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Befriending Risky Peers: Factors Driving Adolescents' Selection of Friends with Similar Marijuana Use

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Abstract

Adolescents often befriend peers who are similar to themselves on a range of demographic, behavioral, and social characteristics, including substance use. Similarities in lifetime history of marijuana use have even been found to predict adolescent friendships, and we examine whether this finding is explained by youth's selection of friends who are similar on a range of more proximate, observable characteristics that are risk factors for marijuana use. Using two waves of individual and social network data from two high schools that participated in Add Health (N = 1,612; 52.7% male), we apply longitudinal models for social networks to test whether or not several observable risky attributes (psychological, behavioral, and social) predict adolescent friendship choices, and if these preferences explain friend's similarities on lifetime marijuana use. Findings show that similarities on several risk factors predict friendship choices, however controlling for this, the preference to befriend peers with a similar history of marijuana use largely persists. The results highlight the range of social selection processes that lead to similarities in marijuana use among friends and larger peer groups, and that also give rise to friendship groups whose members share similar risk factors for substance use. Friends with high "collective risk" are likely to be important targets for preventing the onset and social diffusion of substance use in adolescents.

Keywords

marijuana use; adolescence; peers; social networks; social selection; friendship

INTRODUCTION

As alcohol and drug use emerges from early to late adolescence (Eaton et al. 2012), adolescent friends are often found to be alike in their avoidance of, or engagement in, these

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AUTHOR CONTRIBUTIONS

KD conceived of the study aims and analytic strategy, performed the statistical analyses, and coordinated and drafted the manuscript; HG participated in developing the study aims and analytic strategy, performed the statistical analyses, and contributed to drafting the manuscript; MP contributed to drafting the manuscript; DK contributed to drafting the manuscript; JT conceived of the study aims and participated in coordinating and drafting the manuscript. All authors read and approved the final manuscript.

risk behaviors. Research has documented how processes of social influence give rise to similarities in substance use and other deviant behaviors among friends and peer groups (Andrews et al. 2002; Brechwald and Prinstein 2011; Clark and Lohéac 2007; Ennett et al. 2006; Goodwin et al. 2012; Maxwell 2002; Pollard et al. 2010; Prinstein et al. 2001; Tucker et al. 2014). Friends have been found to be particularly influential on substance use in middle and late adolescence (Burk et al. 2012). Recent studies that utilize developments in social network analysis have found that friendship selection also plays an important role. That is, adolescents tend to befriend peers whose risk behaviors are similar to their own, as has been found in studies of alcohol use (Kiuru et al. 2010; Knecht et al. 2011; Mercken, Steglich, Knibbe, et al. 2012; Sznitman 2013), smoking (de Vries et al. 2006; Huisman 2014; Mercken, Steglich, Sinclair, et al. 2012), drug use (Poulin et al. 2011), delinquent behaviors (Knecht et al. 2010), and internalizing behaviors such as depressive symptoms (Goodwin et al. 2012; Kiuru et al. 2012) and anxiety (Van Zalk et al. 2011). Youth also show strong preferences to select friends with similar demographics such as age, race/ethnicity, and gender (Goodreau et al. 2009; Moody 2001); attributes that are often correlated with these risk behaviors and so may heighten the similarity in substance use among friends. This social context – whereby youth aggregate into homophilous friendships – generates peer groups with particular norms, opportunities, and identities related to substance use, and the ongoing socialization of group members. These selection and influence dynamics promote and sustain substance use among particular subsets of socially connected youth.

Much of this work has focused on how friendships and substance use influence one another over a relatively short timeframe: for example, how substance use at Time 1 ($t1$) predicts change in friendships between $t1$ and $t2$, with the time period often ranging from a few months to one year. As such, findings that youth befriend peers with similar substance use suggest that youth observe their peers using or abstaining from substances, or gain knowledge about their peers' behaviors, which provides opportunities for friendship sorting based on current substance use practices. For example, youth who drink alcohol or take drugs at parties may befriend other peers who are doing the same and, as the friendship develops, socialization processes are likely to reinforce further the alcohol and drug using norms among these friends.

However, a recent study investigating peer network effects on the initiation of marijuana use, using data from the National Longitudinal Study of Adolescent Health (Add Health), found not only that friendship sorting occurred based on similarities on *current* (past month) marijuana use, but also that friendship choice was predicted by similarities in having *ever used* marijuana (i.e., a similar history of use) (de la Haye et al. 2013). Moreover, a similar history of marijuana use was just as strong or an even stronger predictor of friendship choice than current marijuana use. These findings are surprising given adolescents' history of lifetime marijuana is a much more “distal” behavior, compared to past month use which should be more observable and salient to friendship choices.

Similarity on a multitude of characteristics leads to social connections among youth and adults (McPherson et al. 2001). Lazarsfeld & Merton (1954) characterized two key dimensions of homophily - *status homophily* and *value homophily*. Status homophily refers

to sociodemographic characteristics linked to social status (e.g., race, ethnicity, gender, age, social class), whereas value homophily refers to personal beliefs and internal states. The psychological literature shows that an individual's attraction to others with similar backgrounds and beliefs is likely motivated by increased ease in communication, and a greater sense of shared identity (McPherson et al. 2001). Indeed, similarity among adolescent friends on risk behaviors and personal beliefs (e.g., academic motivation and self-worth) has been linked to greater friendship stability (Hafen et al. 2011). The dimensions of homophily that lead to similarity in the history of marijuana use among adolescent friends are unclear, but are important for understanding why and how "at risk" youth aggregate into peer groups that may later have risky behavioral norms. It is possible that "having ever used marijuana" is an important factor in friendship choices, particularly if the initiation of marijuana use was fairly recent, or in contexts where peer groups and friends are fairly stable. However, it is also plausible that friendships are based on similarities in adolescent characteristics that are *associated* with having tried marijuana. Conceptualized as a multiplicative model of risk (Donovan et al. 1991) operating within an ecological system of personal, peer, and school contexts (Bronfenbrenner 1977), we propose that selection based on similarities in risk factors for marijuana use that are more observable and salient among school peers give rise to adolescent friendships and peer groups comprised of youth who are *similar in their susceptibility to substance use*. Risk factors for marijuana use that are likely to be most relevant to *value* or *status*-based social selection (Lazarsfeld and Merton 1954) include dimensions of personality (e.g., neuroticism, conscientiousness, extraversion; see Gullone and Moore 2000; Kotov et al. 2010), mental health and self-esteem (Newcomb et al. 1986), and involvement in deviant behaviors (Hawkins et al. 1992). Because individuals in peer groups with many risk factors are more likely to initiate and use substances, their high-risk friends are more likely to be exposed to substance use behaviors, accelerating the diffusion of substance use among peer groups with a high "collective risk". These peer groups may be critical targets for preemptive interventions and substance use prevention.

