adolescents in middle school and high school. Data were collected on a sample of 7^{th}- through 12^{th}-graders in 1994 (wave 1). Participants were interviewed again in 1996 (wave 2) and 2001/2002 (wave 3). The sample for the current study was limited to participants present at the third wave of data collection in 2001/2002 who responded to at least one question about their gambling behavior ($N = 4,536$; 53.6% female). Data on drinking collected at all three waves were used; data on gambling were available only at the third wave.

All analyses were conducted once with the total sample ($N = 4,536$), and then again for "young" participants ($N = 1,253$), defined as participants under the age of 21 at the third wave of data collection. Conducting the analyses in this way allowed for limited comparison to see if the results from younger participants, for whom both behaviors were illegal during the entire length of the study, noticeably differed from those from the total sample.

Measures

Gambling activity participation was measured at wave 3 using three binary indicators corresponding to three types of gambling activities: playing the lottery (daily, scratch-off, lotto), gambling at a casino (craps, blackjack, roulette, slot machines, video poker), and other gambling (e.g., cards, BINGO, horse racing, sporting events, other).

Three measures of past-year drinking were of interest: drinking frequency, drinking quantity, and a combination of frequency and quantity (labeled "intensity"). Drinking behavior was examined in these different ways because it is unknown which dimensions of drinking are most important to gambling behavior. Frequent drinking was defined as drinking more than once per month in the past 12 months. Heavy drinking was defined as drinking three or more drinks per drinking day on average in the past 12 months. High intensity drinking was defined as drinking three or more drinks on average more than once per month in the past 12 months.

Modeling Approach

First, LCA was used to identify types of adolescent and young adult gamblers using the indicators of gambling activity participation. Then, LCA for repeated measures was used to identify latent classes describing longitudinal patterns of drinking frequency, quantity, and intensity. Typically, LCA uses manifest indicators that were all measured at the same time. In LCA for repeated measures, one or more indicators are drawn from multiple points in time. The identified classes may be interpreted as "trajectory classes," as the classes represent groups of individuals who have similar trajectories or profiles of behavior over time.

Second, multivariable modeling was used to model gambling and drinking trajectories simultaneously. The term "multivariable modeling" refers to an advanced latent class modeling technique that models two or more behaviors simultaneously. This approach linked gambling to patterns of drinking, and provided a way to describe how gambling type was related to drinking trajectory.

Results and Discussion

Five types of gamblers were identified: non-gamblers, lotto players, lotto and casino players, lotto and other players, and "all" players (i.e., participants who played all three activities). Participants were most likely to be gamblers who engaged in all types of gambling, but they were approximately equally likely to be

non-gamblers. Participants were least likely to be lotto and other players. (Results for the total sample are discussed; in general, results for young participants were similar. Additional results, including all results for young participants, are presented in Chapter 3, pp. 65-80).

Drinking frequency was characterized by trajectory classes of: "consistent infrequent" drinkers who did not drink frequently at any of the three waves, "wave 3 starters" who started drinking frequently at the third wave but did not do so previously, "wave 2 starters" who started drinking frequently at the second wave and continued to do so at the third, and "consistent frequent" drinkers who drank frequently at all three waves.

Drinking quantity was characterized by trajectory classes of: "consistent light" drinkers who did not drink heavily at any of the three waves, "wave 3 starters" who started drinking heavily at the third wave but did not do so previously, "wave 2 starters" who started drinking heavily at the second wave and continued to do so at the third, "desisters" who drank heavily at the first two waves but not at the third, and "consistent heavy" drinkers who drank heavily at all three waves.

Drinking intensity was characterized by trajectory classes of: "consistent light or infrequent drinkers," who did not drink intensely at any of the three waves, "wave 3 starters" who started drinking heavily and frequently at the third wave but did not do so previously, "wave 2 starters" who started drinking heavily and frequently at the second wave and continued to do so at the third, and "consistent frequent heavy" drinkers who drank heavily and frequently at all three waves.

Gambling was highly related to longitudinal patterns of drinking, regardless of the drinking measure. Participants who were consistently infrequent, light, or low intensity drinkers over time were most likely to be non-gamblers. Conversely, participants who were frequent, heavy, or high intensity drinkers at any time were most likely to be members of the all types of gambling latent class. Overall, consistent frequent, consistent heavy, and consistent high intensity drinkers had the highest probabilities of being members of the all types of gambling latent class.

Interestingly, drinking frequency compared to quantity was more predictive of gambling latent class membership. In addition, there was an increasing trend in the chance of engaging in all types of gambling given drinking trajectory — the longer participants had been frequent drinkers, the greater their chance of engaging in all types of gambling. There was not, however, a stronger than expected relation between drinking frequency latent trajectory class membership and membership in gambling latent classes characterized by participation in one or two types of gambling activities (lotto, lotto and casino, lotto and other).

