1st Visible Path Award Winner

Nathaniel Bulkley

The International Network for Social Network Analysis (INSNA) awarded its first annual Visible Path Graduate Student Award for new research on social networks and professional performance today.

The winner, Nathaniel Bulkley, a doctoral student working with Assistant Professor Marshall Van Alstyne at the University of Michigan School of Information, conducted surveys and studied six months of email data and accounting records from an executive recruiting firm representative of professional services firms organized around client practices. An interesting finding was that characteristics of the recruiter's internal networks were statistically significant predictors of performance, but the size of their private rolodexes were not.

Bulkley's winning paper, "An Empirical Analysis of Strategies and Efficiencies in Social Networks" can be downloaded from http://www-personal.umich.edu/~natb/

The abstract of his paper is:

> *This research examines hypotheses ab out the efficient and strategic uses of social networks by a specific group of white collar workers. We examine existing theory that relates network structure to performance and put forward two new hypotheses. The first addition merges explore/exploit theory with so cial networks, proposing that optimal network characteristics evolve over the course of a career from those favoring exploration to those favoring exploitation of knowledge and relationships. The second concerns efficient movement of information through a network, proposing that frequent short communication outperforms infrequent lengthy communication. Using a unique data set containing email patterns and accounting records for several dozen executive recruiters, we find statistically significant differences related to network (1) structure (2) flow and (3) age. Consistent with existing theory, more central position is associated with higher output. Consistent with the two proposed theories, exploration strategies among early career recruiters and exploitation strategies among senior recruiters are both positively associated with performance, while more frequent shorter messages are associated with higher output. Results of this research have the potential to create a more complete understanding of different types of efficiency associated with social networks.*

In brief, Bulkley's email analysis found relationships between centrality and performance, while also showing how aspects of how social networks are used re late to performance. Shorter, more frequent responses were associated with higher performance and professional's network use evolved over the course of a career from an emphasis on accumulating to exercising social capital.

Bulkley's findings suggest professional service firms may be able to develop more efficient and effective communications strategies through the use of relational measures derived from electronic data sources.

A recent BusinessWeek story (Feb. 13) highlighted the growing popularity of dashboards that incorporate real-time data. Will future dashboards emphasize real-time relational measures?

Bulkley's research was featured at at INSNA's Sunbelt conference in Vancouver: http://www.insna.org/2006/sunbelt2006.html

The presentation of the award and Buckley's talk was Friday, April 28, 5:00 - 6:00 PM

Early last year, INSNA announced the newly-created Visible Path Graduate Student Award at the Sunbelt XXV International Social Network Conference in Redondo Beach, California. INSNA gives the annual award, which carries a $5,000 prize plus paid expenses to the Sunbelt conference, to a graduate student in recognition of research on how social networks are used to improve individual and inter-organizational performance.

The Visible Path Graduate Student Award recognizes a graduate student's research on how social networks improve professional performance. The award is given annually to a graduate student in recognition of research at the interface between inter-organizational science and social network analysis. The award recognizes research on organizational science, in which social networks are used to improve individual and inter-organizational performance. For example, research focusing on how people in organizations, especially corporations, use their own social networks to accelerate strategic processes with people outside their organization would be eligible.

"Social network analysis touches many disciplines — anthropology, sociology, psychology, political science, economics and communications science for starters — yet there are few awards that are specifically designed to support basic social network research," said Bill Richards, INSNA president and professor of communications at Simon Fraser University. "This award seeks to encourage research for benefit of everyone who is interested in the juncture of social network analysis and organizational performance."

The award taps into broadening awareness of social network analysis sparked by articles, popular business books and new companies selling web services and software that capitalize on social networks.

"The timing is right for graduate students looking to uncover social network insights that can advance an increasingly popular discipline with growing opportunities for application" said Stanley Wasserman, professor of sociology, psychology, and statistics at Indiana University and chief scientist for Visible Path Corp. in New York."

To apply for this year's award, students should submit a paper (written in English) to the committee before 1 September 2006. The paper must be written between September 1, 2005 and August 31, 2006. Eligible students must be sole (or first) author on the submitted paper. Letters of support should accompany the submission. Submitted papers will be evaluated by a committee of four judges; their decision will be final. Judging will be on the basis of the level of originality in the ideas and techniques, the possible applications and their treatment, and potential impact. The awardee will give a formal presentation at Sunbelt 2007 in Greece. The committee may arrive at the conclusion that none of the submitted papers merits the award.

The award will made for the second time in 2007. Funds for the award have been provided by Visible Path Corporation, New York (http://www.visiblepath.com).

Details for the 2007 Visible Path Graduate Student award will be announced shortly.

2006 Vancouver Symposium on sex, drugs, and social networks

April 24-25, 2006

This symposium provided an opportunity for leading social networks researchers, infectious disease epidemiologists, and public health practitioners to discuss their common problems and approaches. It was organized around some of the puzzles and difficulties that face us. Discussions were guided by 5 papers that were distributed in advance and outlined by their authors at the meeting itself.

A series of questions (see below) was prepared as an organizing tool and to guide the authors of materials for the meeting.

The Symposium specifically focused on social networks, drug networks (including those of the users of drugs, those of the neighborhoods in which drugs are used, those of the suppliers of drugs, and the related policing and governmental agencies), and the sexual networks through which STDs spread. It considered HIV, tuberculosis, syphilis and hepatitis. An important part of the discussion was how the ideas raised at the meeting help to understand and/or to intervene in the HIV and hepatitis epidemics in Vancouver — but materials and issues ranged more broadly than this.

To give some coherence to the sessions, papers were invited addressing specific topics prepared for distribution to all participants a few weeks before the meeting. While Vancouver would have made an appropriate location to use to illustrate most of the relevant issues, authors were encouraged to take a more general approach so they may include issues particular to other locations as well as ones seen in Vancouver. Some of the Symposium's papers were also presented at the Sunbelt conference that filled the rest of the week.

Questions to focus and guide discussion:

1. What network phenomena can shape epidemics and the responses to epidemics? These might include social influence networks, bridges between groups (HIV- and HIV+, IVDU and non-IVDU sex partners, etc...), political networks and organizations.

2. What local social phenomena help shape these networks? Possibilities include various kinds of social pressures, behaviour, event occurrence and event attendance, the epidemics themselves, local neighborhood stakeholders, and relevant bureaucratic structures.

3. What more general factors shape social, sexual and drug-related networks?
How does this happen? Possibilities include norms? customs? politics? policing? economics? We must go far beyond simple propinquity as explanations!

4. What kinds of data do we need to collect to study these issues? Which of these data are routinely available? Which are normally collected in epidemiologic or political research? Which require network designs? Specifically, what data — social network and other — are already available in Vancouver? ... or elsewhere? ... and how might we go about designing appropriate studies?

5. What kinds of simple interventions might reduce HIV and STD spread?
And how do sexual network patterns affect their impact? And do political or workplace network dynamics or structures affect their feasibility ; or is this more an issue of non-network-based norms, values or interests? For example, given the extent to which IVDUs and other drug users are a core for some STDs: How are their social networks connected to the larger communities of drug users and ordinary residents? Why is there so little STD screening, cure, or therapy at drug treatment, needle exchange, and safe injection sites?

6. How do transportation networks affect risk networks and social networks?
In India and parts of Africa, truck routes seem to affect HIV transmission dynamics. In Vancouver, does the Skytrain structure crime? drug use? HIV or STDs?

7. What is the agenda for network research in relation to wars, transitions, natural disasters, urban redevelopment and other 'big events'?

A selection from the following papers were presented and discussed at the Symposium and/or the Sunbelt:

Evaluation of partner notification for syphilis; before and after enhanced social network strategies; Vancouver, Canada.
Ann Jolly, Public Health Agency of Canada, Centre for Infectious Disease Prevention and Control, AL0602B Room 2310, LCDC Bldg #6, Tunney Pasture Ottawa, Ontario K1A 0K9, Canada; Darlene Taylor, British Columbia Centre for Disease Control STD Division Epidemiology Services BC Centre for Disease Control 655 West 12th Ave Vancouver, BC V5Z 4R4, Canada; Gina Ogilvie, British Columbia Centre for Disease Control STD Division Epidemiology Services BC Centre for Disease Control 655 West 12th Ave Vancouver, BC V5Z 4R4; Michael Rekart, Director, STD/AIDS Control, BCCDC and Clinical Professor, Medicine, UBC.

Sex partner concurrency in a high HIV prevalence community.
Caroline Korves ck2187@columbia.edu Columbia University Mailman School of Public Health New York, New York USA; Maureen Miller, Columbia University Mailman School of Public Health New York, New York US

The importance of "house regular" clients and bridging in sexual networks of massage parlour-based commercial sex workers (CSW) in Vancouver, Canada.
Valencia Remple, University of British Columbia, BC Centre for Disease Control Epidemiology, Vancouver, BC, Canada; David M Patrick, UBC, BCCDC Epidemiology Vancouver, BC, Canada; Mark W Tyndall, BC Centre for Excellence in HIV/AIDS Vancouver, BC, Canada; Caitlin Johnston, BC Centre for Excellence in HIV/AIDS Vancouver, BC, Canada; Ann Jolly, Public Health Agency of Canada, Centre for Infectious Disease Prevention and Control, AL0602B Room 2310, LCDC , Bldg #6, Tunney Pasture Ottawa, Ontario K1A 0K9, Canada.

Comparison of networks resulting from respondent driven sampling and a social network inventory.
Elizabeth Costenbader, and William A. Zule, Research Triangle Institute, International, Behavioral Health Research Division, Substance Abuse Treatment Evaluations Intervention, 3040 Cornwallis Road PO Box 12194, Research Triangle Park, NC 27709-2194, USA; Georgiy Bobashev,Research Triangle Institute, International, Social & Statistical Sciences, 3040 Cornwallis Road PO Box 12194, Research Triangle Park, NC 27709-2194, USA.

Degree Distributions of Sexual Networks: Should We Buy Scale Free.
Deven Hamilton, University of Washington, Sociology, 2032 NE 177th, Shoreline, WA 98155, USA; Mark Handcock, University of Washington, Sociology and Statistics.

Connectivity, Density, and Diffusion: Low degree networks can be as effective as scale free.
Martina Morris, University of Washington, Department of Sociology, Box 353340, Seattle, WA 98195-3340, USA; David Hunter, Penn State University, Department of Statistics, University Park, PA, USA; Jim Moody, Ohio State University, Department of Sociology, Columbus, OH, USA.

Effects of TND Network on Monthly Substance Use.
Thomas Valente, Alan Stacey, Jennifer Unger, Steve Sussman, all from University of South California, Department of Preventive Medicine, 1000 S. Fremont Ave., Unit #8 Alhambra, CA 91803, USA.

The Winnipeg Injection Drug Use Social Network study: the molecular epidemiology of hepatitis C within social networks of injection drug users.
John Wylie, Cadham Provincial Laboratory 750 William Ave. Winnipeg, Manitoba R3C 3Y1 Canada; Ann Jolly,

Centre for Infectious Disease Prevention and Control, Population and Public Health Branch, Health Canada Brooke Claxton Bldg Level 01 Postal Locator 0900 B1 Tunney's Pasture Ottawa, ON K1A 0K9 Canada; Lena Shah, Department of Community Health Sciences Faculty of Medicine University of Manitoba Winnipeg, Manitoba, Canada.

Assessing the Effects of Social Network Variables on Project Retention: It's How You See Them Not How They See You That Matters.

Scott Clair, Richard Spoth, ChungYeol Shin, Cleve Redmond, all from Iowa State University, Partnerships in Prevention Science Institute, 2625 North Loop Drive Suite 500, Ames, IA 50010, USA.

Exposure to Cognitions through social networks leads to Marijuana & Alcohol Use.

Kathryn Coronges, Institute of Prevention Research University Southern CA Los Angeles, CA, USA; Tom Valente, Institute of Prevention Research University Southern CA Los Angeles, CA, USA; Alan Stacy, Institute of Prevention Research University Southern CA Los Angeles, CA, USA.

The relative contribution of sex and drug ties to STI-relevent network connectivity.

James Moody and jimi adams, both from The Ohio State University, Sociology, 372 Bricker Hall, 190 North Oval Mall, Columbus, OH 43210, USA.

Substance-based Informal Social Networks: Investigation into Stronger Ties.

Michael Read, Ph.D. Student University of British Columbia Sauder School of Business OBHR Division.

Homophily and Assimilation among Adolescent Substance Users.

Michael Pearson, Napier University, Centre for Maths & Stats, 2/62, 219 Colinton Road, Edinburgh, Mid Lothian EH11 4BN, Scotland; Christian Steglich, ICS / Department of Sociology, University of Groningen, The Netherlands; Tom Snijders, ICS / Department of Sociology, University of Groningen, The Netherlands; Patrick West.