THE CURRENT STUDY

The current study tests whether the observed tendency for adolescents to select friends with similar histories of marijuana use (de la Haye et al. 2013) is explained by friends' selection on other risk factors associated with substance use. We also account for the role of current (past month) marijuana use in explaining this phenomenon. Specifically, we hypothesize that preferences for friends with similar histories of marijuana use will be partially or fully explained by friendship preferences based on a broad range of established risk factors for substance use that are relatively more proximate and observable among school peers. These risk factors include personality dimensions of neuroticism, low conscientiousness, and low extraversion (Gullone and Moore 2000; Kotov et al. 2010); poorer mental health and self-esteem (Newcomb et al. 1986); involvement in delinquency (Hawkins et al. 1992); and weaker academic orientation and school attachment (Hawkins et al. 1992).

METHODS

Sample

Data for this study come from Add Health (Bearman et al. 1997), which was established in the early 1990s as a school-based probability sample of American adolescents in Grades 7–12. Sixteen schools participating in Add Health were developed as “saturated school samples” by inviting all enrolled students to complete baseline in-home interviews. The analytic sample for this study focuses on data from two of these 16 saturated schools that met the data requirements for our longitudinal network analysis (the remaining 14 schools were excluded because they were too small, had too much missing data, or had very low rates of marijuana use). Our analyses are also limited to data collected at Wave I (1995) and Wave II (1996), when friendship nominations to school mates were assessed, and to grade-level cohorts captured at Wave I and Wave II (participants in grade 10/11 at Wave I, who were in grade 11/12 at Wave II, or participants who met these criteria at either wave). We adopt this complete social network design, where we focus on a bounded group of schoolmates for whom we have relatively complete information on their behaviors and patterns of friendships over time, because it allows us to test factors that predict friendship choices (from a defined set of potential friends), as well as test for effects of the network on changes in behavior (Veenstra et al. 2013).

This resulted in a total sample of $N=1,612$, nested in two schools (School 1: $N=1,193$, mean age=16.34; School 2: $N=419$, mean age=16.47). The average response rate for eligible students at Wave I was 79%, and retention rates at Wave II were 88.1% in School 1 and 87.4% in School 2. New students were not added at Wave II. The characteristics of these two schools differed substantially: one has a large, ethnically heterogeneous student body and is located in a major metropolitan area (School 1); the other has a smaller student body that is predominantly white and is located in a mid-sized town (School 2).

All study procedures were approved by the institution’s Internal Review Board.

Measures

Questionnaires were self-administered and completed at school or at home. Personal and school-related risk factors linked to increased risk of substance use, and that may also be relevant to adolescent school peer networks, were computed using data from Wave 1.

Friendships—Respondents were asked to nominate five best male and five best female friends from a roster of students enrolled in their school. School-based friends who also participated in the study were coded with their respective identification numbers (out-of-school nominations were given specific codes). Only friendship nominations among participants in the current analytic sample were retained in subsequent network analyses (i.e., friends were also survey respondents) so that friends’ self-reported marijuana use was available. However, students who *did not* nominate a friend in the current analytic sample were *not* excluded from the analyses: they were simply coded as having 0 nominations at that particular Wave. Due to errors in Wave I data collection, 5% of the current sample

could only nominate one male and one female friend; students with “limited nominations” were dummy-coded and this was included as a control in all models.

Marijuana use—Respondents reported on the number of times they had used marijuana in their lifetime (Wave 1 only), in the past year (Wave II only), and in the past 30 days (Wave I and Wave II). A dichotomous measure of history of marijuana use was computed at each wave where 1 = *ever used marijuana*, with changes from 0 to 1 in history of use between waves capturing marijuana initiation. A dichotomous measure of current marijuana use was computed for each wave where 1 = *used marijuana in the past 30 days*.

Personality risk factors—Scales were derived from Add Health items and identified as valid and reliable proxy measures for three dimensions of personality by Young & Beaujean (2011). *Neuroticism* was calculated by summing 6 items (e.g., “You like yourself just the way you are”), *extraversion* was calculated by summing 3 items (e.g., “I feel socially accepted”), and *conscientiousness* was calculated by summing 4 items (e.g., “When making decisions, you generally use a systematic method for judging and comparing alternatives”). All items were rated on a 5-point scale (1 = *strongly agree*, 5 = *strongly disagree*) and the final scale was reverse coded, as necessary, so that high values represented high neuroticism, extraversion, and conscientiousness.

Depressive symptoms—Using the CES-D (Radloff 1977), depressive symptoms were calculated as the mean of 19 items assessing the frequency of experiencing different symptoms of depression (e.g., loss of appetite, feeling depressed) during the last week (1 = *never or rarely*, 4 = *most of the time or all of the time*; $\alpha = .86$).

Self esteem—Six statements (e.g., “you have a lot of good qualities”) were rated in terms of respondent’s agreement (1 = *strongly agree*, 5 = *strongly disagree*). Items were averaged, after reverse coding some items, so that lower scores indicate low self-esteem ($\alpha = .84$).

Delinquency—Fifteen items asked about the number of times (from 0 = *never* to 3 = 5 or more times) the adolescent had engaged in specific delinquent behaviors over the past year, such as theft, selling drugs, and property damage. Due to skewness, responses > 1 were set equal to 1 for each item, and a summary variable was created by calculating the proportion of delinquent acts the adolescent engaged in ($\alpha = .80$).

