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A Natural Experiment of Peer Influences on Youth Alcohol Use

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Abstract

This study estimates peer effects on alcohol use, drawing from a database of about 2,000 randomly-assigned roommates on a college campus. The estimation of peer influences also takes into consideration ego's history of alcohol use and friendship with the peer. College students averaged an additional two-fifths of a binge drinking episode per month and an additional one-half of a drinking episode per month when randomly assigned a roommate who drank in high school than when assigned a roommate who did not drink in high school. An individual's prior history of alcohol use proves important. Peer effects on binge drinking as well as drinking for those who already drank in high school were about twice as large as average peer effects. When one did not have a history of alcohol use, negative peer influences were absent. Also important is the friendship between peers. When a peer is considered a best friend, the step-up effect (or positive interaction effect) increased by 1.25–1.61 drinking episodes per month. However, even when a peer is not considered a best friend, a drinking peer still increased ego's drinking episodes by 0.75–1.00 per month.

Mouw (2006 p.79) calls peer influences “network” social capital and defines them as “the effect of characteristics of friends, acquaintances, or groups on individual outcomes.” He emphasizes that as social capital, peers are part of larger social structures and outside the domain of individual traits. In the study of youth delinquent behavior, peer influences have been a central concern and the observed correlation among peers in delinquent behavior is one of the most enduring findings (e.g., Giordano, Cernkovich and Pugh 1986, Haynie 2001, Kreager and Haynie 2011, Matsueda and Anderson 1998, Matsueda, Kreager and Huizinga 2006).

Although commonly recognized as one of the most potent social contexts, peer influences are difficult to investigate. The main complexity is caused by social homophily—individuals' tendency to choose those similar to themselves as friends (Cohen J. 1977, Kandel 1978, McPherson, Smith-Lovin and Cook 2001, Moffitt 2001, Mouw 2006). As a result, it is difficult to determine how much of the observed similarity among friends in survey studies is due to causal peer effects and how much is due to the fact that “birds of a

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feather flock together.” When Christakis et al. (2007) published their widely publicized finding that an individual’s probability of becoming obese increased by 57% when he or she had an obese friend, critics quickly pointed out that the survey data used in the study are incapable of separating friend effect from friend selection in the survey data (Cohen-Cole and Fletcher 2008).

In this study, using data from a natural experiment of randomly assigned roommates at a large public university (the College Roommate Study or ROOM), we address the issue of friend selection for one type of youth behavior—alcohol use—in the United States. We estimated peer effects on binge drinking (defined as having five or more drinks in a row for men and four or more for women, or 5+/4+) as well as drinking. Natural experiments such as randomly-assigned roommates on a college campus provide an invaluable opportunity for estimating peer influences (e.g., Sacerdote 2001). Natural experiments rely on study design to remove potential bias caused by friend selection.

Our overall objective is two-fold. We generated credible estimates of peer effects. We also provided the evidence as to how history of alcohol use and friendship among peers influence the strength of peer effects. Because an experimental study design controls for potential bias from selection, the analysis is expected to yield credible estimates of peer effects.

We performed three analyses. First, we estimated average peer effects controlling for ego’s history of alcohol use in high school. Second, we estimated peer effects conditional on ego’s history of alcohol use in high school, hypothesizing that individuals with a history of alcohol use were more easily swayed by a drinking roommate than those without such a history. Third, we estimated the average effects and the conditional effects for those who considered his or her roommate a best friend and for those who did not consider his or her roommate a best friend. For the third analysis, peer effects among friends are expected to be substantially larger than peer effects among non-friends.

BACKGROUND

Alcohol Use among Youth and Peer Influences

It should be noted that college drinking is sometimes considered developmentally normative rather than delinquent because a large majority of college students experiment with it. Schulenberg and Maggs (2002) describes five developmental models explaining college drinking. Among them, the transition catalyst and heightened vulnerability to chance events model suggests that cultural norms in college promote a period of normative experimentation in the form of alcohol use. Nevertheless, binge drinking is generally considered a high-risk form of alcohol use.

High-risk drinking among youth can have severe negative consequences for those who drink and even for those around them—academic difficulties (Singleton and Wolfson 2009), health issues (Wechsler et al. 1994), suicide attempts (Schilling et al. 2009), physical and sexual aggression (Roudsari, Leahy and Walters 2009), sexual victimization (Palmer et al. 2010), and fatal traffic crashes (Hingson R, Zha W and Weitzman ER 2009). Alcohol use is associated with more than 50% of sexual assaults among college students. Alcohol use is

linked with serious personal injuries and accidents. Approximately one-third of 18–24 year olds admitted to emergency rooms for severe injuries are under the influence of alcohol. Heavy drinking is related to homicides, suicides, and drownings. Alcohol is involved in about 50% of all fatal traffic accidents. Consequences of heavy drinking also have “secondhand effects” similar to the effects of secondhand smoking including noise, property damage, vomit, and littering.

Alcohol use is widespread on U.S. college campuses. It is a major part of the college culture and present at many social occasions and peer interaction functions (Thombs 1999). College students tend to consider alcohol use an acceptable behavior (Eastman 2002, Johnson 1989). Many view college years as a period during which they can use alcohol excessively before taking on the responsibilities of adulthood.

College is a transition period between adolescence and full adulthood. Most college students start living in a residence hall or rented apartment away from parents, intensifying a process of independence begun during adolescence (Borsari and Carey 2001).

Borsari and Carey (2001) outline a number of mechanisms through which peers influence college drinking. Direct peer influence can take the form of friendly gestures (e.g., buying a drink or a round of drinks) or overt pressures to drink (e.g., pressuring peers to play drinking games). Peers may also influence college drinking indirectly by acting as role models. Through their own drinking behavior, peers indicate what behaviors are accepted and appropriate.

Theoretical Framework

The social learning perspective and the social control perspective on delinquency have had a great deal of influence on the interpretation of peer influence. The social learning perspective considers peer influence critically important. Sutherland’s (1947) differential association theory maintains that delinquent behavior is acquired through close association with peers where the attitudes and norms of delinquent peers are learned.

Social learning theory is an expansion of Sutherland’s theory. According to Bandura (1971, 2–3, 13–15, 26–27)’s social learning perspective, human behavior is a result of an interaction between an individual’s internal forces and external conditions. In contrast to the differential association theory, the social learning perspective believes that humans are capable of developing hypotheses about which behavior may be beneficial and acceptable. Social learning theory emphasizes two additional concepts: imitation and operant conditioning (Akers 2001, Akers 1985). When first initiated, delinquent behavior is often imitated or learned from the observation of similar behavior in others. Operant conditioning is also a form of learning in which an individual’s behavior is shaped by its consequences. A positive consequence of a delinquent act encourages delinquency and a negative consequence discourages the behavior. Social learning theory highlights social aspects of behavior-learning. Delinquent behavior is more likely to be sustained when an individual is embedded in a social environment where delinquency is rewarded and unlikely to be punished. The social learning perspective suggests that excessive drinking among youth

could be learned via intimate social interactions with drinking peers who act as if drinking and binge drinking are acceptable or normal.

The social control perspective calls special attention to social bonds between an individual and society, suggesting that an individual is more likely to engage in delinquency when these bonds are weak or broken (Durkheim 1897, Hirschi 1969, Kornhauser 1978, Sampson and Laub 1993). Control theory highlights the difficulty of isolating the causal effect of peers from social homophily, arguing that delinquent peers tend not to cause delinquency and interpreting the observed association among delinquent peers as spurious.

In a later version of control theory, Gottfredson and Hirschi (1990) recognizes an individual's stable characteristic of low self-control as part of the causal structure. They described delinquency-prone individuals as those who lack self-control over their own desires and who are incapable of resisting the immediate gratification provided by crime or analogous behaviors. Social institutions such as family and school play an important role in shaping self-control. In family, self-control is cultivated during early childhood through careful rearing and effective discipline. Schools have a particular interest in maintaining an environment in which antisocial behaviors are discouraged, and they have the authority and means to implement effective discipline. Gottfredson and Hirschi propose to measure low self-control by a number of individual characteristics and behaviors: the urge to gratify desires immediately; lack of diligence and persistence in a course of action; lack of commitment to job, marriage, and children; lack of skills and planning; tendency to drink excessively; use of illegal drugs; and gambling. Hirschi and Gottfredson (1994, p16) consider their general theory of crime accounting for all types of criminal, deviant and reckless behaviors.

The theory of self-control suggests that individuals may respond to peer influences and social control differentially. Individuals with weaker self-control may be more susceptible to negative peer influences. The theory of self-control suggests that individuals who already have a drinking history may engage in additional alcohol use when they have more contact with drinking peers in college.