These findings suggest that because drinking is linked to participation in multiple types of gambling activities, not just playing one or two specific games, prevention and treatment programs may have to target gambling and drinking simultaneously to be effective for individuals at highest risk of developing gambling problems. If all types of drinking are linked to participation in multiple types of gambling, as the results of the current study suggest, any kind of drinking may be an important risk factor for gambling problems. ***It is also interesting that drinking frequency, regardless of quantity, was most strongly related to gambling behavior in general. This finding suggests that prevention and treatment providers should be concerned about regular drinking behavior, even if it is low in quantity, when targeting gambling.***

Empirical Study #3: Examining Developmental Relations Between Smoking and Drinking Among Adolescents

The first two empirical studies addressed research questions about gambling and substance use. A nice follow-up study to these would have been an examination of the relation between the development of gambling and drinking or another problem behavior. Unfortunately, longitudinal public-use data about gambling are difficult to find because researchers are just beginning to collect such data. Instead, to illustrate the types

of questions that may be addressed in the future about the relation between gambling and other problem behaviors using advanced latent class models that include multiple developmental processes simultaneously, the developmental relation between smoking and drinking was examined. Previous research has shown strong associations among gambling, drinking, and smoking. When longitudinal data about gambling are readily available, it is planned that the methods used in this study will be used in a similar way to model the relation between gambling and drinking, and between gambling and smoking.

Research has provided consistent evidence that there is a strong association between drinking and smoking. Much of this evidence stems from research using variable-centered methodologies. In general, these methods look at average patterns of inter-individual change instead of person-specific change. It is important to understand how specific drinking behaviors are linked to specific smoking behaviors over time. Therefore, it is necessary to take a person-centered approach to examine within-individual patterns of change over time.

Purpose

The purpose of the third empirical study was to:

1. Identify types of adolescent smokers and describe change over time in smoking behavior.
2. Identify types of adolescent drinkers and describe change over time in drinking behavior.
3. Explore the extent to which developmental transitions in drinking vary by type of smoking among adolescents.

It was hypothesized, in part, that adolescent smoking and drinking would be characterized by classes of: no use, a type of less serious drinking/smoking, and a type of more serious drinking/smoking. It was also hypothesized that whereas non-using participants would have relatively stable behavior over time, less serious and more serious drinkers and smokers would have relatively variable behavior over time. In addition, it was hypothesized that developmental transitions in drinking would be strongly related to smoking such that transitions to less serious and more serious types of drinking from non-drinking would be more likely for more serious types of smokers. Latent transition analysis (LTA) was used to identify types of smokers and to describe change over time in smoking; LTA was used to identify types of drinkers and to describe change over time in drinking. The relation between developmental transitions in drinking and type of smoking was described by modeling the two behaviors simultaneously over time using advanced latent class modeling techniques.

Participants

Data were from the National Longitudinal Survey of Youth, 1997 (NLSY97), a survey sponsored and directed by the U.S. Bureau of Labor Statistics. The original study was designed to collect data about characteristics affecting the transition from school to the labor market. Data have been collected annually since 1997 on approximately 9,000 participants (seven waves of data from 1997 to 2003 were available at the start of this study). The original NLSY97 sample consisted of a nationally representative (in 1997) sample of 6,748 adolescents born from 1980 to 1984 (the cross-sectional sample). Data for the current study come from all participants aged 15-16 years in 1998 who were members of the cross-sectional sample, and who responded to at least one question about their drinking or smoking behavior ($N = 2,563$; 47.9% female; 49.1% age 15). Data from the 1998 (time 1) and 1999 (time 2) waves were used to model smoking and drinking development.

Measures

Smoking was measured using two questions about past-month cigarette use frequency and quantity. Smoking frequency had responses corresponding to: (1) no use, (2) one to fourteen smoking days, and (3) fifteen or more smoking days. Smoking quantity had responses corresponding to: (1) zero cigarettes, (2) one or two cigarettes per smoking day, and (3) three or more cigarettes per smoking day.

Drinking was measured using two questions about past-month alcohol use frequency and quantity. Drinking frequency

had responses corresponding to: (1) no use, (2) one or two drinking days, and (3) three or more drinking days. Drinking quantity had responses corresponding to: (1) zero drinks, (2) one or two drinks per drinking day, and (3) three or more drinks per drinking day.

Modeling Approach

First, latent transition analysis (LTA) was used to identify types of smokers and to describe change over time in smoking; LTA was then used to identify types of drinkers and to describe changes over time in drinking. LTA is a longitudinal extension of LCA that models within-individual longitudinal change in a discrete developmental process. In LTA, latent class membership is dynamic in that participants may transition between classes over time. In addition to describing types of individuals and type prevalence, LTA estimates transition probabilities that describe change in latent class membership between adjacent times.

Second, multiprocess modeling was used to model the development of smoking and drinking simultaneously over time. The term "multiprocess modeling" refers to an advanced latent class modeling technique that models change over time in two or more discrete developmental processes simultaneously. This approach linked smoking to drinking, and provided a way to describe how developmental transitions in drinking were related to type of smoking.