School risk factors—*Academic orientation*, represented as a GPA scale, was computed using respondent reports of their past year grades in English/language arts, mathematics, history or social studies, and science (1 = A, 2 = B, 3 = C, 4 = D or lower). Responses were reverse coded so that lower values reflected a low GPA ($\alpha = .75$). *School attachment* was assessed by a 3-item scale that measured agreement (1 = *strongly agree* to 5 = *strongly disagree*) toward feeling close to people at school, feeling a part of their school, and feeling happy at school over the last year ($\alpha = .72$). *Trouble at school* was measured by a 4-item scale assessing the frequency (0 = *never*, 4 = *every day*) that respondents had trouble paying attention, getting along with teachers, getting along with other students, and getting homework done ($\alpha = .69$).

Control variables—Respondent reported gender, race or ethnicity, and grade were included in the analyses as controls. The number of outside-of-school friends the adolescent had was also included, and was derived from the number of nonschool-based friends they had listed during the friend nomination task. Socioeconomic status of the respondent's family was based on the highest level of education attained by either parent (parent report, where 1 = < high school, 2 = high school or trade school, 3 = some college, 4 = college graduate).

Analytic strategy

To identify risky characteristics that predict adolescent friendship choices, which may explain tendencies for youth to befriend peers with similar histories of marijuana use, we used stochastic actor-based models (SABMs) for longitudinal social network data (Snijders et al. 2007, 2010). SABMs are implemented in the RSiena 4.0 program (Ripley et al. 2014), and model the evolution and interdependence of complete social networks and the attributes of the individuals (actors) in these networks.

The overall approach of the algorithm is to simulate changes in the network and actor behaviors between observed panels of data, as continuous time Markov chains, and to identify effects that guide actors' decisions to change two dependent variables: (1) their network ties (i.e., friendships), and (2) their behavior (i.e., history of marijuana use). Model parameters were estimated using a method of moments procedure, and estimates were deemed significant if the *t*-ratio (estimate divided by the standard error) was greater than 1.96. Because our analyses focus on friendship ties among students within the same school, each school cohort was defined as a separate social network, and a model was fit for each school group. This modeling strategy does not assume that the emergent properties of each network are homogenous, and differences in model estimates between the two schools were compared qualitatively. Missing data were imputed by the program (Ripley et al. 2014) and the maximum outdegree for the simulated networks was set at 10 because this was the maximum number of friendship nominations allowed in the survey.

Model specification

For each school-based friendship network, a series of models were estimated. First, a *baseline model* included effects of history of marijuana use and covariates, but not risk factors, in predicting the friendship network (i.e., the patterns of friendship nominations among students) and history of marijuana use. This baseline model replicated the model from de la Haye et al. (2013). Three key types of parameters tested for effects of marijuana use and respondent control variables on friendship network dynamics: (1) *ego* effect, being the effect of the variable on the tendency to make a friend nomination; (2) *alter* effect, being the effect of the variable on the tendency to receive friend nominations (with a squared alter effect included if the variable was continuous to capture non-linearity); and (3) *same* (dichotomous variables) or *similar* (continuous variables) effect, which determines if friendships were more likely among peers who were similar on the variable. The main effect of interest in the baseline model is “same history of marijuana use”, which captures the tendency for adolescents to nominate friends whose history of marijuana use is the same as their own (where 1 = *have ever used marijuana*). In this study, we do not differentiate

between friendship nominations that are reciprocated vs. non-reciprocated, or assess if friend reciprocity moderates the effects tested in the model.

Models also controlled for endogenous network effects, including tendencies for actors to befriend peers who have already selected them as a friend (reciprocity), and to befriend friends of friends (transitivity) that can also explain observed patterns of behaviors and network ties (Veenstra et al. 2013). The inclusion of these structural effects is standard and necessary when modeling network data (Snijders et al. 2007; Veenstra et al. 2013).

This baseline model also simultaneously predicted the initiation of marijuana use (i.e., a change between the two study waves from no history of marijuana use to having initiated use). An effect of friends' history of marijuana use on marijuana initiation was included, to account for the role of friend influence in explaining similarities in adolescents' history of marijuana use. Effects of control attributes on marijuana initiation were also included in the baseline models.

The *second phase of model estimation* built on the baseline model and added effects of current (past month) marijuana use on friendship choices. This model evaluates the extent to which history of marijuana use plays a role in friendship choices over and above the effects of current marijuana use.

The *third phase of model estimation* tested for effects of each of the risk factors on friendship choices. Three types of effects (variable ego, variable alter, same/similar variable) were tested for the following risk factors: neuroticism, extraversion, conscientiousness, depressive symptoms, self-esteem, delinquency, GPA, school attachment, and school trouble. Because these risk factors are likely to be correlated and the SABMs are sensitive to collinearity, a separate model was estimated to test each risk factor. These models included all parameters from the phase 2 model, plus the three new effects (ego, alter, similar) of the risk factor on friendship selection, and the effect of the risk factor on change in history of marijuana use (i.e., marijuana initiation).

Finally, risk factors that were found to significantly predict friendship choices and/or history of marijuana use in the third phase were included in a *final model*, alongside parameters included in the baseline and phase 2 models. Because of potential collinearity among effects, a stepwise approach to specifying the final model was used, whereby the risk factor with the strongest effect on friendship choices was added to the baseline model first. Subsequently, additional significant risk factors were score tested against this new model (Ripley et al. 2014), and if they remained significant predictors of friendships--over and above other effects in the model--they were estimated in the final model. This process was repeated for all risk factors identified as significant in the third phase.

A reduction in the size of the "same history of marijuana use" effect on friendship choices in the final model, relative to the baseline model, was viewed as evidence that the tendency for adolescents to select friends with the same history of marijuana use was partially or fully explained by the selection of friends based on other risky attributes identified as significant predictors of friendships.