Methodological Difficulties of Estimating Peer Influences

The empirical estimation of peer influences has been plagued by two difficulties. The primary difficulty is endogeneity; that is, observational survey studies cannot separate peer influences from friend selection (Cohen J. 1977, Glueck and Glueck 1950, Hirschi 1969, Kandel 1978, Manski 1993a, Moffitt 2001, Moww 2006). A survey may find a similar level of binge drinking among friends, but the finding does not establish how much of the similarity is due to friend influence and how much is due to the probable scenario that individuals become friends because of similar behaviors and attitudes. In other words, we are unable to determine whether the similarity among friends is because one takes on the color of one's company or because birds of a feather flock together. A second difficulty in the estimation of peer effects stems from the fact that peers influence each other simultaneously (Manski 1993b, Moffitt 2001). If the study design does not take this into account, peer effects may be overestimated.

Lazarsfeld and Merton (1954) introduced the term “homophiles” to describe the similarity in attitudes, attributes, and behaviors among friends. Friends have been found to be similar in educational aspiration (Duncan, Featherman and Duncan 1972), voting preferences (Berelson, Lazarsfeld and McPhee 1954), height (Berkowit 1969), activities, needs, attitudes, personality (Berscheid and Walster 1978), sexual experiences (Billy and Udry 1985), and delinquency (Matsueda 1982, Matsueda and Anderson 1998). At least a portion of the similarity between friends may thus be due to selection rather than influence. Ignoring selection may overestimate peer influences on delinquency, rendering it difficult to evaluate social learning theory and/or social control theory.

Over the past few decades, a number of approaches have been adopted to address the selection bias due to social homophily. For a review of these approaches, see Mouw (2006). Apart from randomized experiments, the use of longitudinal data seems the most promising. Kandel (1978) assessed the influence of levels of homophily on delinquency and education outcomes, using longitudinal data on adolescent friendship pairs, friends-to-be, and former friends. The study demonstrated that both selection and socialization played a part. Adolescents who had common attributes tended to become friends, and these friends also tended to become more similar as these relationships continued. Matsuda and Anderson (1998) showed that association with delinquent peers fostered future delinquent behavior. Other longitudinal studies documented that individuals with drinking friends were more likely to begin drinking (e.g., Reifman et al. 1998) and to increase drinking subsequently (Curran, Stice and Chassin 1997). Recently, SIENA models based on longitudinal measures of homophily tendency based on sex, race and ethnicity, class in school, network closure, and reciprocity of friendship nominations were used to control for peer selection in survey studies (Snijders and Baerveldt 2003, Steglich, Snijders and Pearson 2010, Weerman 2011).

Longitudinal data may be sufficient to adjust for selection effect in the estimation of causal peer influences. However, longitudinal survey studies cannot reject the hypothesis that individuals become friends because of a similarity in predispositions that leads them to develop even more similar attitudes and behaviors as time goes on. While an ego knows his or her potential friend’s predisposition, this information is unlikely to be available to survey researchers. So long as friends are chosen, it is difficult to establish a causal peer influence using observed survey friend data.

Randomly-assigned College Roommates as a Solution

Randomly-assigned roommates on a college campus represent a major opportunity for research on peer influences. An appropriately designed roommate study addresses both endogeneity and simultaneity typically encountered in a peer-effect study based on observational data. The randomization is usually conditional on a set of housing preferences (e.g., gender, location, and number of roommates) expressed by students when they apply for housing. The conditional random assignment provided by the lottery ensures that roommates are unselected or uncorrelated in attitudes and behavior before they become roommates. Roommates provide an intimate peer environment that is assigned rather than self-selected. To avoid simultaneity, college outcomes of subjects must be predicted by their roommates’ pre-college attitudes and behavior or attitudes and behavior before they begin

sharing a room in a residential hall. Using college measures of roommates to predict college measures of subjects exaggerates peer effects.

Data from randomly-assigned college roommates have been used in studies of academic achievement (Foster 2006, Kremer and Levy 2008, Sacerdote 2001, Zimmerman 2003), fraternity membership (Sacerdote 2001), drug use and sexual behavior (Duncan et al. 2005), and attitudes towards affirmative action (Boisjoly et al. 2006).

Duncan and colleagues (2005) investigated peer effects on binge drinking at a Midwestern public university. The study reported a conditional peer effect among males. A male student who drank in high school drank more in college when paired with a roommate who also drank in high school than when paired with a roommate who did not drink in high school. Such a conditional peer effect was not found among females. Neither did the study report a main effect of drinking peers in the male-female combined sample, the male-alone sample, or the female-alone sample. Relatively small sample sizes may be responsible for the inconclusiveness of this previous study. Our current project has gathered a sample of more than 2,000 randomly assigned college roommates drawn from a large racially and economically diverse public university. This sample size was about three times as large as that employed in Duncan et al. (2005).

Hypotheses

In this analysis, we tested three hypotheses. The first concerned main or average effects: the drinking behavior of college students is positively influenced by the high school drinking behavior of a randomly assigned roommate. Main effects averaged the impact on students with and without a prior history of alcohol use. These main effects also averaged the impact on students whose roommates were best friends and students whose roommates were not best friends. The second and third hypotheses tested a conditional peer effect. The second hypothesis decomposed and compared two components of an average roommate effect: *step-up effect* and *initiation effect*. A step-up effect is the effect of having a personal history of drinking and being paired with a drinking roommate vs. a non-drinking roommate. An initiation effect is the same as a step-up effect except that the ego did not have a prior history of alcohol use. The third hypothesis anticipated that the roommate effect on alcohol use would be larger when the roommate is considered a best friend than when the roommate is not considered a best friend.

DATA, MEASURES AND METHODS

Data Sources

The online survey of the College Roommate Study or ROOM was conducted in the spring semester of 2008, drawing its sample from students enrolled as freshmen, sophomores, and juniors at the university. Table 1 illustrates the sampling process. These students were thus freshmen in the fall semesters of 2007 (N=632), 2006 (N=965), and 2005 (N=470), respectively. Regardless of whether a participant is a freshman, sophomore or junior, he or she is matched with a freshman roommate in this study.

We worked with the university's Housing Department in sample selection. In each academic year, a large majority of incoming freshmen completed an online housing application. This application asked a number of questions about an individual's housing preferences, gender, race/ethnicity, and smoking status. We use, as an illustration, the university housing assignment process for freshmen in the fall 2004, the year prior to our study. The 2004 data are used for the illustration because the information on the overall enrollment is unavailable for 2005–7. The same procedure for housing assignment was implemented in 2004–7 at the university.

Of the 3,800 first-year students applying for university housing in the 2004–2005 academic year, 3,195 applied by the May application deadline. Of these, 2,135 did not request a specific roommate. Of the 2,135 students, 1,515 did not request to participate in a themed housing program (e.g., foreign languages, health sciences, substance free, and global business). These 1,515 students were all in the same random assignment pool and thus met the eligibility requirements for inclusion in our study.

To randomly assign roommates to the remaining pool of 1,515 students, the university housing office placed applications into a large database, which was loaded into the software program RMS for random matching. Every student was then randomly assigned a unique RMS-ID number. After the first student had been placed in a room, the RMS program assigned his or her roommate as the next student in the chronological RMS-ID order who had compatible gender, smoking status, and type of requested room. In the procedure, roommates were essentially randomly assigned to each other within each gender/smoking/type of room cell.

A web survey in the Roommate Study collected the information on alcohol use and socio-economic background. The online survey was completed by 2,664 or 79.5% of the eligible students. Students who did not live on campus, who were too young (under 18) to be included in the alcohol study, and who were in a study-abroad program in a foreign country for the semester were not considered eligible. Of the 2,664 online survey participants, 543 were removed from analysis because their roommates did not respond to the survey.

The data from the Freshman Survey were used for validating the randomization of roommate assignments. The Freshman Survey was designed by the Cooperative Institutional Research Program (CIRP) at the Higher Educational Research Institute at the University of California at Los Angeles (UCLA). Each year, a large number of universities administer the Freshman Survey to entering students during orientation or registration. The survey attains a range of student characteristics including a small number of health behaviors. Our randomization validation analysis only included individuals in CIRP who were also in the Roommate Study and who had explicitly consented to our using their CIRP responses.

Our ROOM analysis was based on about 2,000 students that are roommates one another, with the actual sample size in each regression varying slightly because of the missing value in the dependent variable. To ensure our analytical sample is representative of the undergraduate student population at the university, we compared the characteristics of ROOM with those of the undergraduate student population. The mean incomes defined in

the section of Measures are 4.62 and 4.75, respectively for ROOM and CIRP. Levels of father education are 5.49 and 5.21, respectively for ROOM and CIRP. See next section on Measures and Table 2 for the coding of income and education. The proportions of males, Asian, Hispanics, African Americans, whites, and others are 0.38, 0.07, 0.058, 0.122, 0.659, and 0.091 for ROOM and 0.42, 0.073, 0.093, 0.092, 0.657, and 0.086 for the student population according to online information on *Student Headcount by Level, Race/Ethnicity, and Sex, Fall 2011*. The slightly larger proportion of African-American students in ROOM is due to our deliberate oversampling of these individuals for the Roommate Study.

