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Peers and the Emergence of Alcohol Use: Influence and Selection Processes in Adolescent Friendship Networks

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Abstract

This study addresses not only influence and selection of friends as sources of similarity in alcohol use, but also peer processes leading drinkers to be chosen as friends more often than non-drinkers, which increases the number of adolescents subject to their influence. Analyses apply a stochastic actor-based model to friendship networks assessed five times from 6th through 9th grades for 50 grade cohort networks in Iowa and Pennsylvania, which include 13,214 individuals. Results show definite influence and selection for similarity in alcohol use, as well as reciprocal influences between drinking and frequently being chosen as a friend. These findings suggest that adolescents view alcohol use as an attractive, high status activity and that friendships expose adolescents to opportunities for drinking.

The present study seeks to advance understanding of the role of peers in the emergence of alcohol use in several ways. First, using five waves of data from an especially large U.S. sample, we provide unusually precise estimates of the strengths of peer influence toward similarity in alcohol use and of the tendency to select friends similar to oneself for alcohol, which are the traditional focuses of research in this area. Next, we also advocate giving greater attention to peer processes that would result in frequent drinkers being chosen as friends more often than non-drinkers. This phenomenon merits attention because it would subject more adolescents to influence toward drinking and, thereby, contribute to higher

overall rates of drinking. Toward that end, we offer and test three potential explanations of why drinking would coincide with having attracted friends. Finally, we take advantage of our sizable sample of networks to assess the consistency of peer processes across a sizable set of locales and grade cohorts.

Peer Influence, Selection, and Similarity

For decades, scholars have framed studies of peer influence as a competition between influence and selection as explanations of similarity among friends (Brechwald & Prinstein, 2011). The idea that peer influence leads people to adopt their friends' behaviors is central to core theories such as social learning (Burgess & Akers, 1966), differential association (Sutherland, 1939), reference groups (Newcomb, 1950), and balance (Heider, 1958). Other scholars argued that a preference for selecting friends similar to oneself explained observed similarity (Glueck & Glueck, 1950; Hirschi, 1969). Early studies by Cohen (1977) and Kandel (1978) set the standard that research on peer influence must also address the contribution of selection to similarity. Indeed, determining the relative strength of the two remains the stated purpose of leading studies (e.g., Burk, Van Der Vorst, Kerr, & Stattin, 2012; Knecht, Burk, Weesie, & Steglich, 2011).

In our view, it is more useful to focus on the joint consequences of influence and selection than to treat them as competing alternatives. Indeed, the two inherently intertwine because the direction of any peer influence totally depends on which friends people choose. Selecting friends similar to oneself means that peer influence will come from friends whose alcohol use correlates positively with one's own. Therefore, selection for similarity will guide peer influence toward creating greater uniformity of alcohol use within existing clusters of friends, which will add to the segregation of the friendship network based on drinking.

The same dynamic would also follow from adolescents choosing friends similar to themselves on risk factors for alcohol use, such as poor school performance or family relationships. If this selection tendency is strong, many adolescents high on risk factors will receive influence from friends who share the risk and therefore frequently drink.

Notably, the combination of peer influence with the tendency to select similar friends should not, in itself, change the overall rate of alcohol use. Standard models of peer influence imply a symmetric process: If a frequent drinker and a non-drinker are friends, the friendship should increase both the chances that the drinker will drink less and that the non-drinker will drink more. Thus, choosing similar friends would combine with peer influence to strengthen initial differences in alcohol use, but it would do little to raise the overall rate of drinking.

If Drinking Coincides with Having More Friends

An alternative pattern of friendship preferences would direct peer influence toward diffusing alcohol use across adolescents, rather than segregating it into clusters of similar friends. If adolescents generally tended to choose friends who drink over those who do not, then most adolescents would be exposed to peer influence toward a level of drinking higher than their own (Feld, 1991). In this case, peer influence would tend to raise the overall rate of drinking, consistent with the sizable increase that occurs during adolescence. Interestingly, two studies have reported positive cross-sectional correlations between alcohol use and how often adolescents were chosen as friends (Balsa, Homer, French, & Norton, 2010; Moody, Brynildsen, Osgood, & Feinberg, 2011). Notably, a third study demonstrated that this association increased after taking into account other correlates of drinking, such as poor school grades and weak relationships with parents (Kreager, Rulison, & Moody, 2011).

We seek to understand the sources of this association between alcohol use and being preferred as a friend. Toward this end, we test three potential explanations that correspond to different network processes. The first portrays drinking alcohol as a high status activity that makes adolescents more attractive. In this view, adult-like antisocial behaviors such as drinking convey an appealing image of sophistication, autonomy, and adventurousness (Dijkstra, Cillessen, Lindenberg, & Veenstra, 2010; Moffitt, 1993; Matza & Sykes, 1961). Indeed, several studies indicate that adolescents rate others who engage in these behaviors as more popular (e.g., Becker & Luthar, 2007; Dijkstra, Lindenberg, Verhulst, Ormel, & Veenstra, 2009) and that attraction to youths who engage in adult-like behavior grows in early adolescence (Bukowski, Sippola, & Newcomb, 2000; Kiesner & Pastore, 2005). These findings also raise the question of whether the attractiveness of drinking is truly ubiquitous in adolescent culture or largely limited to certain types of adolescents, such as those already at greater risk for drinking or in particular demographic groups.