RESULTS

Descriptive statistics for respondent and network characteristics

Participants' demographics, marijuana use, and risky attributes are summarized in Table 1. In School 1, 37.2% of students at Wave I and 45.0% at Wave II had a history of marijuana use, while in School 2 it was 48.8% at Wave I to 59.4% at Wave II. Using available data, 7.8% of participants in School 1 and 10.6% of students in School 2 used marijuana for the first time over the year of the study. Typically the majority of participants who had tried marijuana in their lifetime *were not* current users: in School 1 approximately 20% of participants had used marijuana in the past month at either wave; and in School 2 the corresponding percentages were 29.9% (Wave I) and 24.9% (Wave II).

Table 2 describes changes in the school friendship networks over the one year study. On average, participants identified 2–3 friends at each wave, with the number of nominations ranging from 0–10 (the survey limit), and the number of nominations received ranging from 0–18. Within a given wave approximately one third of friendship choices were reciprocated; between waves respondents maintained an average of one stable friendship and also established an average of one new friendship. However, some of these “friendship terminations” will be attributed to missing friendship data at Wave II (School 1 = 19.9%, School 2 = 12.6%). More than 20% missing data is not desirable for the SABMs (Ripley et al. 2014). However, the impact of missing Wave II friend nominations is thought to be minimal for two reasons: we retained information on the friend nominations *received* by network members who did not provide friend nomination data at Wave II (and so retained information on their role in the overall network structure); and RSiena has procedures for imputing missing data in the simulations that uses the last observed value of a tie (i.e., Wave I observations) when this is available.

Correlations among the set of risk factors that are hypothesized to explain the selection of friends with similar histories of marijuana use are presented in Table 3. The coefficients indicate that, in both schools, risk factors such as high neuroticism, low conscientiousness, low extraversion, depressive symptoms, delinquency, and school trouble tend to be positively correlated with each other, and negatively correlated with self-esteem, GPA, and school attachment. Current marijuana use also tended to be significantly and positively correlated with risk factors, and negatively correlated with protective factors, in both schools.

Baseline models: Friendship network and history of marijuana use dynamics

Results of the baseline models are presented in the first columns of Table 4 (School 1) and Table 5 (School 2). The results replicate findings that adolescents in both schools nominated friends whose history of marijuana use was the same as their own (positive effect of same history of MJ use: effect 46 in Table 4 and effect 37 in Table 5). Additionally, in both schools, youth who had a history of marijuana use made fewer friend nominations (negative effect of history of MJ use ego: effect 45 in Table 4 and effect 36 in Table 5).

These models control for youth's preferences to select friends of the same gender (School 1), race (School 1), and grade (School 1 and School 2), as well as tendencies in School 1 for

youth in older grades to attract more friend nominations (effect 13: positive grade alter) but to also make fewer nominations (effect 14: negative grade ego). A similar pattern of effects was found for parent education (a proxy for socio-economic status) in School 1 in that youth whose parents were more highly educated received more friend nominations (effect 16: positive parent education alter) but made fewer nominations (effect 18: negative parent education ego).

Structural effects also explain the friendship network dynamics, including the tendency to reciprocate friendship ties and to befriend friends of friends (effect 5: transitive triplets; and effect 7: transitive ties). Students who made the most friendship nominations were less likely to be befriended by their peers in School 1 (effect 8: negative outdegree popularity square root), but were more likely to be befriended by their peers in School 2 (effect 8: positive outdegree popularity square root). In School 1 there was also a tendency to form local hierarchies (effect 6: negative 3-cycle). Structural effects are explained in further detail in the RSiena Manual (Ripley et al. 2014)

In School 1, predictors of history of marijuana use include friends' history of use (effect 53), and having a greater number of outside-of-school friends (effect 49). No significant predictors of marijuana initiation were identified in the baseline models for School 2.

Phase 2 models: Friendship network, history of marijuana use, and current marijuana use dynamics

The second column of results in Table 4 and Table 5 presents models where current marijuana use (1 = *any past month* use) is included as a predictor of friendship choices, over and above the effects described in the baseline model. In School 1 (Table 4), youth were likely to form and maintain friendships with school peers whose *current* marijuana use was the same as their own (effect 43: positive same current MJ use); however, current use did not predict the tendency to send or receive friend nominations. In School 2 (Table 5), current marijuana use did not significantly predict changes in the friendship network (effects 32–34). Over and above any effects of current marijuana use, similarity on history of marijuana use remained a significant predictor of friendships in both schools (positive same history of MJ use: effect 46 in Table 4 and effect 37 in Table 5). History of marijuana use also continued to be associated with making fewer friend nominations in School 2 (effect 36: negative history of MJ use ego), although this effect was no longer significant in School 1 (effect 45).

Phase 3 and Final models: Friendship network, marijuana use, and risk factor dynamics

The effects of each risk factor on friendship choices (over and above effects included in the phase 2 models) were first identified in both schools, and only those with significant effects on friendships or marijuana initiation, independent of other risk factors, were retained in the final models. The results from the final models are presented in the final columns of Table 4 (School 1) and Table 5 (School 2).

School 1—In School 1, risk factors that independently and significantly predicted friendship choices and that were included in the final model were neuroticism, delinquency,

GPA, school attachment, and school trouble. The final model indicates that adolescents befriended peers with similar levels of delinquency (effect 28: positive delinquency similarity). They also avoided befriending peers with low GPA scores (effect 29: positive GPA alter); and youth scoring high on school trouble tended to make fewer friend nominations overall (effect 39: negative school trouble ego). Over and above these preferences, there remained significant effects for students to befriend peers whose current marijuana use was the same as their own (effect 43: positive same current MJ use) *and* to befriend peers whose history of marijuana use was the same as their own (effect 46: positive same history of MJ use).