Measures

Table 2 provides descriptive statistics for the variables used in regression analysis using data from ROOM, giving information on variable name, variable construction, the mean, and the standard deviation. The four dependent variables of college binge drinking and drinking were monthly counts of binge drinking or drinking episodes in the first fall semester of college and in the last fall semester. To generate a continuous measure of monthly alcohol use, these variables of alcohol use were coded as 0, 0.5, 1.5, 4.3, 12.9, and 25, respectively, for responses of never, less than once a month, once or twice a month, about once a week, 2–4 times a week, and every day or almost every day (Duncan et al. 2005).

All high school measures of binge drinking and drinking were coded as an indicator or 0–1 variable. Individuals who were engaged in binge drinking in high school were coded as 1, otherwise 0. The drinking indicator was coded similarly. Parental income was coded as a continuous variable of 1–9 for response categories of <\$25,000; \$25,000–49,999; \$50,000–74,999; \$75,000–99,999; \$100,000–149,999; \$150,000–199,999; \$200,000–249,999; \$250,000–499,999; and \$500,000 or more. Parental education was coded as a continuous variable of 1–7 for response categories of middle school or less, some high school, high school graduate, some college, college degree, postsecondary school other than college, and graduate or professional coursework or degree.

The variable of whether a roommate is considered a best friend is constructed from response to the following question: Based on your experience with the roommate during the fall semester of your first year of college, please indicate how much you agree or disagree with that you consider the roommate to be one of your best college friends. “Strongly agree” and “agree somewhat” are coded as one (33.9%), and “disagree somewhat” and “strongly disagree” are coded as zero (65.9%).

Three variables based on housing preferences were used as fixed effects. These were smoking status on the housing form, the residence hall cluster (south campus, north campus, or middle campus) assigned to each student, and whether the residential hall or floor was for females only, males only, coeds, or segregated coeds. The residential buildings in the same cluster tended to have a similar architectural structure, and students in the same building cluster tended to be from the same year.

Analytical Strategies

The main-effect hypothesis was tested by regressing ego's alcohol use in college on both self's and roommate's high school drinking behavior, adjusting for age, gender, socioeconomic characteristics of both self and roommate and fixed effects (Equation (1)):

$$\text{SelfDrinkingCollege}_{ijk} = \beta_0 + \beta_1(\text{RoommateDrank})_{ijk} + \beta_2(\text{SelfDrank})_{ijk} + \beta_3(\text{Controls})_{ijk} + u_k + v_{ij} + e_{ijk} \quad (1)$$

where SelfDrinkingCollege represented self's drinking behavior in college; RoommateDrank and SelfDrank represented "roommate drank in high school" and "self drank in high school"; and Controls were self's and roommate's socio-economic and other background characteristics. Subscripts i , j , and k were indexed for individuals, dorms, and lottery cells, respectively; and u_k , v_{ij} , and e_{ijk} are unobserved effects at the level of cells, dorms, and individuals.

Equation (2) tested the second hypothesis and allowed for peer influence to depend upon a student's drinking in high school. The model included dummy variables for three of the four combinations of self and roommate high school drinking behaviors. A step-up effect was given by β_1 in Equation (2):

$$\text{SelfDrinkingCollege}_{ijk} = \beta_0 + \beta_1(\text{BothDrank})_{ijk} + \beta_2(\text{BothNondrank})_{ijk} + \beta_3(\text{SelfNondrank/RoommateDrank})_{ijk} + \beta_4(\text{Controls})_{ijk} + u_k + v_{ij} + e_{ijk}, \quad (2)$$

where (BothDrank), (BothNondrank), and (SelfNondrank/RoommateDrank) referred to "both drank in high school", "neither drank in school", and "self did not drink while roommate drank in high school"; the combination of (SelfDrank/RoommateNondrank) was the omitted reference group in (equation 2). By the same token, a test of an initiation effect can be carried out by omitting the combination where both self and roommate were non-drinking in high school.

The third hypothesis concerning whether peers are also best friends was investigated by estimating main, step-up and initiation effects separately in two samples. One sample consists of only those who considered the roommate a best friend and the other sample consists of only those who did not consider the roommate a best friend. Equations (1) and (2) were estimated within each of the two samples.

We also conducted an interaction analysis using a more conventional interaction model:

$$\text{SelfDrinkingCollege}_{ijk} = \beta_0 + \beta_1(\text{RoommateDrank})_{ijk} + \beta_2(\text{SelfDrank})_{ijk} + \text{Controls}_{ijk}\beta_3 + \beta_4(\text{RoommateDrank} * \text{SelfDrank})_{ijk} + u_k + v_{ij} + e_{ijk},$$

(3)

where a product of RoommateDrank and SelfDrank is added to the main-effect model (1).

In (2), the focus is to test the effect of whether having a drinking roommate would increase the ego's alcohol use in college than having a non-drinking roommate, given the ego drank in high school. When model (3) is used to test against model (1), it tests whether having a drinking roommate and self drinking together have an additional effect over estimating only two main effects of having a drinking roommate and self-drinking. When a significant model (3) is estimated, the interaction effect of B_4 could be interpreted as the additional effect of having a drinking roommate and self drinking together over either self-drinking and having a non-drinking roommate or self non-drinking and having a drinking roommate. Thus, the interaction effect (B_4) in model (3) is more general than that (B_1) in model (2).

To test the robustness of the findings with respect to the normality assumption for our mixed linear models, we reanalyzed the data using generalized estimating equation for Poisson regression (Liang and Zeger 1993). These models do not need the assumption that the alcohol measures have a normal distribution. These models are also capable of addressing correlated data. The results remain similar.

The study participants were grouped into roommate pairs. Each individual in a roommate pair was used twice in the analysis, once as an ego and once as a roommate. The correlation among roommates within a dorm was addressed by random effect models (Searle 1971, Searle, Casella and McCulloch 1992). Equations (1) and (2) were estimated as a random effect model, which has long been established in the statistical literature for analysis of data that are not independent. The fixed effects were included in the estimation process by adding a set of indicator variables representing the cell. We included fixed effects that measure such factors as gender and smoking status to safeguard against threats to the natural experiment. Adding main as well as interaction fixed effects of gender and smoking systematically would eliminate biases from these factors. All two-way interactions among these indicator variables were first included in the models. However, we then removed interaction terms that could not be estimated because few or zero individuals are in these interaction categories.

We imputed the missing values in the control variables in order to preserve the consistency in the analysis samples between the analysis without controls and the analysis with controls. The small percentage (less than 5%) of missing values was imputed by the multiple imputation technique (Rubin 1987). Then the multiple completed datasets were analyzed separately by the PROC MIXED procedure in SAS before the results were combined to produce the overall inference. The imputation did not alter our findings substantively.

To verify that roommates were indeed assigned randomly, we performed two tests. First, we calculated within-dormitory correlations of six pre-college or high school responses obtained by the CIRP study, which was designed and carried out independently from our Roommate Study. The individuals in this calculation were respondents of the CIRP study, and they also happened to be a subset of the respondents in the Roommate Study. Second, we calculated within-dormitory correlations of seven pre-college behaviors obtained by ROOM. The individuals in the second test were respondents of ROOM. If the roommates were truly randomly assigned, these within-dormitory responses should not be correlated more than that by chance.

We calculated Gamma correlation coefficients $\Gamma = (\sum C - \sum D) / (\sum C + \sum D)$ (Goodman and Kruskal 1954) and their associated p-values of the χ^2 test for the randomization tests. The Gamma correlation coefficient was used because many of the outcomes are ordinal. The Gamma is a simple symmetric correlation ranging from -1 to 1. The coefficient is the proportion of concordant pairs to the total number of pairs, where concordance is recorded when a pair shared the same value of the variable.

To further ensure that estimated peer influences were based solely on variation induced by random assignment, we added the fixed-effect controls for preference “cells” in our regression analysis. This was necessary because the assignment of roommates in our study was random only with preference cells defined by gender, smoking status, and a small number of allowable housing preferences. The fixed-effects added at the cell level helped ensure that our estimates were based on variation within, rather than across, the preference cells.

FINDINGS

The findings in Table 3 attempt to confirm the random assignment of roommates. Table 3 presents the Gamma correlation coefficient and their χ^2 -test-based p-value for six pre-college behaviors (drinking, smoking, partying, hours spent socializing with friends, hours spent watching TV, and hours spent playing video games) measured in CIRP and seven pre-college behaviors (binge drinking, smoking, marijuana use, partying, aggressive behavior, impulsive behavior, and concurrent sexual partnering) measured in ROOM. The Gamma correlation coefficients tended to be small, and none of the 13 χ^2 tests was statistically significant at the 5 percent level. We performed the same tests via logistic regression, which included gender as an additional control. The results in Table 3 were replicated, strengthening the evidence that the roommates were randomly assigned (data not shown).