The second explanation would be that adolescents more often choose drinkers as an indirect result of preference for other attributes correlated with drinking. Suppose, for instance, that students uninterested in school not only were more likely to drink, but also attracted more friends. This possibility is especially relevant because alcohol use is rare in the early years of adolescence, limiting its potential as a basis for choosing friends. If so, preference for friends with risk factors associated with emerging alcohol use could be more potent than a direct preference for drinkers.

The third potential explanation reverses the causal arrow by hypothesizing that having attracted many friends leads to greater alcohol use. Routine activity theory (Felson & Boba, 2010; Osgood, Wilson, O'Malley, Bachman, & Johnston, 1996) argues that problem behavior results, in part, from spending time in situations that offer appealing opportunities for that behavior. This perspective finds support in evidence that many problem behaviors are associated with spending time in unstructured and unsupervised socializing with peers (e.g., Mahoney & Stattin, 2000; Osgood et al., 1996; Vazsonyi, Pickering, Belliston, Hensing, & Junger, 2002). Adolescents report much higher rates of drinking at parties and with friends than in other settings (Bachman et al., 2011: 56–58). We reason that people who attract many friends also will be included in many social events where drinking occurs, and these opportunities will increase their alcohol use.

These three accounts present contrasting images of the association between alcohol use and attractiveness as a friend. If adolescents prefer friends who drink alcohol, they then become subject to influence toward a behavior they consider attractive. Further, the attractiveness of drinking could motivate any adolescent toward drinking as a route to status and friends. If adolescents prefer friends with other attributes correlated with drinking, then the influence toward drinking is coincidental to other preferences. In the routine activity explanation, attracting many friends brings social opportunities that lead to drinking. Thus, drinking would spread due to the social nature of drinking contexts, combined with the number of youth subject to influence from popular adolescents.

The Variability of Friendship Processes Regarding Alcohol Use

Every social network is a separate system of interdependent actors, and peer processes in one locale may or may not apply in others (Becker and Luthar, 2007). Such variability would be likely, for example, if adolescents in some communities viewed drinking as the marker of membership in an elite group, in others as the dangerous activity of a small group, and in still others as a minor matter of personal taste.

Although many network processes, such as reciprocating friendships, appear consistent across settings (Veenstra, Dijkstra, Steglich & Van Zalk, 2013), evidence about consistency

of selection and influence processes for problem behavior is more limited. Little variation was reported in a large-scale study of alcohol use for 79 classroom networks in the Netherlands (Knecht et al., 2010) or in a study on smoking in nine Finnish schools (DeLay, Laursen, Kiuru, Salmela-Aro, & Nurmi, 2013), whereas a study of 12 U. S. schools reported significant variability in the general preference for friends who have ever drunk alcohol, but not other peer processes (Light, Greenan, Ruseby, Nies, & Snijders, 2013). Our study will ascertain variability across a sizable sample of communities in the U. S.

The Present Study

The past 15 years have brought major advances in the study of peer influence (Brechwald & Prinstein, 2011). Researchers are taking seriously the sizable same-source bias in respondents' reports about friends' behavior (e.g., Bauman & Ennett, 1994; Jussim & Osgood, 1989) and the need for carefully distinguishing selection and influence (Veenstra et al., 2013). Further, scholars increasingly realize that interpersonal influence implies complex processes of reciprocal and indirect influence and presents challenging patterns of statistical dependence (Veenstra & Dijkstra, 2011). The availability of network data for large samples (Haynie, 2001; Dijkstra, et al., 2010) and sophisticated stochastic actor-based models (SABMs) of network influence and selection (Snijders, Steglich, & Schweinberger, 2007) have led to a wave of sophisticated new research, as exemplified in this special issue. Our study shares these features as well, and it takes advantage of an especially large U.S. sample of individuals and networks who were studied across five waves of data.

Based on the theoretical issues discussed above, we will address several research questions. The first three reflect the standard interest in peer influence toward similarity and selection of similar friends: (1) Do adolescents alter their drinking behavior toward matching their friends' level of drinking (peer influence)?; (2) Do adolescents select friends similar to themselves for alcohol use?; and (3) Do adolescents select friends similar to them selves for risk of alcohol use? According to Bot and colleagues (2005: 930), earlier (pre-SABM) longitudinal studies of peers and alcohol use typically obtained stronger evidence that adolescents selected friends similar to themselves for drinking than that friends influenced each other's drinking. Several recent studies of alcohol use in European samples using longitudinal network data and SABM analyses found statistically significant levels of both peer influence and selection of similar friends (Burk et al., 2012; Kiuru, Burk, Laursen, Salmela-Aro, & Nurmi, 2010; Mercken Steglich, Knibbe, & DeVries, 2012). Yet, another study found significant selection for similarity but not influence (Knecht et al., 2011), and still another found the opposite (Rabaglietti, Burk, & Giletta, 2012).