Symposium participants

Mara Adelman	Seattle University, Communication
jimi adams	Ohio State University, Sociology
Campbell Aitken	Burnet Institute, CEPHR, Australia
Robert Allan	AIDS Coalition of Nova Scotia
Erik Apedaile	University of Ottawa, Epidemiology and Community Medicine
Sulafa Badi	University College London, Bartlett School of Graduate Studies, UK
Juan Carlos Barahona	Massachusetts Institute of Technology, Media Lab
Dean Behrens	University of Toronto, Sociology
Devon Brewer	Interdisciplinary Scientific Research, Seattle
Alan Brown-Hart	University of Ottawa
Loren Beyerstein	Simon Fraser University, Communication
Dragos Calitoiu	Carleton University, Computer Science
Richard Callahan	University of Washington, Sociology
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David Regeczi	University of Twente, Enschede, Netherlands
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"Big Events" and Networks[1]

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Some, but not all, "big events" such as wars, revolutions, socioeconomic transitions, economic collapses, and ecological disasters in recent years seem to lead to large-scale HIV outbreaks (Friedman et al, in press; Hankins et al 2002). This was true of transitions in the USSR, South Africa and Indonesia, for example, but not those in the Philippines or (so far) in Argentina. It has been hypothesized that whether or not HIV outbreaks occur is shaped in part by the nature and extent of changes in the numbers of voluntary or involuntary risk-takers, which itself may be related to the growth of roles such as sex-sellers or drug sellers; the riskiness of the behaviors engaged in by risk-takers; and changes in sexual and injection networks and other "mixing patterns" variables. Each of these potential causal processes, in turn, is shaped by the nature of pre-existing social networks and the patterns and content of normative regulation and communication that happen within these social networks-and on how these social networks and their characteristics are changed by the "big event" in question. We will present ideas about what research is needed to help understand these events and to help guide both indigenous community-based efforts to prevent HIV outbreaks and also to guide those who organize external intervention efforts and aid.

INTRODUCTION

"Big events" such as wars, political or economic transitions, gentrification or urban desertification, and perhaps some natural disasters can sometimes unleash HIV or other epidemics of sexually- and/or blood-borne infectious agents (Aral 2002; Buve et al., 2002; Hankins et al., 2002; Friedman et al., 1999; Friedman and Reid 2002; Friedman et al., in press; Pederson 2002; Rhodes & Simic 2005; Rhodes et al.,

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The ideas of Dr. Sevgi Aral of CDC helped us formulate this paper. We very much thank her for this assistance.

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2005; Wallace and Wallace 1998). This does not always happen, probably for a mixture of poorly-understood causal patterns plus a degree of random chance (Friedman et al in press; Gisselquist 2005; Kretzschmar and Wiessing 1998; Spiegel 2004).

To some extent, the relationships between Big Events and epidemic outbreaks undoubtedly involve network phenomena. This is because becoming infected with infections of this type is a probabilistic function of (a) one partner being infected and the other not; and of (b) their engaging in a risk behavior together that has a probability of transmitting the infection. The probability that the act will transmit the infection is itself a function of the agent, the behavior and both host and partner characteristics. Furthermore, the probability that two people who have sex together will use a condom, or two people who inject drugs together will share a syringe, is itself a function of the normative communications of which they have been a part.

The points made above about the probability of infection being transmitted overlap with several different kinds of network processes in important ways. The probability that two partners (in sex or injecting) will be discordant in infection status for a given agent is itself a function of their locations in community risk (sexual and/or injecting) networks. Friedman et al (1997, 1999), for example, showed this for HIV in relation to the Seidman 2-core of a large connected component of a network of injection drug users. They showed that probabilities of using a condom or of sharing a syringe are also functions of such "risk network location" variables, as well as of the norms of those in one's social network. The probability that HIV or hepatitis C will be transmitted sexually, it should be added, is a function of whether one (or both) partners has various sexually-transmitted infections—and this is, in turn, a function both of risk network variables and also of behavioral specificities and, thus, of network-based normative processes.

Given this, what are some of the processes that Big Events unleash that may affect whether, how, and in what social locations one or more of these infectious disease epidemics breaks out?

Before addressing this question, it is worth considering that the different categories of Big Events differ in many of their effects on society and community, and also that there is considerable difference between one event of a given kind (say, one war) and another. Nonetheless, Big Events often involve the destruction of housing, neighborhoods, and places of employment; they lead to a variety of forms of movement of people through space, whether as refugees, captives, displaced people, or members of armed forces or clean-up crews; they often create violence; they perhaps cause trauma and post-traumatic stress disorder on a wide scale; and they can lead sometimes to the destruction of long-term hopes and perhaps to the creation of generations of youth without career or other goals. Medical and public health institutions are often weakened, disrupted, or destroyed; and sometimes police forces and centers of economic activity are also harmed or destroyed.

Big Events and risk networks

Although there is relatively little research to base some of these claims on, in this and the next section of the paper we lay out an outline theory of how Big Events may affect risk and social networks in ways that can influence epidemics. In the course of this, we also provide some support for some claims—but, in general, we think that more research is needed to develop a better sense of whether this theory is useful.

All of the processes in the prior section of the paper seem to be able to affect both risk networks and social networks. Sexual networks often get disrupted when spouses or other partners are separated (or one is killed) by a Big Event. New partnerships get formed by refugees in search of physical or economic protection, or as a consequence of forced concubinage, or due to the growth of new attachments.

Economic hardship due to the Big Event often leads some people to sell sex for goods or money; and this can lead to their potentially becoming at high risk for infection and, thereafter, for transmitting infections to large numbers of other people.

Parallel patterns happen with drug injectors. Previous drug-using partnerships may be disrupted. Refugees often need to share drugs and/or syringes as favors to other users in order to be able to buy drugs in a new location (Friedman et al 1999); and the lack of housing faced by many refugees can lead to injectors' doing drugs with wider networks of other people (perhaps in unsafe locations like shooting galleries or other quasi-anonymous injection settings). If the drug trade is disrupted so that access to drugs becomes more difficult, this can lead to more users taking up injection (as seems to have happened in Pakistan [Hankins et al 2002; Strathdee et al 2003] after the US invasion of Afghanistan in 2002) or, contrariwise, to decreases in injection use (as in Argentina in recent years [Rossi and Rangugni 2004]). On the other hand, some people deprived of access to drugs or to the social environments in which they used drugs might stop this form of risk altogether. This seems to have occurred to many US soldiers who injected drugs in Vietnam when they returned Stateside (Robins 1973, 1974, Robins et al 1974; Zinberg 1984).

The possibilities of entrepreneurial activities in the sex or drug trades may be improved due to Big Events. This can arise due to the combination of an increase in potential workers due to economic desperation (and perhaps due to relaxed or changed normative climates, as is discussed below) plus a weakening of police controls over these activities due to institutional disruption or due to increased willingness (and perhaps need) of police staff for graft to look the other way.

One network phenomenon that has been understudied is "quasi-anonymous risk networks" (QARNs), which are sites or events in which multiple people come together and either inject drugs together or have sex together without coming to know each other (Friedman et al 2002). Common examples of these are group sex events such as parties where people go and have sex with a number of partners; gay "baths"; brothels; and shooting galleries and injection houses for drug users. Weeks et al. (2002) have shown that networks of injectors of different race/ethnicity in Hartford who appeared to have only weak linkage on the basis of a social network study (i.e., there were only two paths connecting their otherwise-distinct networks) were connected through many more paths once attendance at the same shooting galleries was taken into account. Although we know of no studies of this, it seems likely that Big Events can disrupt QARNs in an area. It seems likely that they can promote the formation of new QARNs, whether in the form of new brothels with different mixing patterns for clients and different recruitment streams for sex worker employees; new forms of group sex parties; or new forms of multiple-person injection settings. How the destruction, change, and/or formation of QARNs affect epidemics remains, however, an unstudied but important question.

Big Events and social influence and social support networks

When Big Events create large-scale movement of individuals and groups, destroy economic and other institutions, and inflict trauma on large numbers of people, they often greatly weaken or re-shape the social influence and social support networks that form the basis of normative regulation in communities (Heckathorn 1989, 1990, 1999). People who have spent their whole lives in relatively small communities in which relatives, long-term friends, and elders have communication networks that let each other know what the others are doing, and that express authoritative opinions on how people should conduct their lives, can suddenly find themselves in refugee camps or other settings in which none of this is true. This greatly increases the probability that some of them will undertake previously-taboo forms of activity such as drug use, "unchaste" sex, or using violence or money to compel others to engage in sex or prostitution. Although not in itself a network phenomenon, the experience of

living through the Big Event may discredit some previously unquestioned rules of conduct; and the effects of trauma might weaken individuals' ability to live up to such rules of conduct even if they continue to believe in them.

Youth who grow up in such normatively unstructured or, alternatively, normatively conflicted or multivalent circumstances, are likely to form friendship networks that develop their own norms with less supervision and intergenerational transfer than would have been the case prior to the Big Event. In many localities in the former Soviet Union and Eastern Europe after the transitions that those countries went through, some of these youth networks have accepted high-risk sex, high-risk drug use, and sex trading as legitimate activities—and in some of these localities, outbreaks of HIV and/or of bacterial STIs have developed thereafter. In Argentina, there appears to have been a rise in coca paste use among youth after their economic crisis and political transition of 2001 – 2002, although it is not yet clear whether this is associated with increased sexual risk behavior or with infectious disease transmission (Rossi et al., 2006). (Coca paste [also called basuco] is an intermediate step in the manufacturing process between coca leaves and purified cocaine.)

Although we are not familiar with the relevant research, neither normlessness nor post-Big-Event development of previously-taboo norms and behaviors are likely to go unchallenged. Normative reconstitution and restoration processes do occur, often in religious or politically-nationalist form. In Russia, for example, both religious fundamentalism and also authoritarian nationalist political projects took root, in part, in reaction to normlessness, "improper behaviors," and emerging problems that many youth encountered. In addition, communities at risk, such as drug injectors and sex workers, and sometime their neighbors, develop their own protective communications, social networks, and norms (Friedman et al., 2004, 2005)

Sometimes, both restorationist movements and the efforts of communities-at-risk take the form of social movements. This has been the case of drug users' organizations and sex workers' organizations in Eastern Europe and elsewhere, for example. There is a wide literature (Diani and McAdam 2003) that points to the role of social network processes in social movements.

CONCLUSIONS

Both social networks and risk networks are affected by Big Events, and these effects may greatly influence whether or not epidemics break out and, if they do break out, how much damage they do. The theory outlined above attempts to capture some aspects of these processes. This theory, however, is far too general in that very little of it is based on studies of Big Events.

Such research is sorely needed. Wars, transitions, revolutions, urban re-structuring, and ecological disasters are by no means decreasing in frequency or scope. Indeed, given current plans on the part of the United States government, they seem likely to increase. Their consequences will be severe in and of themselves—and these consequences may be much worse to the extent that they unleash epidemics.

Thus, we propose that retrospective studies of Big Events, networks, and related phenomena and epidemics should be organized and funded. Monitoring studies should be set up to provide useful information quickly in localities that seem likely to be caught up in Big Events; and these monitoring data should be such as to allow prospective studies of these localities during and after the Big Event. Additional work is needed into ways in which local populations can effectively respond when caught up in Big Events, and into how outside agencies can helpfully respond without making matters even worse.

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Gender and Chain Reactions in Teenagers' Social Networks

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Over the past ten years or so there has been renewed research interest in the relative impact of peer selection and peer influence on the increasing similarity of teenagers in their substance use. Researchers have concluded that either peer selection or peer influence explained the similarity. This paper examines this research question differently using complete network data and arrives at different conclusions. Findings demonstrate that similarity in the substance use of teenagers and their peers is explained by either peer selection or peer influence for some, by both peer selection and peer influence for others, and by neither for others. Using a sociological approach and a social network perspective this paper demonstrates how chain reactions result in similarity in the substance use of teenagers in their peer groups, by drawing together those who are similar with those who are not. The paper demonstrates how chain reactions involve peer selection, the patterning of peer ties and peer influence, and explores how gender affects all aspects of the chain reaction process.

INTRODUCTION

There has been a widespread belief among researchers since the 1970s that teenagers' peer groups are likely to be homogeneous in their substance use. The source of this homogeneity has been the subject of research in the intervening years. Research evidence during the 1970s confirmed that the homogeneity in the substance use of teenagers was based primarily on peer influence. Kandel's work in the early 1970s was very influential in demonstrating that peer influence was the most important influence on teenagers' substance use (Kandel, 1973:1067; 1974a:107; Kandel, 1978a:24; Kandel, Kessler and Margulies, 1978:87). In a longitudinal study she found that teenagers who had substance using peers at one point in time were likely to be substance users themselves at a later time point. Thus, she concluded that peer influence explained the increasing similarity/ homogeneity. She found that peer influence varied between the substances and was greatest for marijuana use.