Table 4 presents regression estimates of main roommate effects on ego’s college drinking behaviors as well as the associated p-values and sample sizes. A total of four response variables were analyzed. The two binge drinking measures were monthly binge drinking episodes in college in the first fall semester and the last fall semester. The two drinking measures were a monthly count of drinking episodes in college in the first fall semester and the last fall semester. Each line in Table 4 presents results taken from a separate regression model. In a regression model, when the outcome was a binge drinking measure, the prior history of alcohol-use measures binge drinking for self and roommate. Otherwise, when the

outcome was a drinking measure, the prior history of alcohol-use measures drinking for self and roommate.

Roommate's binge drinking has a positive effect on a given student's binge drinking for the first-semester binge drinking measure but not the last-semester binge drinking measure. The roommate effect of 0.42 with a p-value of 0.0074 for the 1st fall binge drinking indicates that living with a roommate who binge drank in high school increased the monthly number of binge-drinking episodes in the first fall semester by 0.42. The roommate effect on binge drinking in the last fall semester is 0.20 and not statistically significant.

The two main roommate effects on monthly drinking episodes for the first and last fall semesters were 0.66 (p=0.001) and 0.47 (p=0.021), respectively. The effects of ego's own alcohol-use experience in high school were large and statistically significant. In Table 5, two of the four main-effect models using ROOM data are presented in full including the controls, the two dependent variables being the first fall semester binge drinking and drinking.

Table 6 presents step-up effects and initiation effects of roommates on own alcohol use from the regression analysis. Each table entry, based on a separate regression model, represents a regression coefficient or roommate effect with its p-value in a parenthesis. Both step-up and initiation effects are based on (Equation 2). The comparison of a step-up and its corresponding initiation effect brings to light the potential importance of the history of alcohol use.

Table 6 shows a statistically significant step-up effect for all four drinking measures. Among those who binge drank in high school, having a binge-drinking roommate in college increased the monthly count of binge-drinking episodes by 1.08 and 0.76 in the first fall semester and the last fall semester, respectively. Having a drinking roommate also increased the monthly count of drinking episodes by 0.96 and 0.88 in the first fall semester and the last fall semester. The four respective p-values for the four step-up effects were <0.0001, 0.0023, <0.0002, and 0.0010, respectively.

Table 6 shows a dramatically different pattern of initiation effects from that of step-up effects. The four initiation effects were all a fraction of the step-up effects in size (-0.02 vs. 1.08, -0.17 vs. 0.76, 0.16 vs. 0.96, and -0.13 vs. 0.88, respectively). With the p-values being 0.92, 0.40, 0.63, and 0.68, respectively, none of the four initiation effects approached the marginal significance of 0.10. In Table 5, four of the eight step-up and initiation effects models are presented in full including the controls, the two dependent variables being the first fall semester binge drinking and the first fall semester drinking.

Among the effects of the controls (Table 5), on average, male students had about one-half of a binge-drinking episode per month more and about one drinking episode per month more than female students. The average monthly drinking episodes in the residential building where the ego resided are positively related to drinking, but not binge drinking. On average, an increase of one drinking episode in the residential building is associated with about one additional drinking episode for the ego. Whites and Hispanics reported the most alcohol use. Asians reported about 0.8 of a binge-drinking episode per month and one drinking episode per month fewer than Whites. Blacks reported 0.6 of a binge-drinking episode and 1.5

drinking episodes per month fewer than Whites. GPA is negatively associated with alcohol use, each GPA point decreasing about one-half of a binge drinking episode and one half of a drinking episode per month. Ego's family income is positively related to both binge drinking and drinking. Roommate's family income is positively associated with binge drinking, but not drinking. Ego's parental education, roommate's parental education, roommate's race and ethnicity, and roommate's GPA are not related to alcohol use.

Table 7 provides findings of main, step-up and initiation peer effects among friends and non-friends. All regression models were estimated with full controls as in other models of peer effects. The two sets of findings contrast sharply. In spite of much larger samples for the analysis of "Roommate considered a friend" than that for the analysis of "Roommate not considered a friend", peer effects were much larger and more statistically significant when the roommate was considered a friend. The main peer effects and step-up effects were about twice as large as and also more significant when the roommate was a friend than when the roommate was not a friend. What is more noteworthy is the substantial step-up effects when the roommate was not considered a friend. For three out of the four outcome variables, a statistically significant step-up effect ranging between 0.75 to 1.09 was obtained in the non-friend models. None of the initiation effects are statistically significant. Thus, for those college students who did not have a history of alcohol use, drinking behavior was not influenced by roommates even when the roommate was considered a friend.

Table 8 provides findings from a more conventional setup of interaction analysis (Model 3). In this setup, each outcome of alcohol use is regressed on own drinking behavior in high school, peer drinking behavior in high school, and the product of the two as well as controls (not shown), each row describing a separate regression model. The two interaction terms for alcohol use in the last fall semester are significant at the level of 0.05; the two interaction terms for the first fall semester are significant at 0.10. These findings indicate that ego drinking in high school plus roommate drinking in high school increases ego drinking in college. More specifically, the first row indicates that those who binge-drank in high school and who were paired up with a roommate binge-drinking in high school had 0.64 more binge-drinking episodes per month in the first fall semester in college than either those who only binge-drank in high school or those who were only paired up with a roommate binge-drinking in high school. The interaction results in Table 8 are more general than the interaction results in Tables 5–7; the latter interaction results are obtained comparing with those who binge-drank in high school and whose college roommate did not binge-drink in high school.

All regression models using ROOM data included a set of fixed effects designed to capture unobserved effects related to roommate assignment as well as the interaction effects among these fixed effects. To simplify the interaction analysis, all the fixed-effect variables were re-coded into a two-category categorical variable in the final models. The interaction terms among the fixed effects that were highly correlated were excluded from the final models. Different ways of specifying the fixed effects do not alter the findings substantively. The within-room correlation is 12% for college drinking; the correlation estimates are smaller and non-significant for binge-drinking measures. The analyses were repeated using the GEE Poisson regression models, and the findings were substantially the same.

DISCUSSION AND CONCLUSION

Figure 1 summarizes the main, step-up and initiation effects for the combined friend and non-friend data (Panel 1), the friend data (Panel 2), and non-friend data (Panel 2) for the four outcomes of alcohol use. All findings are from a naturally occurring experiment on a college campus that has removed the threat of bias arising from selection processes.

In Panel 1, the step-up, main, and initiation effects are visibly ranked, with step-up effects the largest and most statistically significant. Our study shows a statistically significant main or average effect of a drinking roommate on three of the four alcohol-use outcomes. A college student experienced an additional two-fifths of a binge drinking episode per month and an additional one-half of a drinking episode per month when randomly assigned a roommate who drank in high school instead of one who did not. Our data indicate that one's drinking history interacts with peer influences, shaping the strength of peer influence. Step-up effects contrast conspicuously with initiation effects. Step-up effects, or the roommate effects on those who drank themselves in high school, were about one additional drinking episode when assigned a roommate who drank in high school than when assigned a roommate who did not drink in high school. In contrast, no initiation effects were found, or the effects of a roommate's drinking on those who did not drink in high school. This pattern of strong step-up effects and absence of initiation effects was replicated between binge drinking and drinking, and across measures of alcohol use in the first fall semester and the last fall semester. These interaction findings are confirmed by a set of more conventionally obtained interaction findings, where interactions are estimated by two main effects and a product of the two.

Panel 2 shows that peer influence is also affected by whether a peer is considered a friend. A peer effect tends to be larger and more statistically significant when the peer is considered a friend. When a peer was considered a friend, the step-up effect is the largest (ranging from 1.25–1.61 drinking episodes per month) and the most significant. It is important to note that even when a peer was not considered a friend, for three of the four alcohol measures, the step-up effects are statistically significant, ranging from 0.75–1.09 drinking episodes per month). The main peer effects are largely statistically non-significant when the peer is not considered a friend.

Our findings show that the presence and the size of a peer effect on alcohol use depend on both a history of alcohol use and friendship between peers. One had to have a history of alcohol use to be swayed by a drinking peer. Step-up effects or the conditional peer effects on binge drinking as well as drinking for those with a prior history of drinking were about twice as large as the peer effects averaged over the entire sample. When one did not have a history of alcohol use, peer influences were absent.