Our next research questions correspond to the three potential explanations for the association of alcohol use with more frequently being chosen as a friend: (4a). Does drinking increase adolescents' attractiveness to most other adolescents?; (4b). Is the association an indirect byproduct of preference for adolescents with other attributes correlated with drinking?; and (4c). Does the frequency of being named as a friend predict future drinking? Previous research is less informative about these research questions. In previous SABM studies assessing the preference for friends who more frequently use alcohol, this relationship was rarely statistically significant, but usually positive (Burk et al., 2012; Kiuru et al., 2010; Rabaglietti et al., 2012). Burk and colleagues (2012) reported significantly greater increases in alcohol use among adolescents who were more often named as friends, but only during mid-adolescence, not in early and late adolescence. Tucker and colleagues (2011) also reported that popularity predicts later alcohol use.

Our dataset includes two grade cohorts from twenty-five communities, which allows us to assess the extent to which these processes vary across settings, relative to their mean levels.

These findings will clarify whether these peer processes are relatively general in this population as opposed to being more specific to the local adolescent culture, thereby addressing our final research question: (5) Are the processes connecting friendships with alcohol use largely consistent across communities and grade cohorts?

Method

Sample and Data Collection

Our data come from the PROSPER study, a prevention trial in 28 small public school districts, half in Iowa and half in Pennsylvania (Spoth, Redmond, Shin, Greenberg, Clair, & Feinberg, 2007). Criteria for selecting school districts included a total enrollment of 1,300 to 5,200 students (all grades) and at least 15% of families eligible for reduced-price school lunch. White race/ethnicity predominated, but the proportion non-white varied considerably (4% – 39%). Half of the school districts were randomly assigned to receive a family-based prevention program during sixth grade and a school-based prevention program in the seventh grade. Present analyses omit one school district that did not permit collection of friendship data.

The fall 2002 and 2003 sixth grade cohorts of these school districts constitute our sample. Students completed questionnaires in the fall of sixth grade (approximate age 11.5 years) and in the springs of sixth through ninth grades. A single high school served each community in ninth grade, but many had multiple schools in earlier grades. Researchers administered questionnaires in students' classrooms. IRB approved procedures allowed students and parents to opt out at any time (i.e., passive consent). Across the five waves, sample-wide participation rates ranged from 86% to 90%. Matching our focus on the grade cohort as an evolving social network, new students who entered a district joined the study, and students who left the district also left the study. Retention was high, with students who participated the first year completing a mean of 4.18 assessments. Analyses include an average of 9,020 students per wave and 13,214 students for at least one wave.

Though not representative of the U.S. as a whole, this sample has other important advantages. Almost all adolescents in these small towns attend the nearest public school (Bielick & Chapman, 2003), so the sample captures a large proportion of adolescents' potential friends. Further, it is important to study alcohol use in non-metropolitan communities, where rates are at least as high as in metropolitan areas (Johnston, O'Malley, Bachman, & Schulenberg, 2010).

Measures

Friendships—Students' nominations of up to two best friends and five additional close friends in their grade and school define the social networks we analyze. The limitation to seven names resulted from time constraints and competing data collection needs. Two coders linked names to grade rosters, aided by a computer program that suggested matches based on phonetic and spelling similarity. The two coders agreed for 98% of the 263,622 names, and they succeeded in matching 83.0% of nominations. Only 1.9% of names produced multiple plausible matches, 0.4% were inappropriate (e.g., celebrities), and the remaining 14.7% appear not to be students in that grade and school.

Table 1 presents the descriptive information about the friendship network data recommended by Veenstra and Steglich (2012). The analysis included all respondents who completed questionnaires at least once, and respondents appeared in the networks for all waves they were enrolled in the district. Table 1 indicates that our data are typical for adolescent friendship networks of this size and that they are suitable for SABM analyses in

terms such as number of friends (outdegree and indegree), reciprocity, density, and stability (Jacard index).

Alcohol use—The measure of alcohol use derives from the question, “During the past month, how many times have you had beer, wine, wine coolers, or hard liquor? Not at all, one time, a few times, about once a week, or more than once a week.” Because only 2.6% of responses fell in either of the top two categories (<1% for the first two waves), we combined responses into the categories of none, once, and more than once. Rates of any past month alcohol use for the five waves were 8.4%, 11.7%, 17.5%, 26.4%, and 36.1%, consistent with national findings of rapid increase over this age span (Johnston et al., 2010). Analyses take into account three demographic variables: gender (0 = female, 1 = male), race/ethnicity (0 = other, 1 = white), and socio-economic status, as reflected by reduced-price school lunch (0 = no, 1 = yes). Table 2 presents means, standard deviations, and correlations for all measures.

Other attributes—We measure risk for alcohol use with a composite of attitudes toward school (eight items, $\alpha = .81$), self-reported grades (1 = mostly less than D, 5 = mostly As), family relations (mean of subscales for affective quality, joint activities, monitoring, inductive reasoning, and cohesiveness, $\alpha = .81$), religious participation (1 = never, 8 = more than once a week), and sensation seeking (three items, $\alpha = .75$). Each of these variables is consistently associated with alcohol use (e.g., Hawkins, Catalano, & Miller, 1992), and treating them separately was not feasible given the complexity of our statistical model. Preliminary analyses support combining them because they have similarly strong relationships with both alcohol use and number of friends, and their correlations with one another are consistent with those relationships. The composite index is the sum of these standardized measures, all scored so that high scores reflect greater risk ($\alpha = .69$), with the result again standardized.