The importance of peer influence has been confirmed by many other researchers. Researchers usually studied one or two of the substances and rarely all three. Among those who confirmed the importance of peer influence for substance use were Dembo *et al.* (1982:376), Brook, Whiteman and Gordon (1983:276) and Jessor and Jessor (1978:69) for drug use; Grube and Morgan (1986:77, 104, 126) for cigarettes, alcohol and drugs, and Akers et al. (1979:638) for alcohol and drug use. While there was no direct evidence in these studies that particular peers influenced particular teenagers into taking the substances, the inference drawn was that peer influence had occurred if peers' substance use, or their perceived substance use, had preceded the teenagers' substance use. Such research, although based on longitudinal data, appears to have exaggerated peer effects and led to exaggerated expectations of homophily in peer groups. Most of the researchers had used perceived peer substance use data which were known to exaggerate peer effects (Kandel, 1980:269, 270) or had used data on dyads of best friends which were more likely that any other friends to be similar to each other.

Even in the 1970s some researchers were alert to the possibility that the reported effects of peers may have been exaggerated. Cohen (1977:239) and Kandel (1978b:436) suggested independently that reports of peer influence may be exaggerated if researchers attribute the similarity in substance use among teenagers to peer influence solely, when many of the teenagers may have chosen their peers because of their similarity to the teenagers' substance use. Thus, the explanation could be due to peer influence or peer selection. Kandel (1978b:433) concluded at the time that both explanations were of equal importance, with half of the observed similarity in teenagers' substance use being due to peer influence and the other half to peer selection. This cautionary note about the exaggeration of the impact of peer influence on similarity in teenagers' substance use has been largely ignored until the 1990s.

But since the 1990s there has been renewed interest in this research question and it has yet to be satisfactorily answered. What is the relative impact of peer influence and selection on teenagers' similarity in their substance use? Many researchers have contributed to this debate. An important aspect of the renewed interest is that researchers since the 1990s have been using social network analysis to try to resolve this question. But even among the social network researchers there have been limitations in the social network data available to examine the question and in the computer technology and mathematical models available to analyse the required data adequately. To date, most researchers have used dyadic or small clique data to examine this question although there is increasing recognition that what is required is complete network, longitudinal data.

One of the earliest papers reporting on substance use in teenagers' peer groups was by Hunter, Vizelberg and Berenson (1991). Using data from the Bogalusa heart study they examined the impact of the students' friendship cliques in school on their adoption of tobacco and alcohol use. Their findings suggested that peer influence and peer selection were at work. Some of the students reported the direct or indirect effects of friends and others confirmed the formation of cliques around a preferred behaviour, which was mainly alcohol use (1991:101). A little later Ennett and Bauman (1993) examined this question further. They used the NEGOPY (Richards, 1989) network analysis programme to group their adolescents into clique members, liaisons or isolates in order to examine whether their social position among their peers was associated with their cigarette use. Clique members were adolescents in a group of at least three members, who had most of their links with other members of the group, and were all connected by a path entirely within the group. Liaisons were not members of cliques but had at least two links with clique members or other liaisons. Isolates were those who had few or no links with other adolescents. They could be in dyads or tree structures, in which the removal of one link would result in the individual being separated from the rest of the network (Ennett and Bauman, 1993:229, 230). Ennett and Bauman (1993:231) confirmed that social position was associated with the adolescents' smoking behaviour with isolates being more likely than those in cliques or liaisons to be current smokers and subsequently confirmed that peer influence and peer selection contributed equally to the homogeneity in cigarette smoking that they had observed in the adolescents' cliques (Ennett and Bauman, 1994:660). Bauman and Ennett (1996:186 – 189) have also concluded that only half of the similarity in teenagers substance use is explained by the influence of their peers, with the other half being due to selection. Although their research was on small cliques, these researchers pointed to the need for complete network data in order to identify peer groups directly and to examine the substance use of individual adolescents in the context of their peer groups (Ennett and Bauman, 1993:234; Bauman and Ennett, 1994:820; 1996:191).

In the meantime, many researchers addressed the question of peer influence and selection using a similar approach to that used by Ennett and Bauman, examining the association between adolescents' substance use and their social position in cliques, liaisons and isolates. Using the NEGOPY program but with slightly different definitions of these social positions, Pearson and Michell (2000:27, 28) supported the findings of Ennett and Bauman (1993:231) when they found that their relative isolates were most likely to have smoked cigarettes ($p<0.08$) and to have taken drugs ($p<0.07$). (These small differences were above the $p<0.05$ level of significance). But Pearson and West (2003:67-69) also

reported evidence of changes in substance use occurring within peer groups, suggesting peer influence, and of changes occurred due to the selection by peripheral members of risk-taking groups. Fang et al. (2003:262) also confirmed, using NEGOPY, that isolates were more likely to have experimented with smoking cigarettes, except among 10th grade boys, where the results were reversed and more group members and liaisons than isolates had experimented. Contradictory results were reported by Abel, Plumridge and Graham (2002). They regrouped students into different social positions from those identified in the NEGOPY programme and they identified school pupils as 'popular', 'try-hards', 'ordinary' and 'loners.' Their findings confirmed that it was those least well connected, the 'loners', who were least likely to smoke cigarettes.

It is difficult to unravel the relative importance of peer influence and selection from these contradictory findings. Also, if isolates are more likely than those in other social positions to smoke cigarettes or take drugs, as some researchers have suggested (Ennett and Bauman, 1993:231; Fang et al., 2003: 262; Pearson and Michell, 2000:27, 28) and, if they were truly isolates, it would appear that neither peer influence nor selection would be associated with their substance use. The definition used, of course, included teenagers who had no peer ties with teenagers who had some peer ties, which is problematic.

These contradictory findings suggest the need for researchers to examine the association between social position and teenagers' substance use with social network data on peer groups larger than cliques. The kind and size of sample chosen, the definition of peer group used and the number of friends a teenager is allowed to name, have profound effects on the size of the peer groups which will ensue and, indeed, on whether some teenagers will be seen as liaisons or isolates. Clique data appear to be inadequate as a way of measuring peer groups for a number of reasons. They are unnaturally small because the teenagers are usually only allowed to name a small number of friends rather than all of their friends (Wasserman and Faust, 1994:256). The criteria for inclusion in a clique appear to be too rigid and exclude some teenagers who have peer ties with clique members. Results from clique studies may exaggerate the level of similarity in behaviour in peer groups because the cliques are so small, while naturally existing peer groups, which would emerge if teenagers were allowed to name all of their friends, may be much larger. The definition of isolate used in these studies is also problematic because it combines, into this category, teenagers who have no peer ties with teenagers who have some peer ties, including those in dyads or tree structures.

Many questions relating to the relative impact of peer influence and peer selection on teenagers' substance use can not be answered using data on the social positions of cliques, liaisons and isolates. Another important issue is that it is not social position per se that is likely to affect teenagers' substance use, but the teenagers' social position among peers, who use any of the substances, that is likely to affect their use. Researchers, including Haynie (2001:1023) and Ennett and Bauman (1993:234), have suggested that these questions can be more adequately addressed using complete network data on all adolescents and their friends in a population. In the remainder of this paper I will examine the question of the relative impact of peer selection and peer influence on the similarity of teenagers in their substance use using complete network data and present findings from my research which propose a new chain reaction explanation (Kirke, 2004, 2006).

METHOD

Complete network data were collected by interviewing all teenagers aged 14-18 years in one community in Dublin in a cross-sectional study. The hidden population of 14-18 year olds was identified by doing a house-to-house census. The census identified 298 teenagers of the required age, of whom 267 were successfully interviewed, giving a response rate of 90%. Data were collected by personal interviews, using a structured questionnaire, in the teenagers' homes (Kirke, 1996:335-338). Teenagers were asked to name all of their friends and pals (i.e. peers). Peer groups were identified by using the 'weak component' and

'adjacency' procedures of GRADAP (Sprenger and Stokman, 1989:17). In social network analysis "…a weak component is a maximal weak subgraph" (Harary et al., 1965:405). This means that it is the maximum unique subset of points which are connected, directly or indirectly, to each other by lines. This was a very appropriate way to identify the peer groups because the peer groups identified included all of the teenagers and their peers who were connected to each other through peer ties by paths of any distance (Kirke, 1996:340). Each peer group was, therefore, distinct from all others and there was no peer tie, however distant, between any of the teenagers in one peer group with any of the teenagers in another. This approach differs from that used by other researchers who had used NEGOPY (Richards, 1989). The peer groups identified would include cliques, liaisons, dyads and tree structures. Isolates would only be those who had no peer ties. Further details of the method used for delineating the peer groups are given in Kirke (1996:335-344) and for all aspects of the study in Kirke (1990:84-105).

RESULTS

Early results (Kirke 1990) indicated that homophily/ similarity in the drug use of teenagers in their peer groups was much lower than anticipated, that it varied by the size of the peer group and that peer influence was much less potent than would have been expected based on previous research. The findings suggested, rather, that a complex process of peer group and individual influences were at play which sometimes resulted in changed drug behaviour on the part of the teenagers and sometimes did not (Kirke, 1990). Thus, even when there were drug users in a peer group who had direct peer ties with teenagers who had not yet used drugs, peer influence did not necessarily occur. A later paper reported on a case study of one all-male peer group in which there was a high rate of drug use (Kirke, 1995). This paper demonstrated the process by which peer influence permeated the peer group and resulted in some, but not all, of the teenagers using drugs. Basically their peers facilitated the drug use of the teenagers when they wished to use drugs, but did not put any pressure on those who did not wish to use them. Peers facilitated the teenagers' drug use by providing the drug and / or being in the company of the teenager for their first and current use of the drug.

These earlier studies (Kirke, 1990; 1995) shed some light on the role of peer influence in drug use, by confirming that it did occur for some teenagers and the process by which it occurred. But these analyses also confirmed that peer influence did not apparently work on some teenagers. They didn't change their behaviour but they maintained their friendships nevertheless.

Since previous research had confirmed associations between social position and teenagers' substance use, I examined the complete network data for such an association. In this study, social position related to being in a peer group or being an isolate. Peer groups varied in size from 26 teenagers to two teenagers, and isolates had no peer ties in the population. The findings were that there was no association between the social position of the teenagers in this study and their ever or current use of cigarettes, alcohol or drugs (Kirke, 2006). When the peer groups were divided into larger peer groups (six or more teenagers), smaller peer groups similar to cliques (five or fewer teenagers), and the tests were repeated, there was still no association. Thus, the findings do not support those of previous researchers who found an association between social position and substance use. These findings confirm, therefore, that social position per se was not associated with the teenagers' substance use. But the real question to ask is whether the social position of teenagers, relative to other peers who are substance users, has an impact on their substance use. This question is addressed below (Kirke, 2004).

The question of the relative impact of peer selection and peer influence on the teenagers' use of all three substances was examined more comprehensively in a recent paper (Kirke, 2004). In this paper multilevel analyses were used to examine this question. Retrospective data on the timing of the selection of peers, the timing of changes in the teenagers' use of the three substances and reports by the teenagers of peer influence, were combined with dyadic data on each peer tie, in case studies of the three largest peer groups. The purpose of the paper was to examine:

1. whether there was any direct evidence in the teenagers' peer groups of similarity in their substance use and whether there was evidence of peer influence having occurred between those who were similar;
2. whether there was evidence of the relative impact of peer influence and selection on similarity; and
3. whether the peer group had contributed to the similarity.

The findings, using dyadic data for the complete network, confirmed that similarity had occurred between teenagers and their peers in their use of the three substances. Similarity was greatest for alcohol use and lowest for cigarette use. The results were similar in the three peer groups studied. The rate of use of alcohol was the highest, and of drug use was the lowest, reflecting the level of similarity among the teenagers forming those peer groups (Kirke, 2004:7, 8). Was there any evidence of peer influence having occurred? Traditionally researchers have assumed that peer influence has occurred within the peer tie if teenagers have become similar to their peers in their substance use. In this study peer influence was not assumed in such circumstances. Instead, two indices of peer influence were used: whether the teenagers had been in the company of their peers and whether the teenagers had been provided with the substance by their peers. If their peers were involved in either way, or in both ways, it was accepted that peer influence had occurred. The findings confirmed that peer influence had occurred for a large proportion of the teenagers. Influence was more likely to have taken the form of being in the company of peers than being provided with the substances by their peers. Surprisingly, those who provided the substance and those with whom the adolescent used the substance were frequently different people. Thus, more than one peer was often involved in the peer influence process. This would suggest the need to approach this question using social network rather than dyadic peer data.