There was some evidence to suggest that the effect of befriending peers based on similar history of marijuana use was partially explained by preferences to befriend peers based on similar *current* marijuana use, and selection based on other risk factors. Unstandardized SABM estimates can also be interpreted as conditional odds ratios (ORs) that reflect the likelihood of an actor *i*, who is making a change to his or her friendships at each “mini-step” of the simulations, choosing between a range of possible outcomes. The odds of an actor befriending a peer whose history of marijuana use was the same as their own vs. different to their own (where 0 = *no use* and 1 = *any history of use*), was greatest in the baseline model (OR = 1.31, 95% CI = 1.16, 1.46) compared to the model accounting for current marijuana use (OR = 1.22, 95% CI = 1.08, 1.38), and the final model that also accounted for selection on risk factors (OR = 1.18, 95% CI = 1.04, 1.38). However, as the confidence intervals for these odds ratios overlap, we cannot interpret this difference as being statistically significant.

Predictors of marijuana initiation in the final model for School 1 were consistent with the baseline model: friends' marijuana use (effect 53: positive total friend exposure) and having a greater number of outside-of-school friends (effect 49: positive outside-of-school friends). In addition, having a low GPA was found to predict marijuana initiation (effect 51: negative GPA) in this school.

School 2—In School 2, risk factors that were independently and significantly associated with friendship choices, and thus included in the final model, were conscientiousness, GPA, and school trouble. Results for the final model (Table 5) indicate that students tended to befriend peers who scored similarly on their GPA (effect 27: positive GPA similarity), and that youth with higher GPA scores also tended to nominate more friends (effect 26: positive GPA ego). Students also befriend peers who scored *differently* on getting in trouble at school (effect 31: negative school trouble similarity), which was unexpected although *heterophily* has been identified in other studies of adolescent social networks (de la Haye et al. 2011) and may be driven by youth trying to establish social ties with peers who differ from them on characteristics that are linked to social status (e.g., doing well at school). In phase 2, current marijuana use *was not* found to predict friendship choices in this school (and so was not included in the final model), whereas similar history of marijuana use (effect 37: same history of MJ use) remained a significant predictor of friendship choices over and above the effects of other risk factors.

The odds of a respondent in School 2 selecting a friend whose history of marijuana use was the same as their own (vs. selecting a friend whose history of use differed) *did not* change across the three models (baseline model: OR = 1.36, 95% CI = 1.17, 1.57; model with current marijuana use: OR = 1.39, 95% CI = 1.19, 1.63; final model: OR = 1.36, 95% CI = 1.13, 1.62). Thus, in School 2 we found no evidence that selection of friends with a similar history of marijuana use was explained by tendencies to select friends based on more “proximate” behaviors or attributes, such as current marijuana use or other risk factors. However, the significant effect of lifetime marijuana users nominating fewer friends (effect 36: negative history of MJ use ego) in the baseline and phase 2 models was no longer significant in the final model, indicating that this preference for fewer friends was better explained by other risk factors (i.e., the tendency for youth with low GPA to nominate fewer friends).

In this final model for School 2, marijuana initiation was significantly predicted by low conscientiousness (effect 40: negative conscientiousness).

DISCUSSION

This article sought to identify the role of various risky attributes in adolescents’ friendship choices, and if these social selection processes result in adolescent friends being similar in their history of marijuana use. Specifically, we tested two possible explanations for the positive association between similarity in history of marijuana use and friendship: (1) the driver for friendship formation is actually similarity in current marijuana use, rather than similarity in history of use; (2) this effect is a proxy for friendship selection based on personal and school risk factors that are more observable to peers and associated with history of marijuana use. We found minimal support for these two explanations, suggesting that adolescents’ history of having used marijuana may be a salient factor in their friendship choices.

With respect to the first mechanism, we did not find strong evidence that adolescents’ selection of friends with a similar history of marijuana use was explained by friendship choices based on current marijuana use. Similarity in current (past month) marijuana use was associated with friendship choices in School 1, but not in School 2. Although we cannot test for school-level factors that explain this difference between two schools, one reason for this difference may be that the rates of marijuana use were lower in School 1 than in School 2, making current marijuana use more rare, and potentially socially salient in School 1. In School 1, we found minimal evidence that the selection of friends based on current marijuana use partially explained the effect of homophilic selection for history of marijuana use, as the size of the latter effect decreased slightly (but not significantly) once the former effect was controlled. The odds of a student befriending a peer whose history of marijuana use was similar to their own remained strong and significant, indicating that this effect is not due to current marijuana use per se.

In models testing the second hypothesized explanation, we found that a range of risk factors (e.g., personality, delinquency, GPA, school attachment, school trouble) were independently associated with friendship choices. However, when included in a model of *multiple* risk

factors and marijuana use, only a few risk factors significantly predicted friendship choices, and evidence that this explained similarity on a history of marijuana use among friends was minimal. In School 1, some of the effect of similarity in history of marijuana use among friends could be explained by the selection of friends with similar delinquent behaviors and GPAs (the latter a marginally significant effect). Thus, marijuana use was a proxy for delinquency (and potentially low GPA), and youth were forming friendships based on similar delinquency and GPA, which gave rise, in a small part, to similarities in drug use. In School 2, although similarity in GPA scores predicted friend choice, there was no evidence that accounting for this reduced the size of the effect for similar history of marijuana use. Thus friend similarity on history of marijuana use could not be explained by similarities in academic performance. Although low GPA significantly predicted the initiation of marijuana use in School 1, this relationship was not significant in School 2, and therefore similarities among friends in GPA may not explain their similarity in drug use because this is not a strong predictor of marijuana use in this particular school.

Overall, there was some evidence that observed homophily on history of marijuana use in School 1 was a proxy for friendship choices based on current marijuana use, delinquency, and GPA, but not in School 2. And in both schools, the tendency for youth to select friends with a similar history of marijuana use remained strong and significant even when controlling for these alternate explanations. It is plausible that friendship choices based on characteristics not accounted for in this study spuriously gave rise to the observed similarities on history of marijuana use. For example, we could not account for beliefs or attitudes toward substance use, which may be discussed among peers and be a basis for friendship choices, and may be a fruitful direction for future research. However, it is worth noting that many *value*- and *status*-based characteristics relevant to homophily (Lazarsfeld and Merton 1954) were accounted for in our models, including demographics (gender, race, age, sociodemographics), social structure (i.e., tendencies for youth to select friends based on characteristics such as having many friend nominations (popularity) or being a friend of a friend), as well as the wide range of additional risk factors. The SABMs also accounted for associations between respondents' characteristics (demographics, drug use, risk factors) and popularity (based on the number of friend nominations they sent and received), and therefore controlled for the possibility that risky youth held popular (or marginalized) social positions and thus befriend one another. None of these mechanisms were found to explain the effect of homophily for history of marijuana use.