Statistical Model

Our analyses use the Siena (Simulation Investigation for Empirical Network Analysis) statistical model and RSiena software developed by Snijders and colleagues (Ripley, Snijders, & Preciado, 2011; Snijders et al., 2007; Steglich et al., 2010). This model characterizes the evolution of the network and the actors' behavior in continuous time as a Markov process following a pair of discrete choice logistic equations. The first equation specifies the probability of choosing any other network member as a friend, whereas the second equation indicates the probability of each possible level of the measure of behavior. The parameters correspond to the processes of interest, and the software derives estimates from change over time in networks and behavior. To address the endogenous and reciprocal nature of network processes, the SABM simulates the implications of possible parameter values (Knecht et al., 2011). The resulting estimates optimize the match between the later waves of data and the results of simulations that begin with earlier waves.

Reported results come from data for 50 community by cohort networks. One network was omitted due to a missing wave of data and two because a school closing in one district created chaotic school transitions that precluded the SABM analysis. The analyses did not converge satisfactorily for the other omitted network. Reported analyses used five phase 2 sub-phases and 4,000 phase 3 iterations. Absolute values of convergence t were less than .1 for all parameters in all networks.

We derive sample-wide means and standard deviations of estimates from a meta-analysis of the 50 sets through hierarchical linear models using the HLM software (Raudenbush & Bryk, 2002). In this random intercept model, we fix Level 1 variance to the squared SABM standard errors, grade cohort serves as Level 2, and school district as Level 3. The model

corresponds to SIENA's meta-analysis for combining results across networks, differing only in an extra level of analysis to account for nesting of cohorts within communities. The multi-level analysis also yields an estimate of the total, non-chance variation of each parameter across networks, which enables us to address our research question about the variability of peer processes for alcohol use (RQ5). We report the standard deviation for this reliable variance, computed as the square root of the summed variance for cohorts and districts.

Additional HLM analyses compared estimates for treatment and control districts (a level 3 variable) to insure that effects of the PROSPER prevention trial did not alter results. No significant differences emerged for any peer processes for substance use. Four nominally significant differences for parameters not central to our interests (i.e., selection for other attributes and non-peer effects on drinking) could easily be due to chance (no $p < .02$ in 35 tests).

Specific parameters of our model address each of our research questions. The peer influence of RQ1 corresponds to a similarity effect on respondents' behavior (Siena's average-similarity term), here reflecting the tendency to change one's own alcohol use toward the mean of one's friends' use. "Similarity" terms for selection, which reflect tendencies to choose friends similar to oneself for an attribute, will assess selection for similarity in alcohol use (RQ2) and selection for similarity in risk of alcohol use (RQ3). "Alter" selection terms capture the overall tendency to choose friends with particular attributes. We use these to assess the preference for friends who drink more (RQ4a) or who have attributes correlated with drinking (RQ4b), two of the potential explanations of the association between drinking and frequently being chosen as a friend. To gauge the generality of any preference for drinkers as friends (RQ4a), we also estimate interactions between the alter term for alcohol use and other respondent attributes. Finally, an effect of indegree (number of times chosen as a friend) on behavior addresses the routine activity hypothesis that this form of popularity leads to increased alcohol use through greater opportunities (RQ4c).

Results

Influence from Friends

Table 3 presents the results from our SAB analysis of processes of friendship selection and of stability and change in alcohol use. Our first research question (RQ1) is whether adolescents change their alcohol use to become more similar to their friends and to avoid change toward behavior different from their friends. We found strong evidence that this is the case, as reflected in the parameter estimate for mean similarity to friends for alcohol use (in the lower portion of Table 3, which concerns influences on alcohol use). The odds of non-drinking adolescents beginning to drink were 55.1% higher if their friends' mean drinking increased by one standard deviation. This calculation is based on RSiena scaling of similarity so that a maximum difference on the variable's original index equals one. Thus, given a standard deviation increase for friends' drinking (.545 on the original metric), an increase in respondent drinking would correspond to a .273 (.545/2) gain in similarity with friends, relative to the same behavior change with no change in friends' drinking. The corresponding odds is $\exp(.273 \times 1.607) = 1.551$. In contrast, the next row of Table 3 indicates that friends' risk of use did not significantly influence respondents' use, after controlling for their friends' use and their own risk.

The HLM analyses indicate that peer influence on alcohol use is characteristic of this entire sample of networks, rather than applying to some but not others. The mean estimate of 1.607 and the standard deviation of .020 for the reliable variation across networks imply that true (logistic) relationships for 95 percent of networks fall in the range of 1.567 to 1.648 for peer influence toward similarity.

Selecting Similar Friends

Consistent with most past studies, Table 3 shows that early adolescents in these communities tended to select friends similar to themselves with regard to alcohol use (RQ2, the first row of similarity effects on selection). This process will contribute to clustering or dividing networks in terms of drinking. Coefficients for selection processes indicate the log odds of adding or retaining someone as a friend relative to the log odds for choosing others, conditional on the rest of the model and given the current state of the network. Thus, students were more likely to add or retain a friend who matched their own drinking status by 28.5% higher odds than for choosing someone of the opposite status (e.g., non-drinkers choosing frequent drinkers). This relationship broadly characterized our sample of grade cohorts and school districts: The mean and standard deviation of this estimate imply that 95% of the networks fall in the narrow range of .235 to .267.