Although these findings have confirmed that the teenagers had become similar to their peers in dyads and in peer groups, and that peer influence had occurred for most of the teenagers who had used substances, these findings did not confirm whether those who were similar in their substance use had experienced peer influence *from each other*. Having examined the multilevel data for each of the peer group case studies, the findings confirmed that teenagers adjacent to each other in the peer groups were likely to be similar in their substance use and to form chains of users of similar substances and that peer influence had occurred in nearly all of the peer ties in the chains. But the findings confirmed that, although peer influence had occurred, it had *not necessarily been between the teenagers and the peers to whom they were similar in the substance use chains*. Similarity in peer ties had occurred through peer influence *between those who were similar* for proportions varying from 68.9% to 34.4% of the peer ties in the peer groups studied. Similarity was due to selection *between those who were similar* in proportions varying from 17.8% to 40.6% of the peer ties in the peer groups, since the teenagers had already taken their first substance before forming the peer ties. Although selection explained the similarity in these peer ties, however, peer influence had also occurred. But the peer influence had come *from different peers* before the formation of the peer ties. In some other peer ties peer influence, which had occurred, *could not have been between those who were similar* (6.6% - 18.8%) because of differences in the timing of the formation of the peer tie and the substance use of the teenagers and their peers. Thus for some of the teenagers, similarity had resulted from peer influence only, for others similarity had resulted from selection and for other teenagers similarity had resulted from neither peer influence nor selection *between those who were similar*. When similarity had resulted from selection, peer influence had also occurred but by peers outside these chains.

These findings confirm those of Bauman and Ennett (1996); Kandel (1978a, b) and Cohen (1977) that either peer influence or selection is usually at work when teenagers and their peers become similar in their substance use. But these findings (Kirke, 2004) suggest that researchers should be more cautious about attributing similarity to peer influence when the peer in the dyad, or peer group, may have had

nothing to do with increasing the similarity of the substance use of the teenager with whom he or she has a peer tie. They would also suggest that it would be prudent to check whether peer influence by others had occurred when selection explains the similarity. Otherwise the role of peer influence may be underestimated.

The third question which was being explored in this paper was whether the peer group had contributed to the similarity. The answer is that the peer group contributes to the similarity by linking those who are similar in their substance use with those who are not (see figures, Kirke, 2004). When a teenager selects another as a peer, the resulting peer tie connects the teenager directly and indirectly into a peer group. The peer group may be very small or very large. Whatever the size of the peer group, the resulting pattern of peer ties in it is an unpredictable outcome of the formation of the new peer tie. Nevertheless, that pattern is important to the individual's substance use, as is the location of the peer whom the individual teenager has selected. Through the patterning of the peer ties an individual, who forms a new peer tie, may be connected to a chain of users of a particular substance or to a chain of non-users. Thus, the selection of one peer links the teenager into a pattern of peer ties in the peer group. The peer group contributes to the similarity of the teenagers in their substance use by linking teenagers, who are already similar, to teenagers who become similar through their continued association with their peers in the peer network. The result is a*chain reaction process.* The chain reaction results from linking those who are similar with those who are not. Some of those who are similar in these chains will have influenced each other; others will have been influenced by others outside the chains. The outcome is the same: chains of similar users, in which the chain reaction has been brought about by peer selection, the patterning of their peer ties and peer influence. The peer group contributes to the similarity in a profound manner by providing a pattern of peer ties in which peer influence can flourish (Kirke, 2004: 26, 27).

Another aspect of the chain reaction process which I have addressed is the role of gender. Traditionally, the role of gender in the substance use of teenagers is addressed as an individual attribute: whether the teenagers' gender is associated with their substance use. I think it would be more appropriate to address it as a social network variable which affects the composition and structure (i.e. the patterning of peer ties) of peer groups. In recent work I have examined the role of gender in the chain reaction process and have found that it has an effect on all aspects of it: the selection of peers, the patterning of peer ties and peer influence (Kirke, 2006). Teenagers selected their peers strictly along gender lines, resulting in almost all single gender peer ties and peer groups. The patterning of peer ties in the complete network also reflected a gender influence, with different patterns emerging for males and females. Males clustered into large more dense groups, while females generally were in smaller groups and less densely clustered, with many in dyads or tree-like structures. Those less densely clustered like this were considered to be isolates in previous research (Ennett and Bauman, 1993:231; Fang et al., 2003:262). There is a possibility that, by doing so, the impact of the social position, isolate, on substance use may have masked a gender effect.

Peer influence, on the other hand, operated differently for males and females. For males, mixed gender influence was only important for their current cigarette use, but for females, it was important for all substance use other then their ever cigarette use. Thus, single gender patterns of peer ties would be sufficient for chain reactions to occur in all but their current cigarette use for males, but female teenagers need mixed gender patterns to ensure chain reactions occur for all substances other than their first cigarette use. Thus the patterning of peer ties along gender lines, or across gender lines, will have a profound effect on whether, or when, chain reactions will occur for male and female teenagers.

These findings suggest, therefore, that gender impacts on the composition and structure of the networks teenagers form with their peers. The gender composition of peer groups reflects the impact of gender on peer selection, which is usually single gender and rarely mixed gender while males and females are in their childhood and early teenage years. The structure of the networks also appeared

to vary by gender with males being more likely than females to form larger more dense patterns. Since male teenagers who were substance users, had been predominantly influenced by other males, and females predominantly by males and females, the structure and composition of this complete network would have enhanced the likelihood of male teenagers being influenced while, at the same time would have hindered the likelihood of females being influenced. Changes in the pattern over time will alter the likelihood of influence for males and females.

CONCLUSION

This paper has examined the question of the relative impact of peer selection and peer influence on the similarity of teenagers in their substance use. Previous researchers have suggested that either peer selection or peer influence explain the similarity, usually in equal measure. Findings presented in this paper suggest that researchers can not assume that peer influence has occurred between teenagers who are similar, because the results presented confirm that, for some teenagers who become similar in their substance use, peer influence has occurred between them, for others peer influence has not occurred, for some, peer selection explained the similarity (although peer influence had also occurred by other peers outside the chain) and, for others, neither peer selection not peer influence explained the similarity. Findings also confirmed, contrary to previous research, that social position per se was not associated with the teenagers' use of any of the three substances, but their social position, relative to other teenagers in their peer groups who had used the substances, was of immense importance. The paper proposes a chain reaction explanation, which includes peer selection, the patterning of peer ties and peer influence, for changing similarity in the substance use of teenagers, and suggests that gender plays a role in all aspects of the chain reaction process.

It is not possible to definitively answer the question of the relative impact of peer influence and selection on similarity in the substance use of teenagers even with cross-sectional, complete network data. Using retrospective data on the timing of events adds a longitudinal element and is valuable in that it relates to the teenagers' childhood and early teenage years. But longitudinal, complete network data are required to provide definitive answers and to re-examine the results and the chain reaction explanation presented in this paper. There are huge methodological issues to be addressed in such research.

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The Effect of Personal Network Exposure on Injecting Equipment Sharing among IDUs in Budapest, Hungary[1]

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Until the mid-1990s, the prevalence and incidence of HIV infection was uniformly low in countries across the Central and Eastern European region. In the past decade, however, this has changed dramatically, with a rapid increase in HIV infections in the region, especially in Eastern Europe where 41% of new HIV infection cases were among injecting drug users (IDUs) and as much as 66% of IDUs are infected with HIV in certain regions. While Russia, the largest country in Eastern Europe, has the fastest growing HIV rates in the world, the situation is different in Central Europe. For example, Hungary has low levels of HIV infection – estimated less than 1% of IDUs. Understanding the role of network factors in the spread and prevention of HIV could not only enable us to keep the HIV rates low among IDUs in countries like Hungary, but also provide a means for the effective prevention of other blood-borne and sexually transmitted infections (STIs) that share similar routes of transmission as HIV. Rogers' diffusion of innovations theory may help explain why HIV rates among IDUs are low in Hungary. Valente's related exposure or contagion model postulates that the more individuals within a social network adopt an innovation or a practice, the greater the probability of an individual is to adopt this innovation or practice. Personal network exposure (PNE), measured both within egocentric and sociocentric networks quantifies the extent to which a person is exposed to risk through their social network. The aim of this analysis was to assess the association of PNE and other correlates with injecting equipment sharing among IDUs in Budapest, Hungary.

INTRODUCTION

Until the mid-1990s, the prevalence and incidence of HIV infection was uniformly low in countries across the Central and Eastern European region. In the past decade, however, this has changed dramatically, with a rapid increase in HIV infections in the region, especially in Eastern Europe (Hamers and Downs 2003; Aceijas et al. 2004; European Centre for the Epidemiological Monitoring of AIDS 2005). In Eastern Europe, 41% of new HIV infection cases were among injecting drug users (IDUs). Estimates

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suggest that in certain regions, as much as 66% of IDUs are infected with HIV (Hamers and Downs 2003; Kelly and Amirkhanian 2003; Rhodes et al. 1999). The largest country in Eastern Europe, Russia, has the fastest growing HIV rates in the world (Kalichman et al. 2000). However, the situation is different in Central Europe. In 2004 fourteen Central European countries reported a total of 217 new HIV infections contracted through injecting drug use (European Centre for the Epidemiological Monitoring of AIDS 2005). It is estimated that in Central European countries excluding Poland and the former Yugoslavia, under 2% of IDUs are infected with HIV (Hamers and Downs 2003; Dehne et al. 1999; Robinson 2000; Kilibarda 1993). Hungary, like many Central European countries, has low levels of HIV infection. At the end of 2004, Hungary (population 10 million) had 1,175 diagnosed cases of HIV infection, and the estimated prevalence of HIV among IDUs was less than 1% (European Centre for the Epidemiological Monitoring of AIDS 2005).

In addition to being at risk of HIV infection, IDUs are also at risk of acquiring Hepatitis C (HCV) and Hepatitis B (HBV). In contrast to the very low prevalence of HIV among IDUs in Hungary, the prevalence of HCV among IDUs in Hungary was about 30% in the late 1990s (European Monitoring Centre for Drugs and Drug Addiction 2002; Ujhelyi et al. 1998; Zacher 2003; Topolánszky 2002), and, while HBV infection rates among IDUs in Hungary were 13% for women and 8% for men, only about 7% reported having been vaccinated against HBV (Topolánszky 2002). The presence of HCV and HBV epidemics among IDUs in Hungary is a concern not only in its own right, but also because it suggests that injecting and sex risk behaviors and risk networks among IDUs are very common (Hamers and Downs 2003; Stark et al. 1996; Mikl et al. 1998). This implies that many of the conditions for an expansive and rapid HIV epidemic are present in the Central European region among drug injectors.

Social network theory, an approach that recognizes that individuals are embedded in social and risk networks (Trotter II, Bowen, and Potter Jr 1995; Neaigus et al. 1994), may help explain the discrepancy of HIV rates between Central and Eastern Europe. According to this theory, the potential for epidemic spread of HIV infection within a specific risk-group depends on many supra-individual factors, including the probability of transmission, the average number of contacts (Anderson and May 1988), risk network composition and structures (which includes both the centrality of high-risk individuals and mixing patterns within a network (Friedman et al. 1997; Neaigus et al. 1994), and secondary prevention. Understanding the role of network factors in the spread and prevention of HIV could not only enable us to keep the HIV rates low among IDUs in Central European countries like Hungary, but also provide a means for the effective prevention of other blood-borne and sexually transmitted infections (STIs) that share similar routes of transmission as HIV, such as HBV and HCV, as well as other STIs.

A theory which may help explain why HIV rates among IDUs are low in Hungary is the diffusion of innovations theory (Rogers 2000). This theory describes how an innovation, an idea, practice, or object, is spread among members of a community (Rogers 2003). The exposure or contagion model (Valente 2005), which is related to the diffusion theory, postulates that the more individuals within a social network adopt an innovation or a practice, the greater the probability of an individual is to adopt this innovation or practice. Personal network exposure (PNE) quantifies the extent to which a person within a network is exposed to such an innovation, idea, practice or object (Valente 1995). PNE can be measured both within egocentric and sociocentric networks. Within egocentric networks, PNE is the proportion of adopters among network members and thus measures the direct influence of network members (Valente 2005). Within sociocentric networks, PNE measures both direct and indirect network influence and is calculated by weighting exposure by the inverse of the shortest paths (geodesic distances) between any two members of the sociocentric network (Valente 1995). To incorporate the influence of opinion leaders, PNE can be weighted by network measures (e.g. centrality) (Valente 2005).