Friendship between peers enhances the peer effect on alcohol use. Our analysis that takes into consideration friendship suggests that peer effects estimated in an observational study may be exaggerated. That is, the estimated correlation in alcohol use between nominated friends in an observational study tends to be larger than peer influences in a natural experiment in which peers may or may not become friends. However, our analysis shows

that peers who were not considered friends do exert a substantial effect on an ego's drinking behavior so long as the ego has a history of alcohol use.

Our ROOM data recorded an important aggregate peer effect of the number of monthly drinking episodes averaged over all students in a residence hall in which the ego resided. An increase of one drinking episode per month in the residence hall was associated with 1.14 more drinking episodes for the ego. This effect was likely to be exogenous given each student was randomly assigned a roommate and the fixed effects concerning residence halls were included in the regression model. The level of binge drinking in residence hall, however, does not have an effect on ego's binge drinking.

Our work makes two theoretical contributions. First, our empirical findings lend support to the social learning perspective, demonstrating that social network capital or peer influences can causally affect delinquent behavior. Second, our analysis of the interaction between peers and self drinking history can be considered an initial test of the self-control theory of Gottfredson and Hirschi (1990), which predicts that social control is less effective for individuals with weak self-control. Our analysis shows that individuals with a history of drinking are more vulnerable to the influences of drinking peers. Our work also shows that the social control and social learning perspectives can be evaluated simultaneously in the same model.

Less than 1% of our sample or 19 individuals reported as smokers on the housing application form. Smoking and drinking may be correlated. In spite of the stated housing policy of matching on smoking status in room assignment, our data indicate that smoking students were not matched. In other words, none of the dorm rooms has more than one smoking resident. Apparently, the individuals in our sample were assigned randomly regardless of smoking status. To safeguard against potential confounding from smoking, we used smoking status as a fixed effect in all models we estimated.

The present study has several limitations. The roommate effect represents only a subset of the total peer effects. Our analysis demonstrates a substantial effect of drinking in a dormitory. Many other peer influences are at work on a college campus. For example, we have not taken into consideration effects of other friends on campus and off campus or the effects of campus fraternities and sororities. The total peer effect at work on a college-age student can be many times as large as the ones we estimated.

We realize that that prior history of alcohol use in high school as a measure of self-control is not ideal. Gottfredson and Hirschi (1990) conceive the concept of self-control to be a relatively stable ability to restrain from behaviors that give immediate gratification – an ability that is developed in childhood. Excessive drinking is one of the behaviors they suggested using for measuring self-control. We used binge drinking in high school to measure self-control in regression predicting binge drinking in college; we used drinking in high school to measure self-control in regression predicting drinking in college. History of alcohol use in high school is a composite measure molded by social context, experiences, and biological factors up to the point of measurement. The interpretation of this measure of

self-control may not be clear-cut. Alternatively, self-control in this type of analysis may be measured by genetic propensity for alcohol use when the data become available.

It should be recognized that measuring alcoholism is a complex and difficult task. The pros and cons of the 5+/4+ binge drinking measure have been debated (Wechsler and Nelson 2001). The 5+/4+ measure has a number of weaknesses. The measure does not take into account age and body weight though these pieces of information could be readily incorporated into a regression analysis when they are available. Criticism points out that the 5+/4+ measure does not always reliably predict blood alcohol content at or above 0.08% or higher blood alcohol concentrations (BACs) (Perkins, DeJong and Linkenbach 2001). Not all those who drink 5+/4+ are alike. Some get drunk more and suffer more serious consequences than others (Read et al. 2008). Some binge-drinkers drink at levels far higher than the binge threshold (White, Kraus and Swartzwelder 2006). These authors suggest distinguishing more heavy drinkers from those just beyond the binge threshold so that the more severe consequences of these heavy drinkers could be targeted for analysis.

On the other hand, a growing consensus emerges that recognizes the measure reflects an important high-risk drinking pattern. The 5+/4+ measure represents the amount of ethanol intake that results in an increase in the risks of accidental injuries because of an impairment in psychomotor and cognitive effectiveness. It is suggested that the 5+/4+ measure could be used as a continuous variable, along which each type of alcohol-related harm of various degree is defined (Saha, Stinson and Grant 2007). Others, while agreeing that the most serious alcohol-related injuries are better modeled using a higher threshold, support the continued use of the 5+/4+ threshold (Livingston 2013). Our measures of binge drinking and drinking are two of numerous possible measures of alcohol use. Collecting other variants of alcohol-related measures and even recoding our measures may well reveal important insights we have not uncovered so far.

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References

- Akers RL 2001 "Social Learning Theory" Pp. 192–210 in *Explaining Criminals and Crime: Essays in Contemporary Criminological Theory* edited by P. R and B. R. Los Angeles, CA: Roxbury.
- Akers Ronald. 1985 *Deviant Behavior: A Social Learning Approach*, 3rd Ed. Belmont, California: Wadsworth.
- Bandura A. 1971 *Social Learning Theory*. New York: General Learning Press.
- Berelson B, F Lazarsfeld P and McPhee W. 1954 *Voting*. Chicago: University of Chicago Press.
- Berkowit W 1969 "Perceived Height Personality and Friendship Choice." *Psychological Reports* 24(2):373-&. [PubMed: 5809031]
- Berscheid E and Walster E. 1978 *Interpersonal Attraction* New York: Random House.
- Billy JOG and Udry JR. 1985 "Patterns of Adolescent Friendship and Effects on Sexual Behavior. ." *Social Psychology Quarterly* (48):27–41.

- Boisjoly J, Duncan GJ, Kremer M, Levy DM and Eccles J. 2006 "Empathy or Antipathy? The Impact of Diversity." *American Economic Review* 96(5):1890–905.
- Borsari B and Carey KB. 2001 "Peer Influences on College Drinking: A Review of the Research." *Journal of Substance Abuse* 13(4):391–424. [PubMed: 11775073]
- Christakis Nicholas A. and Fowler James H.. 2007 "The Spread of Obesity in a Large Social Network over 32 Years." *N Engl J Med* (357):370–79. [PubMed: 17652652]
- Cohen-Cole E and Fletcher JM. 2008 "Is Obesity Contagious? Social Networks Vs. Environmental Factors in the Obesity Epidemic." *Journal of Health Economics* 27(5):1382–87. doi: 10.1016/j.jhealeco.2008.04.005. [PubMed: 18571258]
- Cohen J, Jere M 1977 "Sources of Peer Group Homogeneity. *Sociology of Education.*" *Sociology of Education* 50:227–41.
- Curran P, Stice E and Chassin L. 1997 "The Relation between Adolescent Alcohol Use and Peer Alcohol Use: A Longitudinal Random Coefficients Model." *Journal of Consulting and Clinical Psychology*:65(1), 130–40. [PubMed: 9103742]
- Duncan GJ, Boisjoly J, Kremer M, Levy DM and Eccles J. 2005 "Peer Effects in Drug Use and Sex among College Students." *Journal of Abnormal Child Psychology* 33(3):375–85. [PubMed: 15957564]
- Duncan OD, Featherman DL and Duncan B. 1972 *Socioeconomic Background and Achievement*. New York: Seminar Press.
- Durkheim Emile. 1897 "Le Suicide." Paris: Alcan.
- Eastman Peggy. 2002 "The Student Perspective on College Drinking." NIAAA website: <http://www.collegedrinkingprevention.gov/supportingresearch/student1.aspx>
- Foster G 2006 "It's Not Your Peers, and It's Not Your Friends: Some Progress toward Understanding the Educational Peer Effect Mechanism." *Journal of Public Economics* 90(8–9):1455–75. doi: 10.1016/j.jpubeco.2005.12.001.
- Gibson C, Schreck CJ and Miller JM. 2004 "Binge Drinking and Negative Alcohol-Related Behaviors: A Test of Self-Control Theory." *Journal of Criminal Justice* 32(5):411–20. doi: 10.1016/j.jcrimjus.2004.06.003.
- Giordano PC, Cernkovich SA and Pugh MD. 1986 "Friendships and Delinquency." *American Journal of Sociology* 91(5):1170–202. doi: 10.1086/228390.
- Glueck Sheldon and Glueck Eleanor. 1950 *Unraveling Juvenile Delinquency*. New York: The Commonwealth Fund.
- Goodman LA and H Kruskal W. 1954 "Measures of Association for Cross Classifications." *Journal of the American Statistical Association* (49):732–64.
- Gottfredson MR and Hirschi Travis.. 1990 *A General Theory of Crime*. Stanford, CA:: Stanford University Press.
- Haynie DL 2001 "Delinquent Peers Revisited: Does Network Structure Matter?." *American Journal of Sociology* 106(4):1013–57.
- Hingson R, Zha W and Weitzman ER. 2009 "Magnitude of Alcohol-Related Mortality and Morbidity among U.S. College Students Ages 18–24: Changes from 1998 to 2005." *Journal of Studies on Alcohol and Drugs Supplement no.16*:12–20.
- Hirschi Travis. 1969 *Causes of Delinquency*. Los Angeles, CA: University of California Press.
- Johnson PB. 1989 "Reactions, Expectancies, and College Student's Drinking." *Psychology Report* 65:1245–46.
- Kandel DB 1978 "Homophily, Selection, and Socialization in Adolescent Friendships." *American Journal of Sociology* 84(2):427–36.
- Kornhauser Ruth. 1978 *Social Sources of Delinquency*. Chicago: University of Chicago Press.
- Kreager DA and Haynie DL. 2011 "Dangerous Liaisons? Dating and Drinking Diffusion in Adolescent Peer Networks." *American Sociological Review* 76(5):737–63. doi: 10.1177/0003122411416934. [PubMed: 25328162]
- Kremer M and Levy D. 2008 "Peer Effects and Alcohol Use among College Students." *Journal of Economic Perspectives* 22(3):189–206.