Addressing RQ3, we find that adolescents definitely preferred friends similar to themselves on composite risk for alcohol use, thereby indirectly adding to clustering of friends for use itself. Odds for selecting someone identical in risk were 63% higher than for someone at the opposite end of this spectrum. Apart from our interests in peers and alcohol use, we found preferences for having friends of the same gender, ethnicity, and SES (based on receiving free school lunch).

Alter Effects: Who is More Attractive as a Friend?

Next, consistent with the position that adolescent culture treats alcohol use as attractive (RQ4a), the overall alter effect for alcohol use indicates that adolescents who drank alcohol were more likely to be added or retained as friends. This pattern will increase the proportion of adolescents exposed to influence from friends toward drinking. Compared to choosing a non-drinker, odds for choosing someone who drank alcohol once in the past month were 8.1% higher, and for choosing a more frequent drinker they were 16.9% higher. This preference was widely shared; interaction terms show that it did not differ significantly in relation to the chooser's gender, race/ethnicity, or risk for alcohol use. However, students who received reduced-price school lunches were somewhat more prone to select friends who use alcohol (7.8% higher odds). The preference for friends who drink alcohol is relatively consistent across these networks, with 95% of these district/cohort networks having true parameter values in the range .072 to .084 (mean = .078, $SD = .003$).

Table 4 shows how the general preference for friends who drink combines with the preference for friends who are similar for drinking. This table presents the relative odds of selection for all combinations of own drinking (ego) and potential friends' drinking (alter). Regardless of their own drinking, adolescents' are most likely to add or retain friends whose drinking status matches their own. Yet the differential is far weaker for friendship choices by non-drinkers than by more frequent drinkers. Non-drinkers had only 10.0% higher odds (1.041/0.947) of choosing another non-drinker over someone who drank two or more times, whereas the more frequent drinkers had 50.2% higher odds (1.221/0.813) of choosing someone who matched them over a non-drinker.

The remaining alter effects of Table 3 address whether preference for friends with attributes correlated with alcohol use might account for the association between use and number of friends (RQ4b). The odds of being added or retained as a friend were lower for adolescents who were white (−7.5%) or received reduced-price school lunch (−3.9%), and higher for adolescents who already had more friends (18.3%). A preference for friends at greater risk of alcohol use would indirectly produce more friendships with alcohol users, but that estimate is too weak to have meaningful consequences (0.7% higher odds per standard deviation).

Does Having More Friends Lead to Alcohol Use?

In support of the routine activity explanation of the association of drinking with receiving many friendship choices (RQ4c), those adolescents frequently named as friends were likely to increase their alcohol use. For each additional friendship, the odds of an increase in drinking grew by 5.6%. Thus, compared to adolescents never named as a friend (10% of the sample), those selected by three friends (the median) had 17.9% greater odds of increasing alcohol use, and those named by eight friends (the 90th percentile) had 55.3% greater odds of increase ($\exp(8 \times .055)$). Furthermore, the HLM analysis indicated that this influence on alcohol use applied to all of these grade cohorts and communities, with 95 percent of networks falling in the range of .042 to .067 for this parameter.

Rounding out the portion of Table 3 concerning influences on alcohol use, our model also controls for individual characteristics, and we found greater odds of increased alcohol use for females than males and for adolescents higher on the risk index. Finally, the linear and squared terms capture average patterns of change in drinking across waves, including stability, regression, and mean increases.

Network Structure and Selection Baserates

Table 3 also presents results for selection processes that do not pertain to our research questions. The constant term, outdegree density, calibrates the overall odds of naming any other student as a friend. Those overall odds decline following school transitions in which schools merge (e.g., multiple elementary schools to a single middle school) and somewhat less so after transitions without mergers.

We replicate widely observed network structure effects on friendship selection, including strong tendencies of adolescents to reciprocate friendships from others, to prefer friends already selected by their friends (transitive triplets), and toward hierarchy in friendships (negative three-cycles). Our model also includes the tendency to become friends with people who choose the same friends (balance). To resolve convergence difficulties, the balance term is fixed to the positive value that was statistically significant in preliminary results and varied little across networks.

“Ego” selection effects concern whether adolescents with various characteristics tended to name more or fewer friends. We see in Table 3 that respondents’ level of alcohol use was unrelated to this tendency. The odds of adding or retaining any other person as a friend were lower for males than females (−12.1%), for white than non-white adolescents (−4.5%), and for adolescents higher on risk factors for alcohol use (−4.2%). Estimates of ego effects would be more meaningful if we had also controlled for prior number of friends chosen (outdegree, activity). We omitted this element because it created convergence difficulties, and our substantive interests did not concern ego effects.

Discussion

Influence and Selection for Similarity in Alcohol Use

The standard focus of research on peer influence has been influence toward acting similarly to one’s friends (RQ1) and the tendency to select friends similar to oneself (RQ2). Findings from prior studies are mixed, but the relatively strong influence we found was decidedly significant (over 16 times its standard error). In our view, accumulated evidence suggests that adolescents’ drinking has an important influence on their friends’ drinking. This conclusion supports several long-standing theories (Burgess & Akers, 1966; Heider, 1958; Sutherland, 1939) and aspects of widely used approaches to preventing problem behaviors (e.g., Botvin, 2000).

Consistent with prior studies, we also found clear evidence of a moderately strong tendency for adolescents to select friends who are similar to themselves for drinking (RQ2). This selection process will tend to cluster and divide the network in terms of drinking, thereby directing peer influence toward amplifying preexisting differences in drinking, which in turn will further the division of the friendship network.