PNE to risk or protective behaviors through direct and indirect ties to other IDUs who engage in these risk behaviors and who are members of the sociocentric network thus may influence an individual IDU's injecting behavior. We hypothesize that if PNE is positively associated with injecting equipment

sharing, then, according to the contagion model, sharing may be a social epidemic – the more individuals are exposed to injecting equipment sharing, the more likely they are to share. The aim of this analysis was to assess the association of PNE and other correlates with injecting equipment sharing among IDUs in Budapest, Hungary.

METHODS

Between October 2005 and February 2006, 83 injecting drug users were recruited in Budapest, Hungary from non-treatment settings using a combination of street outreach and chain referral methods (Heckathorn 1997; Gyarmathy and Neaigus 2005; Gyarmathy et al. 2006) for a United States National Institute on Drug Abuse funded study on network risk for HIV, HBV and HCV among IDUs in Budapest (study ongoing). Participants were recruited from areas of the city where drug users often congregate, from the needle exchange, and through referral by other IDUs who were in the study. Candidate participants who self-reported injecting drugs in the past 30 days were eligible to participate. Eligibility of drug use was verified by urine tests (heroin, cocaine, amphetamine and methamphetamine) for those reporting drug use in the past 2-3 days. Injecting route of drug administration was verified by inspection of injecting marks for those who reported injecting in the past 30 days. Participants were paid HUF 2000 (about USD 10) for participation and HUF 500 (about USD 2.5) for bringing in their nominated network members or other IDUs who were eligible to participate in the study. The Institutional Review Boards at the National Development and Research Institutes, Inc. in New York, USA and the Hungarian Academy of Sciences in Budapest, Hungary approved all human subjects procedures.

After providing their informed consent, eligible participants were administered a structured survey interview that took about 2 hours to complete. Then participants received counseling about and were tested for HIV, HAV, HBV, HCV and syphilis infections.

MEASURES

The interview included questions about demographics, socio-economic status, drug use and injecting behaviors, sexual risk behaviors, self-reported HIV and HCV infections, knowledge about HIV and HCV transmission, heroin dependence and injecting equipment sharing. The dependent variables in the analysis were five types of injecting equipment sharing: sharing cookers, sharing filters, receptive syringe sharing, distributive syringe sharing and syringe-mediated drug sharing (backloading) in the past 30 days. Since having an IDU sex partner has been found to be associated with injecting equipment sharing (Evans et al. 2003; Lum, Sears, and Guydish 2005), and we had found strong infection disclosure norms among IDUs in Hungary (Gyarmathy et al. 2006), we created four-way interaction variables for self-report of HCV infection and having an IDU sex partner (1. no reported HCV infection and no IDU sex partner (reference category), 2. no reported HCV infection and IDU sex partner, 3. reported HCV infection and no IDU sex partner, 4. reported HCV infection and IDU sex partner).

Participants were asked using standard naming stimuli (Friedman et al. 1999) to provide us with the real or fictitious name of friends or family whom they would go to for advice, asked a favor from in the past 30 days, with whom they have had sex or used non-injected or injected drugs in the past 30 days. Then, for every nominated network member, more detailed data was collected (Friedman et al. 1999; Neaigus et al. 2006; Weeks et al. 2002) about the network member's demographics, drug use and injecting behaviors and sexual risk behaviors, and how close they are emotionally to the network member. We also assessed the relationships among nominated network members.

Ties among participants who were interviewed for the study were ascertained based on each participant's nominations and on reports of relationships of other participants about their network

members. We used four methods to verify links (Friedman et al. 1999): 1. "storefront link", when participants brought their network members in and linkage data was recorded, 2. "field link", when the participant identified the network member to the staff in the field, 3. "ethnographic link", when staff observed links in the field, and 4. "data set link", when identifying data was used to establish links. We used UCINET (Borgatti, Everett, and Freeman 2002) to create social network measures based on this relationship data. First, we symmetrized the data in order to incorporate into the assessment of network exposure "modeling" or indirect communication (Neaigus et al. 2006), i.e., ties between participants who share injecting equipment. Geodesic distances between each participant were then calculated, along with two measures of centrality. Closeness centrality (how may steps away an individual is from others within the entire sociocentric network that this individual is a member of) was calculated to indicate potential roles of opinion leadership, and degree centrality (the number of ties of each individual within their egocentric network) to indicate the size of their personal network. PNE measures for each of the injecting equipment sharing variables were calculated in SAS® by transposing individual equipment sharing data into an exposure matrix, weighting exposure by closeness centrality (Valente 2005), and multiplying weighted exposure by the inverse of the geodesic distances. PNE measures were then standardized to have a mean of 0 and a standard deviation of 1 for easier interpretation.

Table 1. Description of the sample – injecting drug users in Hungary, 2005-2006

	N (%)		N (%)
Total	83 (100.0)	Shared cookers in the past 30 days	48 (57.8)
Age - mean (SD)	28.5 (5.8)	Shared filters in past 30 days	47 (56.6)
Gender		Distributive syringe sharing in past 30 days	15 (18.1)
male	62 (74.7)	Receptive syringe sharing in past 30 days	17 (20.5)
female	21 (25.3)	Backloading in past 30 days	26 (31.3)
Ethnicity		Degree centrality - mean (SD)	4.4 (5.3)
non-Roma	74 (89.2)		
Roma	9 (10.8)	PNE for sharing cookers (non-standardized) - mean (SD)	136 (78.6)
High school degree	28 (33.7)		
Currently in school	9 (10.8)	PNE for sharing filters (non-standardized) - mean (SD)	147 (85.5)
Marital status single	63 (75.9)	PNE for receptive syringe sharing (non-standardized) - mean (SD)	50.8 (29.4)
Ever had a legal job	63 (75.9)		
Homeless	16 (19.3)	PNE for distributive syringe sharing (non-standardized) - mean (SD)	36.0 (21.2)
Average monthly income above HUF 100 000 (USD 500)	47 (56.6)	PNE for backloading (non-standardized) - mean (SD)	84.8 (49.8)

ANALYSIS

Univariate odds ratios and corresponding 90% confidence intervals were calculated to assess associations between candidate variables and each of the equipment sharing variables. Then, multivariate logistic regression models with stepwise selection (with model entry and retention significance of 0.10) identified significant ($p<0.10$) correlates of equipment sharing, with PNE forced

in as the main exposure variable. In each of these models, equipment-specific PNE measures were used (e.g., for assessing correlates of sharing cookers, PNE to sharing cookers were used; for correlates of sharing filters, PNE to sharing filters was used, etc.)

Table 2. Univariate correlates of sharing cookers in the past 30 days – injecting drug users in Hungary, 2005-2006

Characteristic	did not share	shared	OR (90% CI)	sig. p-value
	N (%)	N (%)		
Total	35 (42.2)	48 (57.8)	(reference)	
Personal network exposure - mean (SD)	-.02 (0.95)	0.02 (1.04)	1.0 (0.7, 1.5)	0.863
Degree centrality - mean (SD)	4.0 (5.7)	4.7 (5.0)	1.0 (1.0, 1.1)	0.5766
Heroin dependence - high				
no	13 (32.5)	27 (67.5)	(reference)	* 0.0876
yes	22 (51.2)	21 (48.8)	0.5 (0.2, 1.0)	
Incorrect knowledge about HIV transmission				
no	30 (52.6)	27 (47.4)	(reference)	* 0.0063
yes	5 (19.2)	21 (80.8)	4.7 (1.8, 12)	
Incorrect knowledge about HCV transmission				
no	31 (50.0)	31 (50.0)	(reference)	* 0.0179
yes	4 (19.0)	17 (81.0)	4.2 (1.6, 12)	
no HCV and no IDU sex partner	25 (52.1)	23 (47.9)	(reference)	* 0.0406
no HCV and IDU sex partner	2 (16.7)	10 (83.3)	5.4 (1.4, 21)	0.3866
HCV and no IDU sex partner	5 (38.5)	8 (61.5)	1.7 (0.6, 5.0)	0.2135
HCV and IDU sex partner	3 (30.0)	7 (70.0)	2.5 (0.7, 8.6)	
Emotionally close to an IDU				
no	26 (56.5)	20 (43.5)	(reference)	* 0.0040
yes	9 (24.3)	28 (75.7)	4.0 (1.8, 9.0)	
Gender				
male	30 (48.4)	32 (51.6)	(reference)	* 0.0547
female	5 (23.8)	16 (76.2)	3.0 (1.2, 7.7)	
Age - mean (SD)	30.2 (5.3)	27.3 (5.8)	0.9 (0.9, 1.0)	* 0.0265
Ethnicity				
non-Roma	31 (41.9)	43 (58.1)	(reference)	0.8836
Roma x	4 (44.4)	5 (55.6)	0.9 (0.3, 2.9)	

* $p<0.10$

RESULTS

Sample description

The mean age of the 83 participants was 28.5 years (median: 28; SD=5.8; range: 18-41), 21 (25%) were female, 9 (11%) were Roma (Gypsy) (Table 1). About a third (n=28; 34%) had a high-school degree and 9 (11%) reported that they were still in school. Most were single (n=63; 76%) and had worked at some point at a legal job (n=63; 76%). Altogether 47 (57%) reported having an average monthly income of HUF 100,000 (approximately USD 500), and 16 (19%) reported being homeless. Altogether 48 (58%) participants reported sharing cookers, 47 (57%) sharing filters, 15 (18%) distributive syringe

sharing, 17 (21%) receptive syringe sharing, and 26 (31%) backloading in the past 30 days. Almost all agreed that syringes can transmit HIV (n=77; 94%) and HCV (n=78; 95%) infections (data not shown in table). About half agreed that cookers, cotton and dissolved drugs can transmit HIV (n=37; 45%) and HCV (n=44; 54%) (data not shown in table). Altogether 26 (31%) reported incorrect knowledge about HIV and 21 (25.3%) about HCV (data not shown in table). The mean degree centrality was 4.4 (SD=5.3). Non-standardized PNE values show that mean network exposure to cookers and filters is the highest, followed by backloading, receptive syringe sharing and distributive syringe sharing.

Table 3. Univariate correlates of sharing filters in the past 30 days – injecting drug users in Hungary, 2005-2006

Characteristic	did not share	shared	OR (90% CI)	sig. p-value
	N (%)	N (%)		
Total	35 (42.2)	48 (57.8)	(reference)	
Personal network exposure - mean (SD)	-.02 (0.95)	0.02 (1.04)	1.0 (0.7, 1.5)	0.863
Degree centrality - mean (SD)	4.0 (5.7)	4.7 (5.0)	1.0 (1.0, 1.1)	0.5766
Heroin dependence - high				
no	13 (32.5)	27 (67.5)	(reference)	* 0.0876
yes	22 (51.2)	21 (48.8)	0.5 (0.2, 1.0)	
Incorrect knowledge about HIV transmission				
no	30 (52.6)	27 (47.4)	(reference)	* 0.0063
yes	5 (19.2)	21 (80.8)	4.7 (1.8, 12)	
Incorrect knowledge about HCV transmission				
no	31 (50.0)	31 (50.0)	(reference)	* 0.0179
yes	4 (19.0)	17 (81.0)	4.2 (1.6, 12)	
no HCV and no IDU sex partner	25 (52.1)	23 (47.9)	(reference)	* 0.0406
no HCV and IDU sex partner	2 (16.7)	10 (83.3)	5.4 (1.4, 21)	0.3866
HCV and no IDU sex partner	5 (38.5)	8 (61.5)	1.7 (0.6, 5.0)	0.2135
HCV and IDU sex partner	3 (30.0)	7 (70.0)	2.5 (0.7, 8.6)	
Emotionally close to an IDU				
no	26 (56.5)	20 (43.5)	(reference)	* 0.0040
yes	9 (24.3)	28 (75.7)	4.0 (1.8, 9.0)	
Gender				
male	30 (48.4)	32 (51.6)	(reference)	* 0.0547
female	5 (23.8)	16 (76.2)	3.0 (1.2, 7.7)	
Age - mean (SD)	30.2 (5.3)	27.3 (5.8)	0.9 (0.9, 1.0)	* 0.0265
Ethnicity				
non-Roma	31 (41.9)	43 (58.1)	(reference)	0.8836
Roma x	4 (44.4)	5 (55.6)	0.9 (0.3, 2.9)	

* $p<0.10$

Univariate correlates of equipment sharing

Significant ($p<0.10$) correlates of equipment sharing are presented in Tables 2-6. We found that equipment-specific standardized PNE was positively associated with sharing filters and inversely associated with distributive syringe sharing, and we found no significant associations between PNE and

sharing cookers, receptive syringe sharing and backloading. Degree centrality was positively associated with sharing filters and backloading. Heroin dependence showed a negative association with sharing cookers, and both incorrect knowledge of HIV transmission and incorrect knowledge of HCV transmission were positively associated with both sharing cookers and sharing filters. Having an IDU sex partner and self-report of being HCV negative was positively associated with sharing cookers, sharing filters and distributive syringe sharing, while having no IDU sex partner and self-report of being HCV infected was associated with distributive syringe sharing. Being emotionally close to an IDU was associated with all forms of equipment sharing, except with backloading. Of the demographic variables, female gender was associated with sharing cookers, receptive syringe sharing and backloading, while younger age was associated with sharing cookers, sharing filters and backloading.

