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A Social Network Perspective on Heroin and Cocaine Use Among Adults: Evidence of Bidirectional Influences

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Abstract

Aims—While several studies have documented a relationship between initiation of drug use and social network drug use in youth, the direction of this association is not well understood, particularly among adults or for stages of drug involvement beyond initiation. The present study sought to examine two competing theories (social selection and social influence) in the longitudinal relationship between drug use (heroin and/or cocaine) and social network drug use among drug-experienced adults.

Design—Three waves of data came from a cohort of 1,108 adults reporting a lifetime history of heroin and/or cocaine use.

Setting—Low-income neighborhoods with high rates of drug use in Baltimore, Maryland.

Participants—Participants had weekly contact with drug users and were 18 years of age or older.

Measurements—Drug use data were self-report. Network drug use was assessed through a social network inventory. Close friends were individuals the participant reported seeing daily or rated as having the highest level of trust.

Findings—Structural equation modeling indicated significant bidirectional influences. The majority of change in network drug use over time was due to change in the composition of the network rather than change in friends' behavior. Drug use by close peers did not influence participant drug use beyond the total network.

Conclusions—There is evidence of both social selection and social influence processes in the association between drug use and network drug use among drug-experienced adults.

Keywords

social networks; social selection; social influence; heroin; cocaine

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Introduction

Given the host of health and economic problems associated with heroin and cocaine use [1-3], there is increasing interest in identifying factors associated with their use. A number of studies have identified substance use among others within the peer group, or social network, as a correlate of substance use [4-9]. However, it is not clear whether individuals are influenced by their network members, or if their own drug use influences their choice of friends. Furthermore, much of the research examining the direction of the association between drug use and network drug use has been conducted among adolescents [5,10-15], whereas less is known about this association among adults who have already initiated substance use. Having an enhanced understanding of the direction of influence between peer drug use and an individual's substance use is crucial to identifying appropriate interventions. The present study used longitudinal social network data to explore the direction of the association between drug use and network members' drug use in an urban community sample of drug-experienced adults.

Social Selection and Social Influence Theories

There are two competing theories which contend different directions of influence between peers and substance use. Social influence theory [16] suggests that observing substance use by network members leads to changes in the substance use among others in the network, such that the other member's substance use becomes more like their friends' behavior [17,18]. In contrast, social selection theory [16] suggests that a person who is using drugs would change networks in order to spend more time with others who are also using drugs [17]. The key difference between these two theoretical perspectives is the direction of influence.

Several studies have examined social selection and social influence processes in relation to substance use among adolescents. Kandel and colleagues [5] found that having peers who use marijuana was a strong predictor of initiating use of marijuana or other illicit drugs among adolescents. Various aspects of the peer network explained 68% and 55% of the variance in marijuana and alcohol use, respectively [10]. Another study of adolescents found that youth who reported being influenced by their friends' behavior were more likely to report drug use [11]. Cleveland and Wiebe [12] found that the similarity between adolescent friends in tobacco and alcohol use was moderated by the level of substance use by others at the school. In addition, Johnson [14] found stronger evidence for the influence of peers on alcohol use compared to marijuana use. This relationship did not vary by gender.

A Social Network Approach

Social networks are an approach to conceptualize and measure the people with whom an individual (index) has social interactions [7,19] and has proven to be particularly instructive in examining these two theories in the context of adult alcohol use [17,20]. A number of studies have used social network data to examine drug use [7,21-24] and have confirmed that the behavior of the social network is associated with the drug behavior of the index member. For example, Latkin and colleagues [7] found that the number of network members the index member shares drugs with was associated with the index's frequency of injection. Among injection drug users (IDUs), turnover in the social network is associated with more HIV risk behavior [21]. Exposure to network sharing of filters has also been linked with index filter sharing among IDUs [22]. Furthermore, a preliminary analysis for the present study found that quitting drugs was associated with a subsequent decrease in social network drug use [23].

Two previous longitudinal studies have used network data to examine the association between peers and alcohol consumption among adults [17,20]. In a study of college students, Reifman and colleagues [17] used structural equation modeling (SEM) with an autoregressive cross-lagged panel design to test bidirectional influences between alcohol use and network drinking. In their model, both alcohol use and network drinking were modeled simultaneously over time. Each was a function of a stability path from the same variable at the previous assessment, the cross-lagged path of the other variable at the previous assessment, and a correlation of the residuals for variables measured at the same assessment.