- Lazarsfeld PF and Merton RK. 1954 "Friendship as a Social Process" in *Freedom and Control in Modern Society*, edited by Berger TAM, & Page CH. Princeton, NJ: Van Nostrand.
- Liang KY and Zeger SL. 1993 "Regression-Analysis for Correlated Data." *Annual Review of Public Health* 14:43–68.
- Livingston M 2013 "Testing Different Thresholds for Risky Episodic Drinking What's So Special About Five Drinks?." *Drug and Alcohol Dependence* 133(1):248–53. doi: 10.1016/j.drugalcdep.2013.04.027. [PubMed: 23726976]
- Manski C. 1993a "Identification of Endogenous Social Effects: The Reflection Problem." *Review of Economic Studies*:60: 531–42.
- Manski CF 1993b "Identification of Endogenous Social Effects - the Reflection Problem." *Review of Economic Studies* 60(3):531–42. doi: 10.2307/2298123.
- Matsueda RL 1982 "Testing Control-Theory and Differential Association - a Causal-Modeling Approach." *American Sociological Review* 47(4):489–504.
- Matsueda RL and Anderson K. 1998 "The Dynamics of Delinquent Peers and Delinquent Behavior." *Criminology* 36(2):269–308.
- Matsueda RL, Kreager DA and Huizinga D. 2006 "Deterring Delinquents: A Rational Choice Model of Theft and Violence." *American Sociological Review* 71(1):95–122.
- McPherson Miller, Smith-Lovin Lynn and Cook James M. 2001 "Birds of a Feather: Homophily in Social Networks". *Annual Review of Sociology* 27:415–44.
- Moffitt RA, ed. 2001 *Policy Interventions, Low-Level Equilibria and Social Interactions*, Edited by Durlauf S and Young P. Cambridge, MA: MIT Press.
- Mouw T 2006 "Estimating the Causal Effect of Social Capital: A Review of Recent Research." Pp. 79–102 in *Annual Review of Sociology*, Vol. 32, *Annual Review of Sociology*.
- Palmer RS, McMahon TJ, Rounsaville BJ and Ball SA. 2010 "Coercive Sexual Experiences, Protective Behavioral Strategies, Alcohol Expectancies and Consumption among Male and Female College Students." *Journal of Interpersonal Violence* 25(9):1563–78. doi: 10.1177/0886260509354581. [PubMed: 20040711]
- Perkins HW, DeJong W and Linkenbach J. 2001 "Estimated Blood Alcohol Levels Reached by "Binge" and "Nonbinge" Drinkers: A Survey of Young Adults in Montana." *Psychology of Addictive Behaviors* 15(4):317–20. doi: 10.1037//0893-164x.15.4.317. [PubMed: 11767263]
- Piquero Alex R., Gibson Chris L. and Tibbetts Stephen G.. 2002 "Does Self-Control Account for the Relationship between Binge Drinking and Alcohol-Related Behaviours?". *Criminal Behaviour and Mental Health* 12:135–54. [PubMed: 12459815]
- Read JP, Beattie M, Chamberlain R and Merrill JE. 2008 "Beyond the "Binge" Threshold: Heavy Drinking Patterns and Their Association with Alcohol Involvement Indices in College Students." *Addictive Behaviors* 33(2):225–34. doi: 10.1016/j.addbeh.2007.09.001. [PubMed: 17997047]
- Reifman A, Barnes G, Dintcheff B, Farrell M and Uhteg L. 1998 "Parental and Peer Influences on the Onset of Heavier Drinking among Adolescents." *Journal of Studies on Alcohol*:59(3): 311–18. [PubMed: 9598712]
- Roudsari BS, Leahy MM and Walters ST. 2009 "Correlates of Dating Violence among Male and Female Heavy-Drinking College Students." *Journal of Interpersonal Violence* 24(11):1892–905. doi: 10.1177/0886260508325492. [PubMed: 18981192]
- Rubin DB. 1987 *Multiple Imputation for Nonresponse in Surveys*. New York: John Wiley and Sons
- Sacerdote B 2001 "Peer Effects with Random Assignment: Results for Dartmouth Roommates." *Quarterly Journal of Economics* 116(2):681–704.
- Saha TD, Stinson FS and Grant BF. 2007 "The Role of Alcohol Consumption in Future Classifications of Alcohol Use Disorders." *Drug and Alcohol Dependence* 89(1):82–92. doi: 10.1016/j.drugalcdep.2006.12.003. [PubMed: 17240085]
- Sampson Robert J. and Laub John H.. 1993 *Crime in the Making: Pathways and Turning Points through Life*. Cambridge, MA: Harvard University Press.
- Schilling EA, Aseltine RH, Glanovsky JL, James A and Jacobs D. 2009 "Adolescent Alcohol Use, Suicidal Ideation, and Suicide Attempts." *Journal of Adolescent Health* 44(4):335–41. doi: 10.1016/j.jadohealth.2008.08.006. [PubMed: 19306791]

- Schulenberg John E. and Maggs Jennifer L.. 2002 “A Developmental Perspective on Alcohol Use and Heavy Drinking During Adolescence and the Transition to Young Adulthood.” *Journal of Studies on Alcohol* 14:54–70.
- Searle SR 1971 *Linear Models*. New York: Wiley and Sons.
- Searle SR, Casella Gand McCulloch C. 1992 *Variance Components* New York: Wiley & Sons.
- Singleton RA and Wolfson AR. 2009 “Alcohol Consumption, Sleep, and Academic Performance among College Students.” *Journal of Studies on Alcohol and Drugs* 70(3):355–63. [PubMed: 19371486]
- Snijders TAB and Baerveldt C. 2003 “A Multilevel Network Study of the Effects of Delinquent Behavior on Friendship Evolution.” *Journal of Mathematical Sociology* 27(2–3):123–51. doi: 10.1080/00222500390213119.
- Steglich C, Snijders TAB and Pearson M. 2010 “Dynamic Networks and Behavior: Separating Selection from Influence” Pp. 329–93 in *Sociological Methodology*, Vol 40, Vol. 40, Sociological Methodology, edited by Liao TF.
- Sun IY and Longazel JG. 2008 “College Students’ Alcohol-Related Problems: A Test of Competing Theories.” *Journal of Criminal Justice* 36(6):554–62. doi: 10.1016/j.jcrimjus.2008.09.007.
- Sutherland EH 1947 *Principles of Criminology*, 4th Ed. Philadelphia: J. B. Lippincott.
- Thombs DL 1999 *An Introduction to Addictive Behaviors*. New York: Guilford Press.
- Travis Hirschi Travis and Gottfredson Michael R.. 1994 “The Generality of Deviance “ Pp. 1–22 in *The Generality of Deviance*, edited by Travis Hirschi t. and Gottfredson MR. New Brunswick, NJ: Transaction.
- Wechsler H and Nelson TF. 2001 “Binge Drinking and the American College Student: What’s Five Drinks?”. *Psychology of Addictive Behaviors* 15(4):287–91. doi: 10.1037//0893-164x.15.4.287. [PubMed: 11767258]
- Wechsler Henry, Davenport Andrea, Dowdall George, Moeykens Barbara and Castillo Sonia. 1994 “Health and Behavioral Consequences of Binge Drinking in College: A National Survey of Students at 140 Campuses.” *JAMA (Journal of the American Medical Association)* 272(21):1672–77. [PubMed: 7966895]
- Weerman FM 2011 “Delinquent Peers in Context: A Longitudinal Network Analysis of Selection and Influence Effects.” *Criminology* 49(1):253–86. doi: 10.1111/j.1745-9125.2010.00223.x.
- White AM, Kraus CL and Swartzwelder HS. 2006 “Many College Freshmen Drink at Levels Far Beyond the Binge Threshold.” *Alcoholism-Clinical and Experimental Research* 30(6):1006–10. doi: 10.1111/j.1530-0277.2006.00122.x.
- Zimmerman DJ 2003 “Peer Effects in Academic Outcomes: Evidence from a Natural Experiment.” *Review of Economics and Statistics* 85(1):9–23.