Table 4. Univariate correlates of distributive syringe sharing in the past 30 days – injecting drug users in Hungary, 2005-2006

Characteristic	did not share	shared	OR (90% CI)	sig. p-value
	N (%)	N (%)		
Total	68 (81.9)	15 (18.1)	(reference)	
Personal network exposure - mean (SD)	0.10 (0.98)	-.46 (1.01)	0.6 (0.4, 0.9)	* 0.0548
Degree centrality - mean (SD)	4.4 (5.3)	4.7 (5.8)	1.0 (0.9, 1.1)	0.8353
Heroin dependence - high				
no	32 (80.0)	8 (20.0)	(reference)	0.6603
yes	36 (83.7)	7 (16.3)	0.8 (0.3, 2.0)	
Incorrect knowledge about HIV transmission				
no	47 (82.5)	10 (17.5)	(reference)	0.8531
yes	21 (80.8)	5 (19.2)	1.1 (0.4, 3.0)	
Incorrect knowledge about HCV transmission				
no	52 (83.9)	10 (16.1)	(reference)	0.4320
yes	16 (76.2)	5 (23.8)	1.6 (0.6, 4.5)	
no HCV and no IDU sex partner	42 (87.5)	6 (12.5)	(reference)	
no HCV and IDU sex partner	7 (58.3)	5 (41.7)	5.0 (1.5, 16)	* 0.0275
HCV and no IDU sex partner	10 (76.9)	3 (23.1)	2.1 (0.6, 7.7)	0.3475
HCV and IDU sex partner	9 (90.0)	1 (10.0)	0.8 (0.1, 5.1)	0.8257
Emotionally close to an IDU				
no	41 (89.1)	5 (10.9)	(reference)	* 0.0646
yes	27 (73.0)	10 (27.0)	3.0 (1.1, 8.2)	
Gender				
male	53 (85.5)	9 (14.5)	(reference)	0.1552
female	15 (71.4)	6 (28.6)	2.4 (0.9, 6.3)	
Age - mean (SD)	28.7 (5.8)	27.7 (5.9)	1.0 (0.9, 1.1)	0.5376
Ethnicity				
non-Roma	60 (81.1)	14 (18.9)	(reference)	0.5709
Roma x	8 (88.9)	1 (11.1)	0.5 (0.1, 3.3)	

* $p<0.10$

Multivariate correlates of equipment sharing

PNE was significantly ($p<0.10$) and positively associated with sharing filters and backloading, and significantly and inversely associated with distributive syringe sharing (Table 7). Degree centrality showed a significant association with distributive syringe sharing, and incorrect knowledge about HIV transmission with sharing cookers and filters. Having no IDU sex partner and self-report of being HCV infected was associated with distributive syringe sharing, and being emotionally close to an IDU with sharing cookers and filters. Of the demographic variables, female gender showed an association with sharing cookers, distributive syringe sharing and receptive syringe sharing, while younger age with all forms of equipment sharing except for distributive syringe sharing.

Table 5. Univariate correlates of receptive syringe sharing in the past 30 days – injecting drug users in Hungary, 2005-2006

Characteristic	did not share	shared	OR (90% CI)	sig. p-value
	N (%)	N (%)		
Total	66 (79.5)	17 (20.5)	(reference)	
Personal network exposure - mean (SD)	-.00 (1.02)	0.01 (0.93)	1.0 (0.6, 1.6)	0.9577
Degree centrality - mean (SD)	4.3 (5.5)	4.9 (4.7)	1.0 (0.9, 1.1)	0.6431
Heroin dependence - high				
no	32 (80.0)	8 (20.0)	(reference)	0.9164
yes	34 (79.1)	9 (20.9)	1.1 (0.4, 2.6)	
Incorrect knowledge about HIV transmission				
no	49 (84.2)	9 (15.8)	(reference)	0.1226
yes	18 (69.2)	8 (30.8)	2.4 (0.9, 5.9)	
Incorrect knowledge about HCV transmission				
no	50 (80.6)	12 (19.4)	(reference)	0.6625
yes	16 (76.2)	5 (23.8)	1.3 (0.5, 3.5)	
no HCV and no IDU sex partner	41 (85.4)	7 (14.6)	(reference)	
no HCV and IDU sex partner	10 (83.3)	2 (16.7)	1.2 (0.3, 4.9)	0.8567
HCV and no IDU sex partner	7 (53.8)	6 (46.2)	5.0 (1.6, 15)	* 0.0195
HCV and IDU sex partner	8 (80.0)	2 (20.0)	1.5 (0.3, 6.3)	0.6683
Emotionally close to an IDU				
no	40 (87.0)	6 (13.0)	(reference)	* 0.0672
yes	26 (70.3)	11 (29.7)	2.8 (1.1, 7.2)	
Gender				
male	54 (87.1)	8 (12.9)	(reference)	* 0.0053
female	12 (57.1)	9 (42.9)	5.1 (1.9, 13)	
Age - mean (SD)	29.0 (5.5)	26.5 (6.4)	0.9 (0.8, 1.0)	0.1185
Ethnicity				
non-Roma	57 (77.0)	17(23.0)	(reference)	0.9687
Roma x	9 (100)	0 (0.0)	zero cell	

* $p<0.10$

Table 6. Univariate correlates of syringe mediated drug sharing (backloading) in the past 30 days – injecting drug users in Hungary, 2005-2006

Characteristic	did not share	shared	OR (90% CI)	sig. p-value
	N (%)	N (%)		
Total	57 (68.7)	26 (31.3)	(reference)	
Personal network exposure - mean (SD)	-.09 (1.00)	0.20 (1.00)	1.3 (0.9, 2.0)	0.2308
Degree centrality - mean (SD)	3.7 (5.3)	6.0 (5.1)	1.1 (1.0, 1.2)	* 0.0831
Heroin dependence - high				
no	26 (65.0)	14 (35.0)	(reference)	0.4870
yes	31 (72.1)	12 (27.9)	0.7 (0.3, 1.6)	
Incorrect knowledge about HIV transmission				
no	42 (73.7)	15 (26.3)	(reference)	0.1485
yes	15 (57.7)	11 (42.3)	2.1 (0.9, 4.7)	
Incorrect knowledge about HCV transmission				
no	45 (72.6)	17 (27.4)	(reference)	0.1913
yes	12 (57.1)	9 (42.9)	2.0 (0.8, 4.7)	
no HCV and no IDU sex partner	35 (72.9)	13 (27.1)	(reference)	
no HCV and IDU sex partner	6 (50.0)	6 (50.0)	2.7 (0.9, 8.0)	0.1349
HCV and no IDU sex partner	8 (61.5)	5 (38.5)	1.7 (0.6, 5.0)	0.4277
HCV and IDU sex partner	8 (80.0)	2 (20.0)	0.7 (0.2, 2.7)	0.6432
Emotionally close to an IDU				
no	33 (71.7)	13 (28.3)	(reference)	0.5028
yes	24 (64.9)	13 (35.1)	1.4 (0.6, 3.0)	
Gender				
male	46 (74.2)	16 (25.8)	(reference)	* 0.0670
female	11 (52.4)	10 (47.6)	2.6 (1.1, 6.2)	
Age - mean (SD)	30.0 (5.6)	25.1 (4.7)	0.8 (0.8, 0.9)	* 0.0008
Ethnicity				
non-Roma	52 (70.3)	22 (29.7)	(reference)	0.374
Roma x	5 (55.6)	4 (44.4)	1.9 (0.6, 6.2)	

* $p<0.10$

DISCUSSION

Contrary to our hypothesis, we found that PNE was not positively associated with all forms of injecting equipment sharing, but only with sharing cookers and filter, and it was inversely associated with distributive syringe sharing. In addition, we found an interaction of having an IDU sex partner and self-report of being infected with HCV as they relate to receptive syringe sharing.

Levels of injecting equipment sharing among IDUs in this sample are similar to reports on injecting equipment sharing from studies conducted in the United States and in other Central European countries, and lower than among IDUs in Eastern Europe. Studies have found that about 20% of IDUs in the US, Estonia, Czech Republic and Poland shared syringes in the past month (Lundgren, Amodeo, and Chassler 2005; European Monitoring Centre for Drugs and Drug Addiction 2002). In contrast, around the same time, studies among IDUs in Saint Petersburg reported 41% sharing syringes, and in Moscow, between 40-75% (Somlai et al. 2002; Reilley et al. 2000; Gore-Felton et al. 2003). The relatively low rates of syringe sharing but high rates of other injecting equipment sharing

may be one reason why levels of HIV are low but of the prevalence of HCV is relatively high among IDUs in Hungary.

The positive association between PNE and sharing filters may indicate that these two sharing behaviors may be linked to a social epidemic. In a previous study we found that filters are often reused by IDUs in Hungary as a backup drug supply (Gyarmathy et al. 2006). In addition, ethnographic observations of injecting events and discussions with participants in this study indicate that retaining and giving away filters may be an act of giving someone a favor so that, in need, this person can also be asked for a favor. In this context, favor usually refers to an alternative drug supply in the form of a second cooking of the filter. The inverse association between PNE and distributive syringe sharing suggests that rather than being a social epidemic, distributive syringe sharing may be situation-specific and reflect the demand and supply of syringes in particular injecting settings, e.g. if there are N new syringes and N+1 IDUs, and one IDU gives his or her used syringe to the IDU without a new syringe, there is no need for the other IDUs to give away theirs. Indeed, the association of degree centrality with distributive syringe sharing corroborates this, since it shows that the more IDUs there are in an IDU's egocentric network, the more likely they are to share syringes. Furthermore, ethnographic findings from this study suggest that syringe sharing occurs either in sexual partnerships or if somebody "falls in", i.e., shows up unexpectedly in a group about to inject drugs, and this unexpected person does not have their injecting equipment handy.

Table 7. Multivariate correlates of sharing cookers, sharing filters, distributive and receptive syringe sharing

	Sharing cookers	Sharing filters	Distributive syringe sharing	Receptive syringe sharing	Backloading
	aOR (90%CI)	aOR (90%CI)	aOR (90%CI)	aOR (90%CI)	aOR (90%CI)
Personal network exposure	1.0 (0.65, 1.5)	1.8 (1.1, 2.8)[b]	0.2 (0.09, 0.47)[b]	0.78 (0.45, 1.4)	1.6 (1.0, 2.5) [a]
Degree centrality	N/S	N/S	1.3 (1.1, 1.5)[b]	N/S	N/S
Incorrect knowledge about HIV transmission	3.7 (1.3, 10.5)[b]	4.3 (1.5, 12.8)[b]	N/S	N/S	N/S
Self-reported HCV infection and no IDU sex partner	N/S	N/S	N/S	13.6 (3.2, 58.2)[b]	N/S
Emotionally close to an IDU	2.7 (1.1, 6.6)[a]	4.0 (1.6, 10.1)[b]	N/S	N/S	N/S
Female gender	3.2 (1.1, 9.8)[a]	N/S	4.1 (1.3, 13.1)[b]	7.2 (2.3, 22.5)[b]	N/S
Age	0.91 (0.84, 0.98)[b]	0.90 (0.84, 0.98)[b]	N/S	0.88 (0.80, 0.97)[b]	0.82 (0.74, 0.90)[b]

Note: [a] $p<0.10$ [b] $p<0.05$

Lack of the association between PNE and injecting equipment sharing may suggest that sharing is not a function of exposure, but rather that all IDUs in a given population are influenced by common structural conditions, such as laws against the possession of syringes and other injecting equipment, that operate independently of exposure. Under this scenario, the model might represent a form of "structural equivalence" (Burt 1987) so that a given behavior occurs because of macro-conditions that affect all IDUs (even singletons) rather than being mediated through social networks. We believe that sharing cookers may be due to such structural conditions. IDUs in this study reported during

ethnographic observations that packaging of drugs by dealers is such that the packaged quantity is too much for one person to use all at one time. Thus, several people buy one package. However, because they find it difficult and unfair to share it dry, they dissolve the drug in one cooker and share it wet instead. In addition, incorrect knowledge about HIV transmission seems to be another reason why IDUs in this study share filters and cookers, since many are not aware that infections can also be transmitted though injecting equipment other than syringes.