Reifman et al. found that network drinking predicted later respondent drinking, but respondent drinking only predicted network drinking for one of the two cross-lagged paths examined. The authors also found that drinking by key network members (i.e., those that the respondent rated the highest level of closeness and those who the respondent spent the most time with) was correlated with respondent alcohol misuse. They further examined the proportion of change in network member drinking that was accounted for by change in the behavior of network members of time and changes in the composition of the network itself in a microsocial analysis. Consistent with social selection, changes in network behavior were mostly accounted for by the gaining and dropping of unique network members (i.e., turnover due to seeking new friends). Also using cross-lagged autoregressive SEM, Bullers and colleagues [20] found evidence of a bidirectional relationship between individual and network drinking among adults.

Despite the increasing number of studies examining the association between drug use and network drug use, there are still a number of gaps in the available research. For example, much of the research examining social influence and social selection theories has focused on adolescents rather than adults [5,10-15]. Previous research on social networks and illegal drug use has largely focused on initiation rather than maintenance or cessation [25]; additional research is needed to determine the direction of the association between illicit drug use and peer drug use at stages of use beyond initiation. Furthermore, it is unclear if findings regarding the association between use and peer alcohol use previously observed in young adults [17,20] apply to illegal substances..

The current study aimed to address these gaps in the research by using social network inventory data to examine the direction of the association between index heroin and/or cocaine use and social network heroin and/or cocaine use among drug-experienced adults. Specifically, we tested the following hypotheses: 1) Substance use by social network members will be associated with index substance use at the subsequent study assessment, which would support social influence theory. 2) Index substance use will be associated with substance use by social network members at the subsequent study assessment, which would support social selection theory. 3) A greater amount of the change in network drug use between assessments will be accounted for by turnover than by changes in the behavior of network members over time. This tested the mechanism of social selection that an individual chooses friends whose behavior matches their own. 4) Drug use by close network members will have a positive association with index drug use at the following assessment. This hypothesis further explored social influence by testing if drug use by closest peers exerts influence on index drug use.

Methods

Sample

Data come from waves one, two, and four of the SHIELD (Self-Help In Eliminating Life-Threatening Diseases) Study [26]. Participants were recruited from neighborhoods in Baltimore, Maryland identified via ethnographic research and police records to have high

levels of drug use. Eligibility criteria included reporting weekly contact with drug users, being 18 years of age or older, and willingness to engage in a HIV risk reduction intervention. A number of respondents ($n = 567$) were recruited from among the social networks of other participants. Only 154 participated in the intervention.

Wave one (1997-1999) included 1637 interviews. Due to funding constraints, participants were prioritized for follow-up at wave two, but all baseline participants were eligible for subsequent interviews. Wave two (1998-2001) included 896 interviews and wave four (2001-2003) totaled 905 interviews. Waves three and five did not include social network data. The median number of days was 245 and 940.5 from waves one to two and two to four respectively. All participants provided written informed consent and were financially compensated. The study was approved by the local Institutional Review Board.

Of the baseline sample, 1,158 had network data for wave two and/or four. An additional 50 individuals had a negative or missing lifetime history of heroin or cocaine use and were not included. Compared to participants lost to follow-up, the retained sample ($n = 1,108$; see Table 1) was less likely to have used heroin and/or cocaine in the prior six months (76.6% vs. 97.3%, $p < .001$) and reported fewer drug-using network members (3.5 vs. 4.0, $p < .001$) at baseline.

Measurement

Participants self-reported the frequency of their drug use in the prior six months for each substance via each route (e.g., snorting, injecting, smoking) on a 8-point Likert scale. Consistent with previous studies of urban adults [27,28], use of cocaine and heroin (though not necessarily together) was more common than use of only cocaine or heroin in this sample [29]. Consequently, we coded whether participants had used heroin and/or cocaine via any route in the past six months [23,30].

The social network was measured using an adapted version of the Arizona Social Support Inventory [31], during which respondents listed all individuals they considered among their social ties. Index report in the inventory was used to determine if each nominated network member was a current heroin/cocaine user, and total count of active drug users in the network indicated the index's exposure to network drug use [23,30,32].

Key peers—Key social network members were identified by frequency of contact and a rating of trust. Indexes were asked how often they see each network member on a six-point Likert scale. A binary variable was created that indicated if any network member was an active drug user who the index sees daily. Indexes were asked how much they trust each network member, on a scale of one (*not at all*) to ten (*trust with their life*). A binary variable was created that indicated if the network included active drug users who the index rated a “ten” for trust.