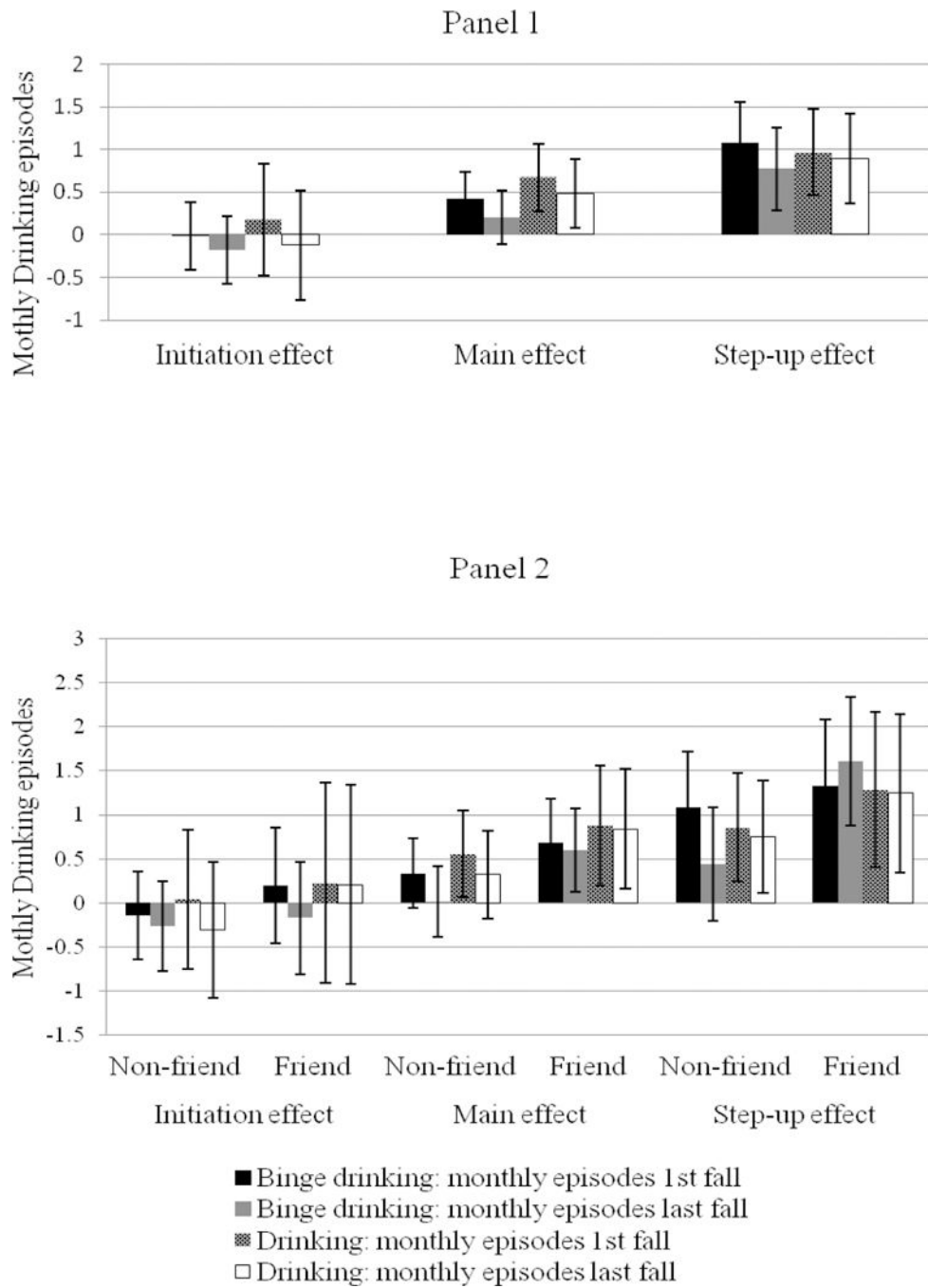


Figure 1. The main, step-up and initiation effects for the combined friend and non-friend data (Panel 1), the friend data (Panel 2), and non-friend data (Panel 2) for the four outcomes of alcohol use

Table 1.

A flow-table illustrating who were sampled and the timing of the sampling

Time line ->	Fall 2005	Fall 2006	Fall 2007	Spring 2008: Two weeks before survey	Spring 2008: time of our survey	N
Freshman in fall 2007	NA	NA	1st fall semester in college	1st spring semester in college	1st spring semester in college	632
Sophomore in fall 2007	NA	1st fall semester in college	2nd fall semester in college	2nd spring semester in college	2nd spring semester in college	965
Junior in fall 2007	1st fall semester in college	2nd fall semester in college	3rd fall semester in college	3rd spring semester in college	3rd spring semester in college	470
Total						2,067

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Table 2.

Descriptive statistics for variables used in ROOM regression analysis

Description or Coding Definition		Mean	SD
College Behavior			
Binge drinking: monthly episodes 1st fall	Count of five [four if female] or more drinks in a row in the fall semester of 1 st year of college	2.16	3.92
Binge drinking: monthly episodes last fall	Same as above for past fall semester (fall 2007)	2.14	3.83
Drinking: monthly episodes 1st fall	Count of monthly drinking times in the fall semester of 1 st year of college	3.71	4.84
Drinking: monthly episodes last fall	Same as above for past fall semester (fall 2007)	3.75	4.90
Pre-college or high school behavior[†]			
Ego binge drinking	Binge drinking before college=1; otherwise=0	0.40	0.49
Ego drinking	Drinking before college=1; otherwise=0	0.61	0.49
Roommate binge drinking	Binge drinking before college=1; otherwise=0	0.40	0.49
Roommate drinking	Drinking before college=1; otherwise=0	0.61	0.49
Controls			
Ego family income	Respond's reported parents' or guardians' total income in the 12 months before college	4.63	2.00
Ego Mom education	Highest level of formal education obtained by mother	5.33	1.39
Ego Dad education	Highest level of formal education obtained by father	5.50	1.49
Ego GPA	Self-reported GPA past fall semester (fall 2007)	3.23	0.54
Ego gender	Male	0.38	
	Female	0.62	
Ego race/ethnicity	Asian	0.070	
	Hispanic	0.058	
	African	0.122	
	White	0.659	
	Other	0.091	
Roommate family income	Respond's reported parents' or guardians' total income in the 12 months before college	4.62	2.00
Roommate Mom education	Highest level of formal education obtained by mother	5.32	1.39
Roommate Dad education	Highest level of formal education obtained by father	5.49	1.49
Roommate GPA	Self-reported GPA past fall semester (fall 2007)	3.23	0.54
Roommate race/ethnicity	Asian	0.069	
	Hispanic	0.057	
	African	0.122	
	White	0.659	
	Other	0.092	
Building alcohol use	Average level of alcohol use in residence hall	1.83	0.29
Roommate a friend	Considering roommate best college friend		
	Strongly agree	0.185	
	Agree somewhat	0.154	

	Description or Coding Definition	Mean	SD
College Behavior			
	Disagree somewhat	0.210	
	Strongly disagree	0.449	
Fixed effects			
Hall gender	Segregated co-ed	0.86	
	Co-ed	0.06	
	All female	0.04	
	All male	0.04	
Campus location	South campus	0.26	
	North campus	0.11	
	Middle campus	0.63	
Smoker status	Yes	0.01	
in housing form	No	0.99	
N		1989–2070	

[†]Roommate's descriptive statistics are the same as those of egos'

Table 3.

Additional evidence for random assignment of roommates in ROOM: Non-parametric Gamma correlation coefficient and P-value of χ^2 test

Strategy	Within-dorm correlation based on pre-college CIRP responses and pre-college Roommate Study responses		
Variables	Gamma	P of χ^2	N
Pre-college Behavior from CIRP			
Had drank	0.16	0.09	434
Smoked cigarettes	-0.41	0.23	438
Partying	-0.05	0.63	416
Hours Socializing with Friends	-0.10	0.49	422
Hours Watching TV	-0.01	0.99	416
Hours Playing Video Games	0.25	0.20	418
Pre-college Behavior from ROOM			
Binge drinking	0.022	0.74	1,032
Smoking	-0.009	0.94	1,009
Marijuana use	0.053	0.48	1,027
Partying	0.066	0.56	1,028
Aggressive behavior	-0.052	0.62	1,024
Impulsive behavior	0.162	0.59	1,033
Concurrent sexual partnering:	-0.283	0.31	1,023

Table 4.