The association of receptive syringe sharing with self-report of HCV infection and not having an IDU sex partner raises concerns. IDUs in this sample believe that once they have HCV infection, "it's all the same" for them, not realizing that they are still at risk for HIV or potentially other blood borne infections. In addition, studies have shown that having an IDU sex partner is associated with sharing both syringes and other injecting equipment (Evans et al. 2003; Neaigus et al. 1995; Strathdee et al. 1997). While in a sexual partnership either partner may be equally likely to give or take used syringes regardless of HCV serostatus, reasoning that "they have unprotected sex anyway", they may not receive used syringes from a third person. However, an IDU who does not have an IDU sex partner may be more likely to receive a used syringe from another person than either one of a couple. Due to their "informed altruism" (Des Jarlais et al. 2004), HCV infected IDUs may put themselves at risk for HIV infection.

Limitations of the study include the small sample size and that we allowed a higher than customary Type I error when calculating confidence intervals. Hence, while on the one hand we may have missed associations due to the small sample size, we may also have identified associations that may not be strong enough for statistical significance in a larger sample. In addition, due to the recruitment methods, the sample may not be representative of all IDUs in Budapest, since we may not have had access to IDUs that are more socially integrated (Gyarmathy and Neaigus 2005) and thus more hidden. Missing links between participants is another limitation, which could lead to underestimating PNE. However, we recruited most nominated network members and we also used links reported by other participants in our analysis, which we believe minimized the underreporting of links.

Network interventions among IDUs in Hungary combined with the provision of legal, sterile syringes and other injecting equipment, and regular testing and counseling services can help to prevent the outbreak of HIV and to control the existing HCV epidemic due to parenteral routes of transmission (Latkin and Knowlton 2005; Gyarmathy et al. 2004; Gyarmathy and Neaigus 2005). Interventions need to focus on disseminating proper knowledge about HIV and Hepatitis infections, especially concerning the sharing of injecting equipment other than syringes. While the currently existing disclosure norms should be encouraged (Gyarmathy et al. 2006), those with HCV infection need to be counseled about the fact that they are still uninfected with HIV and thus are at risk for HIV infection if they take used syringes from other injectors. In addition to focusing on correcting misconceptions about the risks of sharing both syringes and other injecting equipment, infection prevention efforts among IDUs in Hungary need to focus on increasing the distribution, practice and legalization of carrying sterile syringes in order to minimize the situation-specific factors that may lead to syringe and other injecting equipment sharing. Moreover, as much as possible, IDUs should be provided access to appropriate drug treatment so that they can be helped to stop the practice of drug injecting.

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Social Networks and Mathematical Modeling

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Over the past 30 years, mathematical models of the spread of epidemics and the dynamics of societal cooperation have gradually incorporated more and more information about social network structures. This information is important not just to improve the accuracy of models, but also to improve their qualitative behavior and provide an ever deeper understanding of the spread of diseases and the ways in which individuals interact. Some important questions probably cannot be answered without the use of stochastic simulations that account for the social networks of individual agents.

1. Early Disease Modeling

Mathematical modeling studies have shown that the AIDS epidemic is very sensitive to the human behaviors that spread HIV, including: the amount of risky behavior; the manner in which that risky behavior is distributed in the population; and the social network structures within which people practice those risky behaviors. In fact, these models have shown that if we do not understand all three of these factors, then we cannot hope to predict and control the spread of HIV and other sexually transmitted diseases(Hyman and Stanley, 1988, 1994; Stanley, et al., 1991).

One of the earliest indications that this was so occurred in the mid-1980's. At that time, the US Centers for Disease Control was predicting that the AIDS epidemic was already dying out. They predicted this based upon the fact that the epidemic was growing more slowly than exponentially. With infections that are transmitted via casual contacts, such as measles or the common cold, case data which grow less than exponentially does indeed indicate that an outbreak is peaking and will soon be on the decline. Early mathematical models of the AIDS epidemic also demonstrated exponential growth, followed by slowing towards a peak and then decline (Anderson, et al., 1986)

However, while these early models did account for both sexual activity levels and the distribution of those activity levels in the population at risk, they did not account for social network structure. Instead, they assumed random mixing. Simply adding the fact that people who are high risk tend to associate more often with others of high risk, and similarly for those of low risk, to our model, along

with data on the distribution of partner acquisition rates from various studies in homosexual populations, showed that the epidemic should be growing cubically in time. Reanalysis of the CDC data showed that this was indeed the case (Hyman and Stanley, 1988, Colgate, et al., 1989).

This modeling effort showed that the epidemic was decidedly not dying out. This had important policy implications, since many were saying that, since the epidemic was dying out, it would go away on its own, and it wasn't worth spending a lot of money to control it.

Another important feature of the epidemic that biased mixing models captured was the fact that it was primarily the highest risk individuals who were infected first, followed by the next-highest risk individuals, and so on, whereas the random mixing models had most of their early infections in the large low risk groups.

Modeling HIV spread in age and sex- structured populations pointed out another way in which network structures affect the spread of sexually transmitted diseases. Since female partners tend to be younger than their male partners, women tend to become infected at younger ages than men, with the difference in age being societally-determined, and similar to the difference in age at marriage. But more than that, the way that society is structured, ie the network patterns and norms, strongly influences the speed and pattern of spread. Such questions as who goes to brothels, how many wives and concubines men have, and who gets to have multiple female partners, all affect the spread of disease via sex (Stanley, et al., 1991). Collection and analysis of network data have highlighted some of these factors, showing that clustering of heavily interacting individuals into local risk-taking networks, is an important factor in the spread of disease (Rothenberg et al., 2005 and 2005).

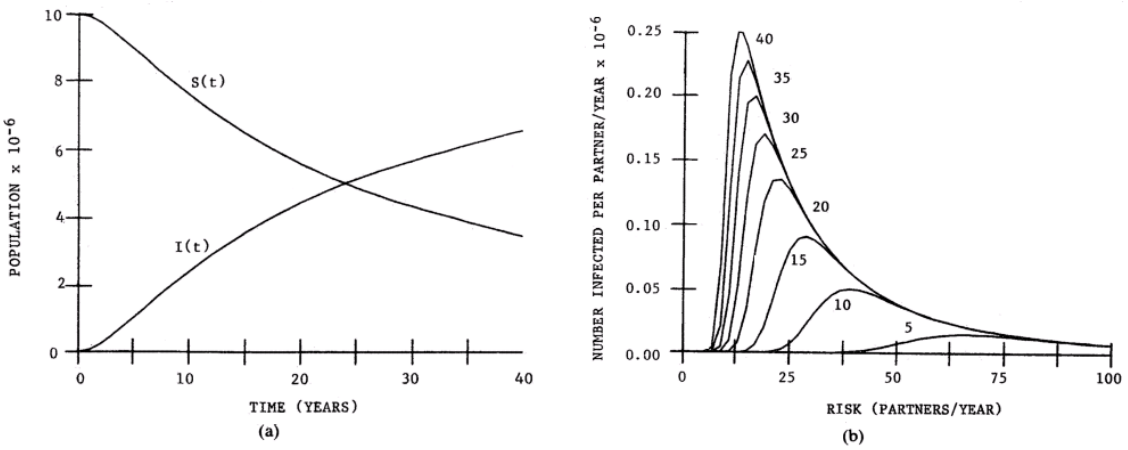

Fig. 1 . The results of a simulation for HIV spread in a homosexual population with biased mixing, where men have a strong tendency to have sex with those who have similar partner-aquisition rates.

(a) Number of susceptibles, S(t), and infecteds, I(t), as a function of time, t. Note that I(t) is proportional to (t-c)2, so that cumulative AIDS cases increase as t3.

(b) the distribution of infections with risk at various times. Note the wave that moves from high to low risk. (graphs taken from Hyman and Stanley, 1988)

Many other investigators have looked at mixing patterns as well. Sattenspiel (1987), for example, collected data on Hepatitis A spread among young children in day care centers and devised a mathematical model which used movement matrices to approximate the network behavior. Many researchers have since used various matrices to approximate between group mixing [see Del Valle, et al. (in review) for a brief review], where groups may be divided by age, sex, place of work, domicile and so on.

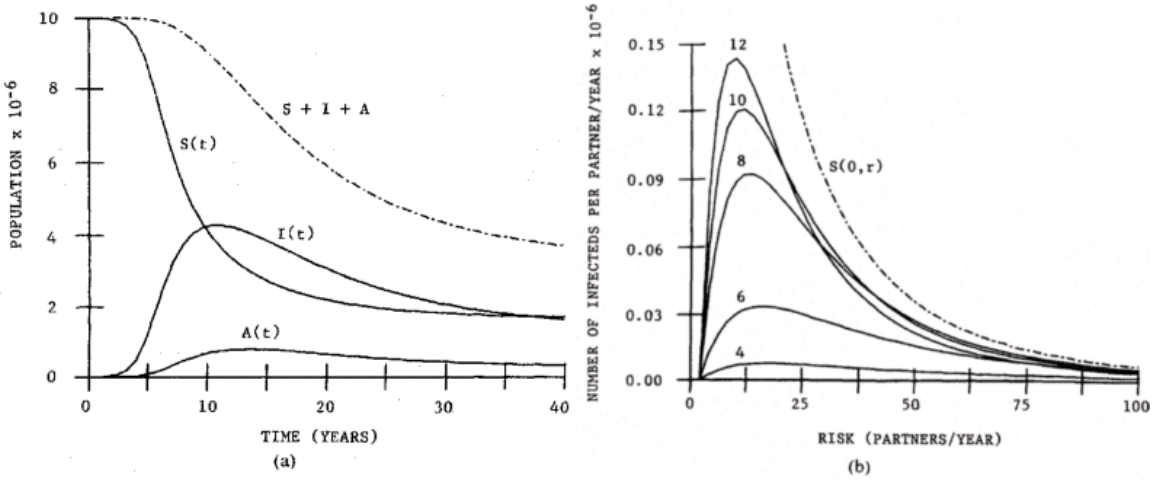

Fig. 2 . The results of a simulation for HIV spread in a homosexual population with random mixing and the same parameters as in Fig. 1.

(a) Number of susceptibles, S(t), and infecteds, I(t), as a function of time, t. Note that I(t) increases exponentially at the beginning of the epidemic.

(b) the distribution of infections with risk at various times. Note that the peak only moves slightly in risk with time, and stays at a fairly moderate risk. (graphs taken from Hyman and Stanley, 1988)

2. How do network patterns form, and what types of patterns are likely to emerge under different circumstances?

Beside the question of how networks are actually structured, there is the question of why they have that structure. Why do some people associate with certain other people? How do groups form? What roles do highly connected individuals play?

One way to gain insights into this question is via game theory. Because interactions between people can be categorized as either cooperative or not, it makes sense to use the well-studied Iterated Prisoner's Dilemma (IPD), and then allow individuals to choose and refuse partners based upon the result of previous interactions. The ability to refuse previously defecting partners can allow cooperators to invade defecting populations (Kitcher (1992) and Schuessler (1989)). The ability to seek out known cooperators as partners provides an incentive for agents to be reliably cooperative, so that they will be chosen as partners, or avoid social ostracism (Hirshleifer and Rasmusen, 1989).

One might think, then, that societies would eventually become universally cooperative. But that is not the case. For example, Dugatkin and Wilson (1991) showed that the ability to choose partners in large populations divided into isolated patches may permit roving defectors to move from one patch to the next, taking advantage of the cooperators in the patches. And in a series of papers where we used a genetic algorithm to evolve populations of automata to play IPD with choice and refusal of partners, where choice and refusal was based upon an expected payoff, we found that less than fully cooperative populations could be relatively stable, lasting for many generations(Stanley et al. 1994, Ashlock, et al., 1996, Smucker, et al., 1995), or oscillating back and forth between two different structures.

These less-than-fully-cooperative populations exhibited interesting network structures, sharing similarities with real populations. A few of these networks are shown in figure 3 as undirected "significant play graphs". Note that all simulations were run with 30 individuals.

Analyzing some of these structures showed why they can remain stable, and why there can be a non periodic oscillation back and forth between the "latching" and "Bob and the Raquels" populations, or why two subpopulations can mutually coexist in a symbiotic relationship, as in "stars and hubs".