Additional segregation based on levels of alcohol use would arise indirectly from the observed preference for similarity on composite risk factors for alcohol use (RQ3). Not only do individuals' own levels of risk predict current and future use, but selecting friends with a similar level of risk also exposes adolescents to an indirect avenue of peer influence. High-risk adolescents will tend to choose high-risk friends with an above-average rate of drinking, and consequently peer influence will further increase their own drinking. This nexus of peer influence in combination with multiple forms of selection for similar behavior will generate considerable impetus toward amplifying initial differences in alcohol use and clustering friendships to segregate users and non-users.

Number of Friends and Alcohol Use

We also move beyond the typical focus on selection of similar friends to examine sources of the positive correlation between adolescents' alcohol use and how frequently they are named as friends (RQ4). This form of popularity is of special interest because it would extend influence toward drinking to a disproportionate number of adolescents (Feld, 1991), thereby producing overall increases in alcohol use. We investigated three potential sources of this pattern, each with different implications.

First, drinkers were more attractive as friends (RQ4a), which accords with portrayals of drinking as bringing higher status in teen culture (Dijkstra et al., 2010; Moffitt, 1993; Matza & Sykes, 1961). As Table 4 demonstrates, the combined result of preferences for friends who drink more and friends similar to oneself on drinking is that drinkers will be highly over-represented among drinkers' chosen friends, but little under-represented among non-drinkers' chosen friends. Thus, for the population as a whole, the general preference for friends who drink will increase exposure to influence toward drinking and thereby further the spread of alcohol use (Moody et al., 2011).

The general preference for drinkers over non-drinkers also implies that adolescents have reason to view drinking as a possible means of gaining friends, which could serve as motivation to drink, regardless of one's friends' drinking. In this vein, it is interesting that poorer students (i.e., those who received reduced-price school lunch) were especially likely to choose drinkers as friends. These students may be more inclined to choose friends who drink in an effort to raise their own low status, which is evident in the negative correlations of indegree and outdegree with receiving reduced-price lunch.

Next, our findings do not suggest that drinking attracts friends as an indirect result of preference for some other attribute correlated with alcohol use (RQ4b). Adolescents' tendency to choose friends with higher risk for alcohol use was far too weak to generate any meaningful correlation (odds ratio of 1.01), and other preferred attributes were not correlated with alcohol use.

Third, consistent with the prediction from routine activity theory (Felson & Boba, 2010; Osgood et al., 1996), frequently being named as a friend was associated with increasing alcohol use (RQ4c). We argue that this finding arises because extensive friendship ties give adolescents greater access to the social gatherings where use occurs. Conversely, this dynamic would protect more socially isolated adolescents, who will less often confront situations conducive to drinking. This pattern raises the rate of drinking among those

adolescents whose influence extends to many peers, thereby increasing the spread of drinking.

Consistency of Peer Processes across Communities and Cohorts

To gain perspective on the meaning of our findings, we examined whether the peer processes for alcohol use were largely consistent across these communities and grade cohorts or were highly variable (RQ5). We assessed this by considering the mean values of the parameters in light of standard deviation estimates that reflect their reliable variation across networks.

We found that four of the five main peer processes linking alcohol use and friendships differed relatively little across these 50 networks of adolescents. The mean effects were at least nine times as large as their standard deviations for estimates of peer influence, selection of friends similar in alcohol use, preference for alcohol users as friends, and the effect of number of friendships on alcohol use. The preference for friends similar in risk of alcohol use was less consistent across communities, with parameter estimates for 95% of the networks spanning .159 to .825 (from Table 3: mean estimate of 0.492 and *SD* of 0.170). Knecht and colleagues (2011) also reported limited variation in most peer processes in their analysis of classrooms in the Netherlands, as did Kiuru and colleagues (2010) and DeLay and colleagues (2013) for schools in Finland. Our results are counter to Light and colleagues (2013) finding of significant variation across U.S. middle schools in the preference for alcohol users as friends. Together, these results suggest that the connections of friendships to alcohol use are largely consistent across schools and communities, at least within regional populations.

Statistical Power in Dynamic Network Analyses of Peer Processes

Our unusually large sample of individuals and networks has yielded clear-cut statistical results for relatively subtle peer processes that most studies would not reliably detect. For instance, multiple previous studies have reported estimates of the general preference for friends who drink (i.e., alter drinking) that were at least as large as ours, but non-significant due to much greater standard errors (Kiuru et al., 2010; Burk et al, 2012, Rabaglietti et al., 2012). We therefore suspect that much of the variability in findings across previous studies reflects limited statistical precision rather than genuine differences in peer processes.

The network-specific results underlying our meta-analyses demonstrate the consequences of the much lower statistical power of typical sample sizes. Despite the high precision of our overall result for peer influence, corresponding network-specific estimates would have reached a significance level of .05 for only 21 of our 50 networks, with significance highly dependent on network-specific standard errors. Estimates were nominally significant for 80% of 10 networks with the smallest standard errors (due to larger samples, higher mean alcohol use, and lower collinearity; $\overline{SE}=.72, \bar{b}=1.60$), compared to 53% of 15 networks with the next smallest standard errors ($\overline{SE}=.92, \bar{b}=1.66$), and only 20% in the remaining 25 networks ($\overline{SE}=1.58, \bar{b}=1.81$).