The different sociodemographics and contexts of these two schools may be especially relevant to understanding the role of substance use and other risk factors in driving friendship choices. The persistence of the history of marijuana use effect in School 2 in particular may be explained by the characteristics of this school. Relative to School 1 (which was a large, socioeconomically diverse, urban school), School 2 was a small school located in a mid-size town, and the student body was predominantly white with educated parents. Additionally, marijuana use was more common in this school (over half of student had used marijuana in their life and a quarter were current users), and their friendship networks were more densely connected (a higher number of friend nominations vs. School 1) and more stable (a lower "turnover" of friends vs. School 1). Thus, the role of *lifetime* drug use in the

selection of friends among this closer-knit community, in which drug use was more prevalent and visible, may be a reasonable and valid phenomenon. Value homophily, whereby youth select friends with similar values and beliefs (Lazarsfeld and Merton 1954), such as generalized beliefs or attitudes towards drug use, may be a particularly salient in communities such as School 2 where there is more social stability, compared a more socially instable and diverse School 1, where we observed stronger evidence of status homophily based on socio-demographics including race, gender, and parent education.

There are a few limitations of this study worth noting. The Add Health data, although a valuable and rich source of longitudinal information on youth and their peer networks, restricted the number of friend nominations to five males and five females. This may have resulted in a biased or restricted distribution of male and female friendship nominations (i.e., outdegree) in these analyses. Further, these data only allowed us to consider the selection of friends within the same school, and an interesting extension would be to consider a broader range of peer relationships that extend beyond the school setting. This may be particularly relevant for drug use risk, especially in larger urban settings. The final limitation imposed by the data set is that network information is only available in a small number of schools that participated in Add Health, and longitudinal analysis of marijuana use was only possible in two of these schools. Thus, we were only able to compare qualitatively the differences in effects observed in these two schools. There are also a couple of limitations to note with regards to our analytic approach. Because we conducted multiple tests of significance, it is possible that some significant effects are due to chance. Additionally, we have not considered whether the peer selection processes explored in this study differ between same-gender and cross-gender friendships, or between friendships that were mutual (i.e., reciprocated) or non-reciprocal. These may be valuable areas for future research.

CONCLUSIONS

The findings from this study did not provide strong evidence that similarities among adolescent friends on a history of marijuana use could be explained by youth selecting friends who were similar in their current marijuana use or other associated risk factors. Nonetheless, the results provide a useful contribution in terms of understanding that adolescent friendships are based on a broad range of characteristics, including diverse risk factors associated with substance use. The selection of friends based on demographic risk factors, behavioral risk factors (e.g., delinquency, low GPA), history of substance use, and current substance use, gives rise to an *aggregation of risky behaviors and/or risk factors* among subsets of socially connected youth. Youth drug interventions that target peer groups who are current users of drugs or other substances may prove effective for changing the behaviors and norms of these groups. In addition, there is likely to be great value in targeting *prevention efforts* on naturally occurring “risky” peer group clusters whose members have an incremental individual and collective risk of initiating drug use. These network-based interventions could address risk factors within the peer group, involve group-based commitments to abstain from drug use, or use network methods to identify opinion leaders within these risky groups who could be targets for drug prevention or cessation initiatives to more effectively diffuse messages and norms within the highest risk peer groups (Campbell et al. 2008; Valente 2012). Alternately, they could develop protective

strategies for youth who are surrounded by risky peers, or create opportunities for at-risk youth to affiliate with lower-risk peer groups (e.g., via mentoring programs or coordinated group-based school activities) to promote the formation of “protective” friendships. Further evaluations of network-based prevention efforts are needed to assess the feasibility, efficacy and potential risks associated with these various approaches (for example, could deviancy training within risky peer groups exacerbate risk behaviors?) (Dishion et al. 1999). Such efforts have the potential to reduce onset and diffusion of drug use across especially risky peer groups within adolescent social networks.

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Table 1

Individual attribute descriptive statistics

Characteristic	School 1 (N = 1193)		School 2 (N = 419)	
	Wave I N = 1193	Wave II N = 1051	Wave I N = 419	Wave II N = 366
Gender (% male)	51.3		56.8	
Race/ethnicity (%)				
Hispanic	39.7		1.0	
Non-Hispanic white	23.1		98.8	
Non-Hispanic black	24.7		0.0	
Asian	33.0		1.4	
Other	1.3		0.0	
Parent education (%) ^a				
Less than high school	24.6		3.9	
High school	20.2		32.5	
Some college or trade school	29.3		34.8	
Graduate of college/university	19.2		28.9	
Mean number of outside-of-school friends	1.9		1.3	
Limited nominations (%) ^b	5.3	0.0	4.8	0.0
<i>Marijuana use</i>				
Any history of marijuana use (%)	37.2	45.0	48.8	59.4
Any past month marijuana use (%)	20.7	19.7	29.9	24.9
<i>Risk factors</i>				
M(SD) neuroticism	12.2 (3.7)		12.1 (3.7)	
M(SD) extraversion	8.7 (2.3)		8.5 (3.0)	
M(SD) conscientiousness	12.6 (2.4)		12.1 (2.6)	
M(SD) depressive symptoms	0.73 (0.39)		0.62 (0.42)	
M(SD) self-esteem	3.92 (0.64)		3.96 (0.61)	
M(SD) delinquency	0.23 (0.21)		0.22 (0.20)	
M(SD) GPA	2.45 (0.79)		2.53 (0.74)	
M(SD) school attachment	2.69 (0.81)		2.57 (0.91)	
M(SD) school trouble	0.97 (0.73)		1.22 (0.74)	

^aParent education had 307 missing cases in School 1, and 114 cases missing in School 2.