Results and Discussion

Smoking was characterized by classes of: non-smokers, light smokers, and heavy smokers. Non-smokers had no past-month cigarette use whereas light smokers were likely to smoke 1-2 cigarettes on 1-14 days in the past month and heavy smokers were likely to smoke 3+ cigarettes on 15+ days in the past month. Similarly, drinking was characterized by classes of: non-drinkers, light drinkers, and heavy drinkers. Non-drinkers had no past-month alcohol use whereas light drinkers were likely to drink 1-2 drinks on 1-2 days in the past-month and heavy drinkers were likely to drink 3+ drinks on 3+ days in the past month.

The majority of participants were non-smokers and non-drinkers over time, but the proportions of heavy smokers and heavy drinkers increased over time; the proportions of light smokers and light drinkers stayed roughly the same over time. In addition, there was high stability of non-smoking, heavy smoking, non-drinking, and heavy drinking over time: participants who were non-smokers, heavy smokers, non-drinkers, or heavy drinkers at time 1 were likely to be members of the same latent class at time 2. Comparatively, the behavior of light smokers and light drinkers was more variable: light smokers and light drinkers at time 1 were likely to be members of any smoking and drinking class at time 2.

The relation between smoking and drinking was explored both cross-sectionally and longitudinally. The cross-sectional relation between smoking and drinking was about the same at times 1 and 2. For example, non-smokers were most likely to also have been non-drinkers, and heavy smokers were most likely to also have been heavy drinkers; heavy smokers also had a fairly high probability of being non-drinkers. Comparatively, the drinking behavior of light smokers was quite variable. Light smokers were approximately equally likely to engage in any of the three types of drinking at both times.

Transitioning from the non-drinking latent class to the heavy drinking latent class between times 1 and 2 was progressively more likely for more serious types of smoking: non-smokers had a low probability of making the transition, light smokers had a slightly higher probability, and heavy smokers had the highest probability of making the transition. Similar progressively increasing and decreasing patterns were seen for: the probabilities of being a heavy drinker at time 2 given heavy drinking latent class membership at time 1, and the probabilities transitioning from the heavy drinking latent class to the non-drinking latent class between times 1 and 2.

The developmental transitions in drinking of those participants who both smoked lightly and drank lightly at time 1 were variable, but there were some interesting patterns. Light drinkers at time 1 were approximately equally likely to be light drinkers at time 2, regardless of their smoking behavior. In addition, non-smokers were most likely to transition from light drinking to non-drinking and heavy smokers were most likely to

transition from light drinking to heavy drinking; light smokers were approximately equally likely to transition to non-drinking and heavy drinking.

Although the current study did not examine how changes in gambling behavior were related to changes in other problem behaviors due to a lack of available data, this study illustrated the potential use of these statistical methods when data are available. Using these methods, it would be possible to identify types of gambling and drinking (for example), describe change over time in both behaviors, and model the relation between developmental transitions in gambling and drinking to examine how within-individual transitions in one behavior are directly related to developmental transitions in the other.

Conclusions

The current project laid the groundwork for future research in several areas. First, in the future it will be possible to validate the order of severity suggested by the latent classes in the first study using a measure of gambling-related negative consequences. In addition, the first study suggested that future research needs to carefully examine how specific demographic characteristics and substance use behaviors are related to specific patterns of gambling behavior, and that it may be necessary to combine type of gambling and frequency/intensity of gambling to fully understand how gambling problems develop. ***The first study also provided support for the idea that types of gamblers can be identified on the basis of the gambling activities in which they engage. This is particularly important for prevention and treatment researchers who currently need additional ways of identifying individuals at potential risk for developing gambling problems.*** In addition, it illustrated the application and importance of latent class models to identifying predictors of types of gambling behavior.

Similar to the first study, the second study provided support for the idea that types of gamblers can be identified on the basis of the gambling activities in which they engage. In addition, the second study illustrated the usefulness of multivariable latent class modeling for gambling research. ***Although the second study did not provide a particularly nuanced look at gambling and drinking, it did provide strong support for the relation between multiple dimensions of drinking behavior and engaging in multiple types of gambling activities.*** Therefore, future research needs to carefully examine how specific drinking behaviors are related to specific gambling behaviors over time in order to more clearly elucidate their relationship.

The third study illustrated the application and importance of advanced latent class models with multiple developmental processes to gambling and problem gambling researchers. Multiprocess models provide a way to explore how developmental transitions in one behavior vary across levels of another behavior. They may also be used to explore how developmental transitions in one behavior vary across developmental transitions in another behavior. ***Using this method to explore how gambling development is directly related to the development of drinking or other problem behaviors may inform the development of effective prevention and treatment strategies to address comorbid behaviors and conditions. Overall, the three studies demonstrate the variety of potential uses of advanced latent class modeling techniques and their applicability for studying the development and predictors of gambling and gambling problems over time.***