Limitations and Future Directions

Shalizi and Thomas (2011) argued that network analyses of social influence are susceptible to bias due to selection of friends who are similar on unmeasured variables. They provide a valuable reminder that analyses of non-experimental data cannot prove causality. Nevertheless, our SABM approach is a process model that estimates assumed causal effects by simulating their consequences. Therefore, we have referred to the results as estimates of effects, but we do not mean to imply that we have proved causation. Notably, relative to

other alternatives, our SABM estimates should reduce the potential for bias by incorporating many relevant processes, including network structural effects on friendship choices, friendship selection processes for all measures, and individual and peer predictors of alcohol use.

Next, future research should test the generality of our findings in populations other than these relatively small, non-affluent, majority White communities in two states of the U.S. The relative consistency of peer processes across these communities and grade cohorts cannot rule out larger differences between populations and age groups. Additional research is necessary to determine whether our findings apply to more populous settings, primarily minority schools, affluent communities, and other regions and countries. Our own data provide the opportunity for future research examining potential predictors of variation in peer processes across communities and cohorts.

Research should also examine the contribution of the dominant institutions of adolescent life to peer processes. For instance, Knecht and colleagues' (2011) failure to find significant influence of friends' drinking on adolescents' own drinking might be tied to the organization of schooling in the Netherlands. In contrast to our communities in which almost all adolescents attend a single high school and mix throughout the school day, in the Netherlands students in any neighborhood attend many different schools and remain in a single classroom for the entire school year. Thus, school friendships there are largely limited to a small classroom group and have little overlap with neighborhood friendships. Kiuru and colleagues (2010) studied Finnish grade cohort networks in schools organized more similarly to those we studied and of comparable size, and their results were closer to ours.

In this vein, it would also be valuable for future research to expand beyond friendship networks defined by the school. Witkow and Fuligni (2010) pointed out that there is far too little research on out-of-school friends. Such friends would be especially relevant because friendships with older adolescents would be a likely means by which peer influence could contribute to developmental increases in drinking.

Finally, we have focused on the association of drinking with attracting many friends because it would combine with peer influence to increase alcohol use. Another possible source that merits investigation is asymmetric influence in which influence from friends who drink is stronger than influence from friends who do not. Dominant statistical models assume influence is symmetric, and that assumption should be tested.

Conclusion

We believe our study is one of the strongest investigations to date of peer processes for alcohol use. It gains considerable statistical power from an unusually large sample of networks and individuals, uses five waves of data across the critical period for the emergence of alcohol use, and assesses characteristics of friends through network data rather than respondents' perceptions. Our statistical model controls for many potential alternative explanations by incorporating a broad set of relevant peer processes.

We have found that adolescent alcohol use is linked to friendship patterns by multiple processes of friendship selection and peer influence. Together, they illuminate a complex pattern by which peer influence and friendship selection shape the spread of alcohol use across adolescent friendship networks. Furthermore, these processes hold broadly across the communities studied, rather than depending on the role of alcohol in the local peer culture. Our findings show that peer relations play an important role in the emergence of alcohol use and that network analysis of friendships is a powerful tool for understanding peer dynamics. These results support the emphasis on peer influence characteristic of current programs to

prevent alcohol and substance use (e.g., Botvin, 2000). Importantly, our analyses reveal additional aspects of peer relations that may guide program developers toward refinements that enhance their programs' effectiveness, such as addressing the general preference for drinkers as friends and the greater susceptibility of adolescents with many friends to begin drinking.

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Table 1
Descriptive Statistics for Friendship Networks and Alcohol Use, Means Across 50 Networks

	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Network Size					
Mean	158.48	174.60	186.56	192.48	189.86
Minimum	60	64	79	84	68
Maximum	307	352	437	420	443
Friendship Ties					
Outdegree	3.36	3.94	4.07	3.98	3.62
SD Outdegree	2.15	2.14	2.13	2.13	2.20
SD Indegree	2.64	2.88	2.97	2.78	2.65
Reciprocity	48.8%	49.0%	49.4%	51.3%	50.3%
Density	2.6%	2.8%	2.7%	2.6%	2.3%
Alcohol Use ^a					
Mean for Males	0.12	0.17	0.25	0.37	0.55
SD Males	0.41	0.49	0.59	0.70	0.82
Mean for Females	0.08	0.13	0.24	0.41	0.58
SD Females	0.34	0.42	0.57	0.71	0.81
	W1-W2	W2-W3	W3-W4	W4-W5	
Change in Network Membership					
Number Leavers	6.51	15.12	17.04	25.37	
Number Joiners	9.24	24.67	17.12	20.22	
Change in Friendship Ties					
Distance (<i>n</i> of changed ties)	548.92	718.51	784.08	670.02	
Jaccard Index	36.6%	24.5%	27.3%	28.3%	
Change in Alcohol Use					
Percent Stable Actors	86.48	69.33	63.43	56.06	

All values are means across 50 networks, with a total *N* of 45,099 person/waves.

^a 0 = no use in the past month, 1 = one time, 2 = more than one time.