^bParticipants who were only able to nominate 1 male and 1 female friend.

Note. Because SABMs use only whole numbers, the depressive symptoms measure was rescaled by multiplying by two, and delinquency was rescaled by multiplying by 5, for all analyses.

Table 2

Friendship network descriptive statistics

Characteristic	School 1 (<i>N</i> = 1193)		School 2 (<i>N</i> = 419)	
	Wave I	Wave II	Wave I	Wave II
% missing nominations	2.3	19.9	1.7	12.6
<i>M</i> friends nominated	2.0	1.8	3.4	3.2
Range of friend nominations made	0 – 10	0 – 10	0 – 10	0 – 10
Range of friend nominations received	0 – 15	0 – 8	0 – 18	0 – 13
Friend reciprocity index	.27	.34	.43	.42
Friend transitivity index	.21	.23	.24	.23

	Period 1	Period 2
<i>M</i> stable friendship ties	0.59	1.26
<i>M</i> new friendship ties	0.78	1.45
<i>M</i> friendship ties dissolved	1.04	1.74
Jaccard coefficient	.25	.28

Note. The reciprocity index is the proportion of friendship nominations that were reciprocated. The transitivity index is the proportion of 2-paths (friendship ties between AB and BC) that were transitive (friendship ties between AB, BC, and AC). The Jaccard index measures the amount of network change between consecutive waves, and expresses quantitatively whether the data collection points are not too far apart. Values of 0.3 or greater are ideal, so that assumptions that the network change process is gradual are met (Snijders et al. 2010).

Table 3

Correlation coefficients for risk factors and current marijuana use (School 1 above the diagonal, School 2 below the diagonal)

Variable	1	2	3	4	5	6	7	8	9	10
1. Neuroticism	-	-.35**	-.26**	.38**	-.091**	.19**	-.18**	-.29**	.21**	.14**
2. Extraversion	-.42**	-	.14**	-.19**	.32**	-.12**	.19**	.44**	-.24**	-.12**
3. Conscientiousness	-.40**	.19**	-	-.10**	.24**	-.13**	.15**	.14**	-.16**	-.10**
4. Depressive symptoms	.51**	-.26**	-.21**	-	-.32**	.17**	-.09**	-.18**	.22**	.09**
5. Self-esteem	-.91**	.39**	.35**	-.47**	-	-.18**	.16**	.26**	-.18**	-.13**
6. Delinquency	.51**	-.26**	-.21**	.18**	-.47**	-	-.27**	-.19**	.30**	.39**
7. GPA	-.14**	.06	.17**	-.19**	.14**	-.19**	-	.15**	-.29**	-.24**
8. School attachment	-.39**	.55**	.24**	-.29**	.37**	-.29**	.25**	-	-.21**	-.16**
9. School trouble	.23**	-.22**	-.23**	.34**	-.21**	.34**	-.39**	-.31**	-	.18**
10. Current MJ use	.11*	.02	-.13**	.16**	-.10**	.16**	-.23**	-.18**	.26**	-

*
 $p < .05$,**
 $p < .01$

Table 4

Results of the SAB models of friendship network and marijuana (MJ) use dynamics in School 1

#	Model Parameter	MJ history (baseline)		MJ history +current MJ use		MJ history +risk factors	
		Est.	SE	Est.	SE	Est.	SE
<i>Effects on Network Dynamics</i>							
1	Rate of change	8.86	0.46 **	8.88	0.53 **	8.81	0.48 **
2	Limited nominations on rate	-0.75	0.32 *	-0.74	0.38 +	-0.59	0.47
<i>Structural effects</i>							
3	outdegree (density)	-4.87	0.12 **	-4.95	0.12 **	-4.95	0.13 **
4	reciprocity	3.08	0.11 **	3.07	0.12 **	3.11	0.12 **
5	transitive triplets	0.71	0.07 **	0.71	0.06 **	0.70	0.08 **
6	3-cycles	-1.09	0.13 **	-1.08	0.12 **	-1.08	0.13 **
7	transitive ties	1.27	0.11 **	1.27	0.13 **	1.27	0.13 **
8	outdegree-popularity (sqrt.)	-0.48	0.08 **	-0.47	0.07 **	-0.52	0.08 **
<i>Control attributes</i>							
9	male alter	0.03	0.05	0.03	0.05	0.06	0.06
10	male ego	0.11	0.07 +	0.12	0.06 *	0.13	0.07 +
11	same male	0.32	0.05 **	0.32	0.05 **	0.32	0.06 **
12	same race	1.15	0.06 **	1.15	0.06 **	1.16	0.07 **
13	grade alter	0.19	0.05 **	0.19	0.05 **	0.19	0.06 **
14	grade ego	-0.14	0.07 *	-0.14	0.06 *	-0.13	0.06 *
15	same grade	0.41	0.05 **	0.41	0.05 **	0.40	0.05 **
16	parent education alter	0.08	0.03 **	0.08	0.02 **	0.06	0.03 *
17	parent education alter squared	0.01	0.02	0.01	0.03	0.01	0.03
18	parent education ego	-0.07	0.03 **	-0.07	0.03 *	-0.07	0.03 *
19	parent education similarity	0.21	0.11 +	0.21	0.12 +	0.21	0.12 +
20	limited nominations ego	0.23	0.16	0.23	0.18	0.20	0.15
<i>Risk and protective factors</i>							