Analyses

Structural equation modeling (SEM)—We tested bidirectional associations of index and network substance use over the three assessment points simultaneously (hypotheses 1 and 2), by using reciprocal, cross-lagged longitudinal paths [17,20] in a SEM [33]. The models were fit with MPlus 5.0 [34] using the weighted least squares means and variance adjusted estimator. Missing data was imputed using MPlus [34]. The Tucker-Lewis Index (TLI), the Comparative Fit Index (CFI), and the Root Mean Square Error of Approximation (RMSEA) were used to test the fit of all models [35].

Significant longitudinal paths were further examined with recursive models to understand the extent to which these relationships were operating through later drug use or network drug use [36]. Recursive models included the longitudinal path of interest ($X_1 \rightarrow Y_2$), a stability path for the independent variable ($X_1 \rightarrow X_2$), and an additional path such that the concurrent level of the independent variable mediated the relationship between the independent variable at the prior assessment and the outcome ($X_2 \rightarrow Y_2$).

Microsocial analysis—We employed a microsocial analysis [17] in order to examine the source of change in network drug use (hypothesis 3). Change scores in network drug use were calculated by subtracting the number of current drug users in the network at wave one from two and at wave two from four. We selected the 20 participants with the greatest increase and the 20 participants with the greatest decrease for each time lag, for a total of 80 observations, and compared the names of their network members at two consecutive assessments. We calculated the difference in total network drug use due to change in behavior by members in the network at two consecutive waves (ΔC) and the difference due to the entrance and exit of unique network members (ΔU). In cases of uncertainty, it was assumed that similar names at two different assessments represented the same person. The amount of change due to each type was compared using paired *t*-tests for those with the greatest decreases and greatest increases separately.

Key peer analysis—The influence of key network members (hypothesis 4) was analyzed by adding measurement of key peer influence to the SEM described above. Specifically, these models also included a path from key peer use at wave one to index use at wave two, key peer use at wave two to index use at wave four, and a stability path between the measurements of key peer use from waves one to two. Total network drug use was still included in the model, such that the coefficients indicated if key peer use explained later index use beyond the total network drug use.

Preliminary Analyses to Explore Clustering

Due to the clustered nature of the recruitment techniques, we calculated the Design Effect ($DEFF = 1 + [\text{average cluster size} - 1] * ICC$), where a $DEFF > 2$ indicates that multilevel modeling is preferable [37]. The Design Effect for clusters by primary index and by neighborhood was estimated to be 1.04 and 1.01 respectively, using the ICC from baseline number of network drug users. Consequently, we did not use multilevel modeling.

Results

The percent of indexes in the retained sample reporting recent drug use at waves one ($n = 1,083$), two ($n = 849$), and four ($n = 890$) was 77%, 71%, and 61% and the mean number of active drug users in the network was 3.5 ($SD = 2.4$), 2.1 ($SD = 2.0$), and 2.1 ($SD = 2.1$), respectively.

Structural Equation Modeling

Figure 1 reports the standardized estimates of the primary SEM. Estimates of both cross-lagged associations which supported social selection (index drug use predicted later network drug use) were statistically significant. Only one of the two estimates of the cross-lagged associations which supported social influence (network drug use predicted later index drug use) was statistically significant. Inspection of the fit indices indicated good model fit. Baseline demographic characteristics (sex, age, and education) were entered into the model regressed on baseline drug use and network drug use, but were not significant and not included in the final model. Intervention status was not significantly associated with the

study outcomes, and inclusion of the intervention variable in the model resulted in little change to the estimates. No moderating effect for gender was found.

Standardized estimates from the recursive models are reported in Table 2. Because dependent variables in the SEM were independent variables in these models, some missing data were not imputed. Consequently, these models included only those participants with full data for the variables included in each model (814 for Model 1, 826 for Model 2, and 631 for Model 3). For the cross-lagged path supporting social influence (Model 1), the estimate remained significant, indicating that the influence of the network on an individual functions through long-term processes. For the two cross-lagged paths supporting social selection (Models 2 and 3), the estimates for the longitudinal path became non-significant (Model 2) or reversed directions (Model 3), indicating shorter-term processes.

Microsocial Analyses

For the 40 observations with the greatest decreases in drug use in the network, the mean ΔU was -6.08 (S.D. = 0.32) and the mean ΔC was -0.83 (S.D. = 0.16), with a statistically significant greater decrease in drug use through entrance and exit of unique members than change in behavior of carryover members ($t(39) = -12.32, p < .001$). Similarly, among the 40 observations with the greatest increases in drug use in the network, the mean ΔU was 5.20 (S.D. = 0.32) and the mean ΔC was 0.43 (S.D. = 0.15). Again the increase in drug use through entrance and exit of unique members was statistically greater than the increase in drug use by behavior change in carryover members ($t(39) = 11.33, p < .001$).