Table 2

Descriptive Statistics and Correlations among Primary Measures

	Mean	SD	Min	Max	1.	2.	3.	4.	5.	6.	7.	8.
1. Drinking, past month	0.30	0.63	0.00	2.00								
2. Times chosen as friend (indegree)	3.72	2.78	0.00	20.00	.04							
3. Number of friends selected (outdegree)	3.71	2.18	0.00	7.00	-.01	.42						
4. Male gender	.49	.50	0.00	1.00	.00	-.14	-.20					
5. White race/ethnicity	.81	.39	0.00	1.00	-.02	.09	.11	-.03				
6. Reduced-price school lunch	.31	.46	0.00	1.00	-.02	-.19	-.16	-.02	-.19			
7. Composite Risk Index	0.00	1.00	-2.19	4.95	.37	-.12	-.18	.16	-.07	.14		
8. Drinking, Friends' mean	0.30	0.55	0.00	2.00	.25	.03	.02	.02	-.01	-.02	.22	
9. Composite Risk, Friends' mean	0.00	0.88	-2.11	4.95	.21	-.09	-.09	.15	-.05	.11	.39	.40

N = 45,099 person/waves, $p < .01$ for correlations $|r| > .012$.

Table 3
Parameter Estimates for SAB Model of Friendship Selection and Influences on Alcohol Use

Parameter Estimates for Friendship Selection	Odds Ratio	Mean rSIENA Estimate ^a	Standard Error	t-ratio	Between Network SD ^b
Base rate of selecting friends					
Constant (Outdegree density)	0.041	-3.186*	0.057	-56.25	0.283
School merger this year	0.479	-0.736*	0.102	-7.20	0.304
School transition this year	0.792	-0.233*	0.041	-5.72	0.195
Effects of network structure					
Reciprocity	6.996	1.945*	0.041	47.38	0.205
Transitive triplets	1.400	0.336*	0.014	24.63	0.070
Balance	1.105	0.100	Fixed		
Three-cycles (hierarchy)	0.661	-0.415*	0.016	-25.31	0.076
Similarity effects: Choosing friends similar to oneself					
Alcohol use	1.285	0.251*	0.021	12.25	0.008
Composite risk for alcohol use	1.635	0.492*	0.041	11.97	0.170
Gender	2.064	0.725*	0.025	29.39	0.130
White versus non-white race/ethnicity	1.180	0.165*	0.023	7.19	0.112
Receipt of free school lunch	1.045	0.044*	0.012	3.76	0.058
Alter effects: Who is more often named as a friend?					
Alcohol use	1.081	0.078*	0.009	8.96	0.003
By ego composite risk	0.994	-0.006	0.011	-0.52	0.036
By ego gender	1.018	0.017	0.015	1.18	0.025
By ego white race/ethnicity	1.002	0.002	0.024	0.08	0.090
By ego free school lunch	1.078	0.075*	0.019	3.92	0.045
Composite risk for alcohol use	1.007	0.007	0.003	2.38	0.011
Male gender	1.014	0.014	0.007	1.87	0.024
White race/ethnicity	0.925	-0.078*	0.011	-7.37	0.042
Free school lunch	0.961	-0.040*	0.008	-5.08	0.023
Prior number of friends (Indegree, square root)	1.183	0.168*	0.009	18.36	0.042
Ego effects: Who names more friends?					

Parameter Estimates for Friendship Selection	Odds Ratio	Mean rSIENA Estimate ^d	Standard Error	t-ratio	Between Network SD ^b
Alcohol use	1.002	0.002	0.021	0.08	0.090
Composite risk for alcohol use	0.958	-0.043*	0.006	-6.78	0.024
Male gender	0.879	-0.128*	0.016	-7.89	0.088
White race/ethnicity	0.955	-0.046*	0.015	-3.12	0.049
Free school lunch	1.019	0.019	0.012	1.63	0.036
<i>Parameter Estimates for Influences on Alcohol Use</i>					
Shape parameters (constant & stability)					
Linear	0.078	-2.550*	0.075	-34.05	0.341
Squared	4.954	1.600*	0.027	59.44	0.097
Friends' Attributes					
Mean similarity for alcohol use	4.990	1.607*	0.098	16.36	0.020
Mean composite risk for alcohol use	1.034	0.034	0.029	1.18	0.007
Effect of number of friends (indegree)	1.056	0.055*	0.004	12.65	0.006
Control Variables (Individual Level)					
Male gender	0.917	-0.086*	0.015	-5.87	0.000
White race/ethnicity	0.964	-0.036	0.026	-1.41	0.009
Free school lunch	0.954	-0.047	0.023	-2.03	0.042
Composite risk for alcohol use	1.325	0.282*	0.009	32.59	0.002

N = 50 networks, 13,214 individuals, 45,099 person/waves.

^a Intercept terms of null HLM models.

^b Square root of the total intercept variance from HLM Models.

Table 4

The Relationship of Ego and Alter Alcohol Use to the Odds of Selecting Someone as a Friend

Log Odds of Selection			
Ego Past Month Drinking	Alter Past Month Drinking		
	None	Once	More
None	0.040	-0.007	-0.055
Once	-0.083	0.120	0.072
More	-0.207	-0.004	0.200
Odds Ratios for Selection			
Ego Past Month Drinking	Alter Past Month Drinking		
	None	Once	More
None	1.041	0.993	0.947
Once	0.920	1.128	1.075
More	0.813	0.996	1.221

Note: Values calculated from parameter estimates in Table 3.