#	Model Parameter	MJ history (baseline)		MJ history +current MJ use		MJ history +risk factors	
		Est.	SE	Est.	SE	Est.	SE
21	neuroticism alter					0.00	0.01
22	neuroticism alter squared					0.00	0.00
23	neuroticism ego					-0.01	0.01
24	neuroticism similarity					0.17	0.23
25	delinquency alter					-0.03	0.03
26	delinquency alter squared					0.01	0.02
27	delinquency ego					0.03	0.04
28	delinquency similarity					0.41	0.15 **
29	GPA alter					0.13	0.04 **
30	GPA alter squared					-0.01	0.03
31	GPA ego					-0.05	0.04
32	GPA similarity					0.20	0.11 +
33	school attach alter					0.03	0.04
34	school attach alter squared					0.03	0.03
35	school attach ego					0.07	0.05
36	school attach similarity					0.19	0.16
37	school trouble alter					-0.06	0.04
38	school trouble alter squared					-0.02	0.03
39	school trouble ego					-0.18	0.05 **
40	school trouble similarity					0.11	0.17
<i>Any past month MJ use</i>							
41	current MJ use alter			0.06	0.09	0.11	0.09
42	current MJ use ego			-0.12	0.10	-0.08	0.10
43	same current MJ use			0.17	0.07 *	0.16	0.08 *
<i>Any history of MJ use</i>							
44	history of MJ use alter	-0.10	0.06 +	-0.10	0.08	0.01	0.07
45	history of MJ use ego	-0.16	0.07 *	-0.05	0.09	0.00	0.09
46	same history of MJ use	0.27	0.06 **	0.20	0.06 **	0.18	0.07 *

#	Model Parameter	MJ history (baseline)		MJ history +current MJ use		MJ history +risk factors	
		Est.	SE	Est.	SE	Est.	SE
<i>Effects on History of MJ Use</i>							
47	Rate of change (i.e., initiation)	0.12	0.03 **	0.12	0.03 **	0.13	0.03 **
<i>Control attributes</i>							
48	male	0.49	0.29 +	0.48	0.28 +	0.30	0.30
49	outside-of-school friends	0.24	0.06 **	0.24	0.06 **	0.19	0.08 *
<i>Risk and protective factors</i>							
50	delinquency					0.25	0.16
51	GPA					-0.43	0.19 *
52	school trouble					0.36	0.19 +
<i>Friend influence</i>							
53	total friend exposure	0.52	0.16 **	0.52	0.17 **	0.50	0.18 **

Note. Model estimates (Est.) are unstandardized coefficients.

+ $p < .10$,

* $p < .05$,

** $p < .01$

Table 5

Results of the SAB models of friendship network and marijuana (MJ) use dynamics in School 2

#	Model parameter	MJ history (baseline)		MJ history + current MJ use		MJ history + risk factors	
		Est.	SE	Est.	SE	Est.	SE
<i>Effects on Network Dynamics</i>							
1	Rate of change	19.81	1.73 **	19.50	1.80 **	19.35	2.32 **
2	Limited nominations on rate	-0.11	1.22	-0.14	0.56	-0.07	0.81
<i>Structural effects</i>							
3	outdegree (density)	-4.40	0.18 **	-4.28	0.17 **	-4.29	0.20 **
4	reciprocity	2.28	0.13 **	2.26	0.10 **	2.30	0.17 **
5	transitive triplets	-0.17	0.20	-0.13	0.15	-0.18	0.13
6	3-cycles	0.51	0.37	0.46	0.28 +	0.54	0.23 *
7	transitive ties	1.08	0.14 **	1.09	0.11 **	1.08	0.10 **
8	outdegree-popularity (sqrt.)	0.33	0.09 **	0.28	0.08 **	0.32	0.08 **
<i>Control attributes</i>							
9	male alter	0.02	0.08	0.02	0.07	0.01	0.09
10	male ego	0.04	0.09	0.05	0.09	0.07	0.08
11	same male	0.11	0.09	0.10	0.06	0.10	0.06
12	grade alter	0.14	0.09	0.14	0.08 +	0.12	0.09
13	grade ego	-0.14	0.10	-0.13	0.08	-0.12	0.09
14	same grade	0.41	0.07 **	0.39	0.07 **	0.40	0.08 **
15	parent education alter	0.00	0.06	0.01	0.06	0.01	0.05
16	parent education alter squared	-0.13	0.08	-0.14	0.07 +	-0.14	0.07 *
17	parent education ego	0.07	0.06	0.06	0.05	0.05	0.05
18	parent education similarity	0.18	0.19	0.17	0.17	0.20	0.24
19	limited nominations ego	0.35	0.28	0.36	0.20 +	0.35	0.24
<i>Risk and protective factors</i>							
20	conscientiousness alter					0.03	0.02
21	conscientiousness alter squared					0.00	0.00
22	conscientiousness ego					0.02	0.02

#	Model parameter	MJ history (baseline)		MJ history + current MJ use		MJ history + risk factors	
		Est.	SE	Est.	SE	Est.	SE
23	conscientiousness similarity					-0.25	0.28
24	GPA alter					-0.06	0.06
25	GPA alter squared					-0.04	0.06
26	GPA ego					0.13	0.07 *
27	GPA similarity					0.44	0.16 **
28	school trouble alter					-0.04	0.04
29	school trouble alter squared					-0.06	0.03 *
30	school trouble ego					0.00	0.04
31	school trouble similarity					-0.49	0.25 *
<i>Any past month MJ use</i>							
32	current MJ use alter			-0.06	0.11		
33	current MJ use ego			-0.06	0.11		
34	same current MJ use			-0.02	0.08		
<i>Any history of MJ use</i>							
35	history of MJ use alter	0.14	0.10	0.15	0.12	0.12	0.13
36	history of MJ use ego	-0.27	0.09 **	-0.23	0.12 *	-0.23	0.13 +
37	same history of MJ use	0.32	0.08 **	0.33	0.08 **	0.30	0.09 **
<i>Effects on History of MJ Use</i>							
38	Rate of change (i.e., initiation	0.25	0.10 **	0.25	0.09 **	0.30	0.11 **
<i>Control attributes</i>							
39	grade	0.53	0.63	0.51	0.42	0.57	0.41
<i>Risk and protective factors</i>							
40	conscientiousness					-0.24	0.08 **
41	GPA					-0.46	0.25 +
<i>Friend influence</i>							
42	total friend exposure	0.24	0.18	0.24	0.18	0.10	0.20

Note. Model estimates (Est.) are unstandardized coefficients.

+ $p < .10$,

10' > d'
**
'50' > d'
*

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