Key Peer Analysis

The model in Figure 2 includes the influence of drug use by network members at the highest level of trust and Figure 3 the influence of drug use by network members who the index sees daily. The association between key peer drug use with subsequent index drug use was not statistically significant in the expected direction in either model when total network drug use was also included. Both models exhibited good fit. Gender was not a modifier of the effect of key peer drug use and index drug use in either model.

Discussion

Consistent with social influence theory, we observed an association between network drug use and later index drug use across waves one to two but not across waves two to four. However, consistent with social selection, the association of index drug use with later network drug use was significant across all waves. These findings provide support for both social influence and social selection processes in the persistence of drug use among adults. Results from the recursive models suggest that the influence of network drug use on personal drug use operates through long-term processes, while shorter-term processes dominate the relationship of index drug use on later friend drug use. Social influence processes may take more time, as attitudes and norms are shifted [38], whereas social selection processes may be more immediate as the individual seeks or cut ties with friends.

The findings from Model 1, suggesting that social selection plays a greater role in adult drug use behavior, may reflect that, in comparison to adolescents, adults have greater control over their choice to spend time with particular individuals. During adulthood, individuals are also less likely to change their attitudes [39], which may mean that they are more selective in the influences of their networks. The mode by which cocaine and heroin are acquired, in comparison to alcohol, may also contribute to the strength of social selection dynamics in our model. Often individuals who use these drugs link with their network members to acquire drugs [40]. Alternative explanations include: (1) that the sample is drug-

experienced, and social influence may be more important to initiation, consistent with the strength of social influence for drug initiation [5]; (2) as more time elapsed between the latter two assessments and we found social influence to operate through long-term processes, the time elapsed between the later assessments may have exceeded the time during which past peer use has an effect on future index drug use; and (3) the episodic users may have quit by the latter waves of the study, thus the use of their peers could not affect their own later use.

The microsocial analysis lent additional support for social selection. The method used for classification - specifically classifying a network member as the same person at two different time points in cases where there was uncertainty - may bias the results towards classifying network members as changing their behavior. Consequently, the estimation in support of social selection is conservative.

We did not find that closest network members exerted stronger influence on drug use behavior than the total network. Results were similar for both measures of closeness. Our findings suggest that social network substance use does influence index substance but does not function through closest friends. One possible explanation is that peer influence on drug use is accounted for by the total amount of substance use around an index ("embeddedness" in a drug-using network).

With regard to gender differences, although women in the current sample had larger social networks, larger support networks, and more individuals with whom they have shared needles [41], there were no difference in the number of active drug users in the network compared to men. Consistent with previous research [14], we did not find that gender was a significant moderator of the social selection and influence processes. Further research is needed to better understand how differences in the network impact drug use outcomes among men and women.

Limitations

Although the present data have the advantage of being longitudinal, inferences are limited by the complexity of causality in social, behavioral, and psychological dimensions. Given the focus on heroin/cocaine-experienced individuals, the structure and influence of the networks observed over the course of this study may have been influenced by unmeasured prior attempts to cease drug use. The data were collected in one metropolitan area, and thus may not be representative of drug users in other locations. It is likely that the participants, drawn from inner-city neighborhoods with high rates of drug use, have a greater probability of having drug users in their network than other populations. Additionally, participants may have larger social networks compared to the broader population and may be individuals who are less easily influenced, as opinion leaders are better suited for network-based interventions [42] such as the SHIELD study. The relative poverty of the sample may limit the ability of respondents to cut network ties, in comparison to more affluent samples.

Despite its limitations, self-reports of drug use have been shown to have moderate to strong reliability and validity [43-45]. Social network members' behavior was reported by the index participant. Participants not using drugs do not have drug interactions with network members, and thus may have less knowledge of their friends' drug use than indexes who use drugs.

Implications and Future Directions

These findings suggest that the social network may be an important avenue for intervention with adult drug users. Consistent with the evidence in support of social influence, a possible intervention to reduce substance use could include training individuals to conduct peer

outreach to their network [26] via education on drug use risks and disseminating treatment information. The focus of the present study naturally poses the questions of whether eliminating drug users from the social network would be an effective way to reduce drug use, as recommended by many treatment programs. These findings do suggest that friends influence drug use, and thus, there may be benefit in reducing the number of people one spends time with when attempting to quit drug use. However, a prior study examining cessation found that many individuals who quit continue to associate with drug users, albeit fewer [23]. Nonetheless, interventions to reduce drug use could engage drug users in discussing how they seek out or avoid spending time with social network members who use drugs, and promote more awareness of seeking out friends who use drugs as a conscious or unconscious expression of a desire to use drugs and a risk for relapse.