Regression-estimated main or average peer effects (p-value) from ROOM: self's drinking behavior was regressed on peer drinking behavior in high school, own drinking behavior in high school and controls (not shown), each row from a separate regression model

OUTCOMES	MAIN EFFECT		N
	Own high school behavior	Roommate high school behavior	
Binge drinking: monthly episodes 1st fall	3.79(<.0001) ***	0.42(.0074) **	2,067
Binge drinking: monthly episodes last fall	3.32(<.0001) ***	0.20(0.20)	2,067
Drinking: monthly episodes 1st fall	3.82(<.0001) ***	0.66(0.001) ***	1,989
Drinking: monthly episodes last fall	3.44(<.0001) ***	0.47(0.021) *	2,070

= p-value<.001;

**
= p-value<.01;

*
= p-value<.05.

All regression models control for ego's and roommate's gender, race/ethnicity, GPA, mother's education, father's education as well as average alcohol use in the dorm building and a set of fixed effects at the level of cells, dorms and individuals.

Table 5.

Full models of average effects, step-up effects and initiation effects for binge drinking and drinking in the 1st fall semester in college using ROOM

Predictors	Binge drinking monthly episodes 1 st fall semester in college			Drinking monthly episodes 1 st fall semester in college		
	Main effect	Step-up effect	Initiation effect	Main effect	Step-up effect	Initiation effect
Alcohol use in high school						
Roommate drank	0.42**			0.66***		
Self drank	3.79***			3.82***		
Self drank/roommate non-drank		--			--	
Both drank		1.08***		0.96***		
Self non-drank/roommate drank		-3.38***		-3.16***		
Neither drank		-3.36***		-3.35***		
Neither drank			--			--
Self non-drank/roommate drank			-0.02			0.16
Self drank/roommate non-drank			3.36***			3.36***
Both drank			4.43***			4.35***
Controls						
Male	0.58***	0.58***	0.58***	0.95***	0.95***	0.95***
Average alcohol use dorm building	0.46	0.48	0.48	1.14**	1.15**	1.15**
Race/ethnicity White (ego)	--	--	--	--	--	--
Asian	-0.81**	-0.82**	-0.82**	-1.08**	-1.01**	-1.01**
Hispanic	0.08	0.04	0.04	0.39	0.40	0.40
Black	-0.61*	-0.63*	-0.63*	-1.61***	-1.57***	-1.57***
Other	-0.37	-0.41	-0.32	-0.48	-0.49	-0.49
GPA (ego)	-0.43**	-0.44**	-0.44**	-0.59**	-0.55**	-0.55**
Family income (ego)	0.13**	0.12*	0.12*	0.19**	0.18**	0.18**
Mother's education (ego)	0.004	0.02	0.02	0.03	0.04	0.04

Predictors	Binge drinking monthly episodes 1 st fall semester in college			Drinking monthly episodes 1 st fall semester in college		
	Main effect	Step-up effect	Initiation effect	Main effect	Step-up effect	Initiation effect
Father's education (ego)	0.015	0.01	0.01	0.09	0.09	0.09
Race/ethnicity White (roommate)	--	--	--	--	--	--
Asian	0.31	0.31	0.31	0.12	0.10	0.10
Hispanic	-0.09	-0.13	-0.13	-0.09	-0.09	-0.09
Black	-0.03	-0.04	-0.04	-0.14	-0.10	-0.10
Other	0.09	0.05	0.05	-0.06	-0.04	-0.04
GPA (roommate)	0.018	0.01	0.01	0.16	0.20	0.20
Family income (roommate)	0.10 [*]	0.10 [*]	0.10 [*]	0.06	0.05	0.05
Mother's education (roommate)	-0.03	-0.03	-0.03	0.003	-0.04	-0.04
Father's education (roommate)	-0.06	-0.06	-0.06	-0.05	0.01	0.01
Fixed effects						
Segregated co-ed	0.09	-0.01	-0.01	-0.35	-0.36	-0.34
South campus	0.36	0.38	0.38	0.59 [*]	0.60 [*]	0.61 [*]
Smoker in housing form	-1.95	-1.96	-1.96	5.95 [*]	6.03 [*]	6.03 [*]
Smoker [*] south campus	4.18	4.38	4.38	5.23	5.25	5.25
Smoker [*] Segregated co-ed	-1.68	-2.02	-2.02	-8.41 [*]	-8.58 [*]	-8.58 [*]
Random Parameters						
Between variance $V(v_{ij})$	0.60 [*]	0.55 [#]	0.55 [#]	2.16 ^{***}	2.14 ^{***}	2.14 ^{***}
Within variance, $V(e_{ijk})$	10.2 ^{***}	10.2 ^{***}	10.2 ^{***}	15.4 ^{***}	15.4 ^{***}	15.4 ^{***}
Within-room correlation	0.06	0.05	0.05	0.12	0.12	0.12
N	2,067	2,067	2,067	1,989	1,989	1,989

*** = p-value < .001;

** = p-value < .01;

* = p-value < .05;

= p-value < .10.

†: The main, step-up and initiation effects are bolded for easy reading.

Table 6.

Comparison of step-up effect (p-value) and initiation effect (p-value) from ROOM, both interactive peer effects based on Equation (2), and each table entry based on a separate regression model

Outcomes	Step-up effect	Initiation effect	N
Behavior in college	<i>For students drinking in high school, effect of being assigned a drinking roommate</i>	<i>For students non-drinking in high school, effect of being assigned a drinking roommate</i>	
Binge drinking: monthly episodes 1st fall	1.08(<.0001)***	-0.02(0.92)	2,067
Binge drinking: monthly episodes last fall	0.76(0.0023)**	-0.17(0.40)	2,067
Drinking: monthly episodes 1st fall	0.96(.0002)***	0.16(0.63)	1,989
Drinking: monthly episodes last fall	0.88(0.0010)***	-0.13(0.68)	2,070

= p-value<.001;

**
= p-value<.01;

*
= p-value<.05;

= p-value<.10.

All regression models control for ego's and roommate's gender, race/ethnicity, GPA, mother's education, father's education as well as average alcohol use in the dorm building and a set of fixed effects at the level of cells, dorms and individuals.

Table 7.

The main, step-up and initiation effects of a roommate when ego considers the roommate (1) a best college friend and (2) not a best college friend, each coefficient from a separate regression model

Outcomes and Effect Type	(1) Roommate considered a best friend			(2) Roommate not considered a best friend		
	Coeff	p-value	N	Coeff	p-value	N
Binge drinking: monthly episodes 1st fall						
main effect	0.68	0.008**	721	0.34	0.095#	1343
step up effect	1.32	0.0007***	721	1.09	0.0006***	1343
initiation effect	0.20	0.56	721	-0.14	0.58	1343
Binge drinking: monthly episodes last fall						
main effect effect	0.60	0.014*	721	0.011	0.96	1343
step up effect	1.61	<.0001***	721	0.44	0.18	1343
initiation effect	-0.17	0.59	721	-0.26	0.32	1343
Drinking: monthly episodes 1st fall						
main effect	0.88	0.012*	707	0.55	0.027*	1279
step up effect	1.28	0.0045**	707	0.86	0.0063**	1279
initiation effect	0.23	0.70	707	0.042	0.92	1279
Drinking: monthly episodes last fall						
main effect	0.84	0.016*	725	0.32	0.21	1342
step up effect	1.25	0.0065**	725	0.75	0.022*	1342
initiation effect	0.21	0.72	725	-0.31	0.43	1342

*** = p-value<.001;

** = p-value<.01;

* = p-value<.05;

= p-value<.10.

All regression models control for ego's and roommate's gender, race/ethnicity, GPA, mother's education, father's education as well as average alcohol use in the dorm building and a set of fixed effects at the level of cells, dorms and individuals.

Table 8.

Conventionally estimated main and interaction peer effects (p-value) from ROOM: self drinking in college was regressed on peer drinking in high school, own drinking in high school, and the product of the two as well as controls (not shown), each row from a separate regression model

Outcomes		Main effect	Interaction	N
Behavior in college	Own high School behavior	Roommate High School behavior	Interaction of own and roommate behaviors	
Binge drinking: monthly episodes 1st fall	2.153(<.0001)	-.076(.77)	.647(.058) [#]	2,067
Binge drinking: monthly episodes last fall	1.70(<.0001)	-.20 (.044)	.787(.020) [*]	2,067
Drinking: monthly episodes 1st fall	3.35(<.0001)	.172(.603)	.792(.061) [#]	1,989
Drinking: monthly episodes last fall	2.83(<.0001)	-.124(.70)	1.01(.016) [*]	2,070

= p-value<.001;

**
= p-value<.01;

*
= p-value<.05;

=p-value<0.1.

All regression models control for ego's and roommate's gender, race/ethnicity, GPA, mother's education, father's education as well as average alcohol use in the dorm building and a set of fixed effects at the level of cells, dorms and individuals.