Social selection is a complex and dynamic process which appears to play an important role in either perpetuating or terminating an IDU's drug use career. Given the bidirectional association between a person's drug use and the drug use of social network members, future studies should use an individual-centered approach to determine if some individuals are more susceptible than others to peer influence on drug use [15]. Additional research should also explore drug availability through social networks, the relationship of network use with addiction severity, and characteristics of influential network members as moderators of the observed associations [46]. An enhanced understanding of these factors may elucidate potential intervention targets.

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Figure 1.

Standardized estimated coefficients from a structural equation model of the bidirectional relationship between drug use and network drug use, using data from waves 1, 2, and 4 of the SHIELD study.

Note. “D. U.” refers to drug use defined as heroin and/or cocaine use in the prior 6 months. All estimates are standardized, and those in bold are statistically significant at $p < .05$. CFI = .997, TLI = .991, RMSEA = .034.

Figure 2.

Structural equation model results for index drug use predicted by both total network drug use and if there are any drug users among those friends rated at the highest level of trust.

Note. “D. U.” refers to the drug use defined as heroin and/or cocaine use in the prior 6 months. All estimates are standardized, and those in bold are statistically significant at $p < .05$. CFI = .994, TLI = .989, RMSEA = .026. Correlations between the residuals are not shown.

Figure 3.

Structural equation model results for index drug use predicted by both total network drug use and if there are any drug users among those friends who the index sees daily.

Note. “D. U.” refers to the drug use defined as heroin and/or cocaine use in the prior 6 months. All estimates are standardized, and those in bold are statistically significant at $p < .05$. CFI = .981, TLI = .972, RMSEA = .050. Correlations between the residuals are not shown.

Table 1

Baseline sample characteristics of those included in the final SEM model, categorized by baseline drug use status (defined as any route or form of opiates or cocaine).

Characteristic	Total Sample (n = 1,108)%	Recent drug use (n = 829)%	No recent drug use (n = 254) %
Male	59.6**	61.8	52.4
Age			
less than 32	18.6	17.9	21.3
33 to 42	49.9	49.8	50.0
43 and older	31.5	32.3	28.7
Black, non-Hispanic	95.9	95.9	96.1
Education: H.S. or G.E.D	53.0	51.6	57.5
Partner Status			
Current Marital Status			
Married	6.6	6.9	5.5
Separated/Divorced/Widowed	27.1	26.7	28.3
Single	66.4	66.5	66.1
Has a current main partner	63.6	63.7	63.1
Health Status			
Currently smokes	88.1**	90.7	79.3
Has been tested for HIV	93.4	92.9	94.9
Has been diagnosed HIV+	18.9**	16.9	25.4
Has had a mental illness	30.6	30.7	30.3
Has any current health problem	42.3*	40.4	48.2
Employment Status			
Current Employment Status			
Employed Full-time	9.4	8.6	12.2
Employed Part-time	12.6	13.2	10.6
Unemployed- seeking work	46.3	46.3	43.3
Unemployed- not seeking work	32.0	32.0	33.9
Received public assistance in the prior 6 months	52.0	50.9	55.5
Housing			
Current Living Situation			
own place	47.6**	45.4	54.9
other's place	40.4	43.4	30.4
boarding or halfway house	4.2	3.7	5.5
shelter or homeless	7.1	4.9	8.3
Homeless at any point in the prior 6 months	20.4	20.8	19.3

* $p < .05$,

** $p < .01$ by χ^2 test for the difference between baseline current users and non-current users. For variables with multiple categories, the upper left cell indicates the p-values of the χ^2 test for the variable.

Recursive models of significant longitudinal paths in the larger structural equation model, using data from waves 1, 2, and 4 of the SHIELD study.

Table 2

Model	Longitudinal Path	β	Autoregressive Path	β	Concurrent Path	β
1	Net Drug Use 1 to Drug Use 2	0.10*	Net Drug Use 1 to Net Drug Use 2	0.32*	Net Drug Use 2 to Drug Use 2	0.59*
2	Drug Use 1 to Net Drug Use 2	-0.06	Drug Use 1 to Drug Use 2	0.49*	Drug Use 2 to Net Drug Use 2	0.62*
3	Drug Use 2 to Net Drug Use 4	-0.12*	Drug Use 2 to Drug Use 4	0.51*	Drug Use 4 to Net Drug Use 4	0.75*

Note. “Net Drug Use” refers to the total number of network members who are current drug (cocaine and/or heroin) users. “Drug Use” refers to current heroin and/or cocaine use by the index.
* $p<.05$ by Wald test.