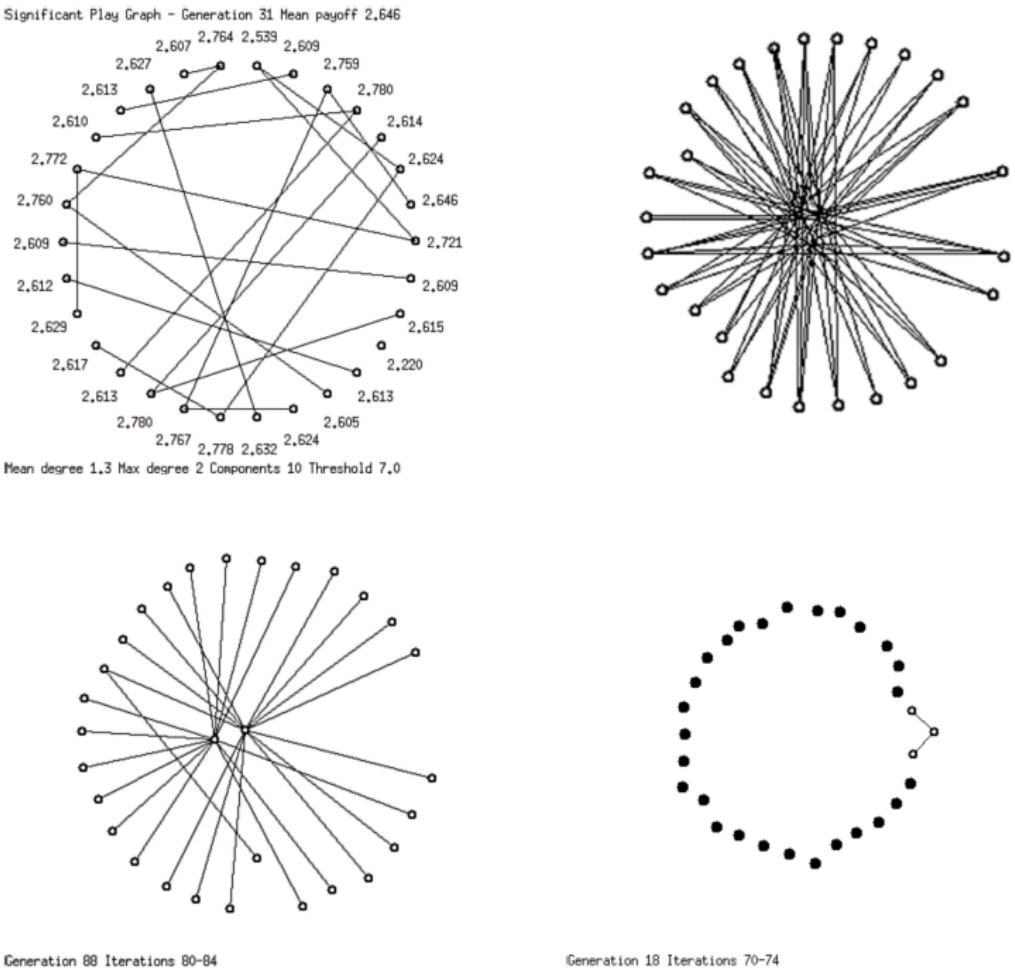

Fig. 3. Different relatively stable networks formed under evolution of IPD with choice and refusal of partners. Shown are the significant play graphs as defined in Smucker, et al. (a) "latchers," who defect once or twice and then cooperate. (b) "Bob and the Raquels," where Bobs are "latchers" and "Raquels" are more cooperative than latchers. Raquels occasionally appear, propagate for a few generations until there are too many for the populations to sustain, then disappear. In this case, there are 3 Raquels, who choose each other but don't refuse the Bobs. (c) "stars and hubs", which are mutually symbiotic. (d) "Wallflowers" where few individuals play others after the first game (figures from Smucker, et al. and Ashlock et al.).

Of course, this is only a toy model, examined for small populations, so it must not be taken too seriously as an explanation for the appearance of particular network patterns, but it demonstrates how one could develop more realistic models based upon other games with more realistic social constraints.

3. Micro to Macro

In Section 1 we looked at situations where extrapolating macro properties from knowledge of the microstructure of networks led to differential equation models which were able to mimic important

properties of an epidemic and lead to useful insights. However, this is not always the case. Sometimes, a model which contains more details of the network is necessary.

Contact tracing is one of the most promising and controversial methods for controlling the spread of sexually transmitted diseases. In contact tracing infected individuals are asked to name their sexual or needle-sharing partners during a certain period of time, usually for the past six months to a year. Well-trained investigators then track down as many of these partners as possible and convince them to be tested.

Because this methodology has been used effectively for decades with other STDs, many investigators have argued that it should be used to control HIV. Others have argued that it violates people's right to confidentiality, and that people will refuse to come in to be tested if they know they will be asked to name partners. Some specialists in the field argue that the potential for putting people at serious risk of ostracization and physical harm are not worth the potential gain, especially when there is the potential for domestic violence.

Studies of contact tracing as a strategy for controlling HIV, and ensuring that people receive early identification and treatment, have had mixed results, but most have found it to be an effective strategy for finding and counseling infected people. What is certainly the case is that we do not know when it will be effective enough to be worth the risks and when it will not. Mathematical models could help to answer some of the questions surrounding this issue.

We have shown that some aspects of contact tracing can be understood with differential equation models (Hyman, et al., 1994), which have the advantage that model sensitivity can be quickly studied without large numbers of simulations. However, due to the fact that tracing involves finding people who were past partners of those who came in to be tested for one reason or another, such models are of limited validity. In particular, they are not useful when epidemics are spreading rapidly, or when partners are traced for a long time back in the past.

Instead, an approach that directly models the network structure, and is based upon individual agents, such as the model of Kretzschmar, et al. (1996), may be a better approach under these circumstances. Such a model could presumably be expanded to account for snowballing, where partners of partners are aggressively traced. The disadvantage of individual agent-based models is that they cannot easily be analytically analyzed, they require large numbers of parameters, and large numbers of simulations must be run before conclusions can be drawn. Perhaps a mixed approach, such as that of Del Valle, et al. (in review), where mixing matrices are calculated from an individual agent based model, with the intention of using them in a differential equation model, will be the best approach.

While studies of contacting tracing's effectiveness have had mixed results, many have found it to be an effective strategy for finding and counseling infected people and for reaching their communities with appropriately targeted education. The cultural behaviors that tie a particular risk network together (such as the pressure to have an attractive partner) can only be changed in the context of, and by the members of that network. Prevention education within endemic networks that addresses the shared symbolic behavior would likely be more effective than the currently-used behavior change models that deliver more generic and decontextualised information to a wider audience, none of which have produced clear results (Fishbein, et al., 1999).

What is certainly the case is that we do not know when contact tracing will be effective and when it will not. It is also not known how risk behaviors are culturally and symbolically construed in any given network. A network-centric approach, tracing disease as well as culture and concepts, and supported by mathematical models, could help to answer some of the questions surrounding this issue.

With today's computer firepower, more and more researchers are beginning to use simulations of individual agent based models to study the spread of epidemics (see for ex. Newman, 2002; Barthélemy, et al, 2005), and to compare their results with differential equation models.

There are many other situations where the influence of the micro structure of networks, and the individuals within those networks, may need to be modeled with an individual agent-based model, or a cross breed such as that of Del Valle, et al. The spread of technologies, especially in rural populations, and the adoption of new risk-reduction behaviors, can not be understood without first understanding the existing conceptual constructs among key players in the network (MacKeigan and Muth, in press).

CONCLUSIONS

Mathematical models can be used to gain insights into many aspects of the world around us, including the spread of disease and the evolution of culture. These models range from the very micro-models of small populations on networks to the large-scale population models of differential equations. What is clear is that we can no rarely learn much of interest from the simple models of the past. Parameters and group structures used in differential equation models need to be informed by network data and analysis, and ideally be extrapolated directly from network data, in order to be most useful. With today's computers, we can begin to link micro structures to macro properties within a single code.

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Homophily and assimilation among sport-active adolescent substance users[1]

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We analyse the co-evolution of social networks and substance use behaviour of adolescents and address the problem of separating the effects of homophily and assimilation. Adolescents who prefer friends with the same substance-use behaviour exhibit the homophily principle. Adolescents who adapt their substance use behaviour to match that of their friends display the assimilation principle. We use the Siena software to illustrate the co-evolution of friendship networks, smoking, cannabis use and drinking among sport-active teenagers. Results indicate strong network selection effects occurring with a preference for same sex reciprocated relationships in closed networks. Assimilation occurs among cannabis and alcohol but not tobacco users. Homophily prevails among tobacco and alcohol users. Cannabis use influences smoking behavior positively (i.e., increasing cannabis increases smoking). Weaker effects include drinkers smoking more and cannabis users drinking more. Homophily and assimilation are not significant mechanisms with regard to sporting activity for any substance. There is, however, a significant reduction of sporting activity among smokers. Also, girls engaged in less sport than boys. Some recommendations for health promotion programmes are made.

1. INTRODUCTION

Smoking, drug-taking and alcohol use tend to be similar between friends (Brook et al. 1983, Doreian 1989). Two underlying dynamic principles which give rise to such similar behaviour have been debated for some time. One is the principle of homophily (McPherson, McPherson et al., 2001) whereby individuals interact more with similar than with dissimilar others. In the context of substance use, for example, this would mean that two actors with the same substance use behaviour pattern would be more likely to share a friendship tie. The other principle is that of assimilation (sometimes known as the principle of influence or contagion) whereby individuals adapt their behaviour to match that of their friends (Friedkin 1998).

In the literature some authors (Ennett and Bauman, 1994; Urberg, 1999) have argued that social processes, such as peer influence and selection, are more important determinants of substance use than

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are processes concerning emotional regulation. Hussong and Hicks (2003) examine the potential etiological models for adolescent substance use involving the peer context, affective experiences, and the interaction between these factors. Regarding sporting activities Moore and Werch (2005) conclude that those sports associated with increased substance use differed for males and females, and also for different types of substance use. They conclude that school-sponsored, male-dominated sports appeared to be associated with an increased substance use risk for males, whereas out-of-school, mixed-gender sports appeared to be for females. In general sport participation has been associated with lower use of cigarettes and marijuana (Baumert P.W. et al., 1998; Melnick M.J. et al., 2001), and increased use of alcohol (Rainey C.J et al., 1996; Winnail S.D. et al., 1997). Our current study broadly replicates these results, but investigates in more detail the co-evolutionary and causal links between sporting activity and network and substance use dynamics. We discuss some of the implications for health programs.

Recently co-evolutionary models taking into account both network and behavioural effects measured from panel data extracted from complete data sets in longitudinal studies have been the subject of rigorous analysis. This does, more than earlier analyses, justice to both the relational aspect of the network data, and to the dynamic nature of the entwined processes of peer influence and friendship selection. In particular stochastic actor-driven models (Snijders, 1996, 2001 ; Steglich et al., 2004) of network change have been analysed using the SIENA software (Snijders, Steglich, Schweinberger Huisman, 2005), which has recently been extended to account for the joint dynamics of networks and behaviour (Steglich, Snijders and Pearson (2004); Snijders, Steglich and Schweinberger (2005)).

The remainder of this paper is organised as follows: Section 2 states the questions and issues addressed in the paper. Section 3 outlines the Methodology employed to answer these questions. The section begins with a description of the theory employed in the analysis of the network and behaviour panel data and the way in which the SIENA program models this data and continues by describing the study design and actual sample data used. Section 4 outlines the results of the analysis carried out by SIENA. Section 5 concludes the paper.

2. QUESTIONS ADDRESSED

We address the following issues in our analysis and discussion:

1. To what degree can homophily and assimilation mechanisms account for the observed co-evolution of substance-use and friendship ties in our data?
2. Does the answer to the preceding question differ among the three substance-use behaviours of tobacco, cannabis and alcohol use?
3. What are the causal relationships between tobacco, alcohol and cannabis consumption? (We use cause in a weak sense here. So, for instance, cannabis use may act as a good predictor for subsequent smoking activity)
4. Questions 1 to 3, but now with sports behaviour as an additional dependent variable.
5. What are the implications for intervention programmes?

3. METHODS

3.1 Modelling of the Panel Data

To address the first question, which is about processes of the evolution of the social network, it is necessary to employ statistical models that represent this evolution in an adequate way. The modelling methods used in this paper are based on the idea that all possible network configurations (directed

graphs) on a given set of actors, jointly with all possible configurations of their values of the behaviour variables (such as smoking and sporting behaviour) form the state space of a stochastic process. The modelling proceeds by observing the network dynamics after specifying parameters and estimating the transition probabilities between the states of the stochastic process. So, for instance, in the simplest of models we may wish to formulate the transition probability associated with a change from an isolated network position to the position of being in a dyadic relationship with another actor. This is illustrated in Figure 1 where a preference is expressed over time for a tie to another actor in the network and Figure 2 where a preference is expressed for reciprocated ties.

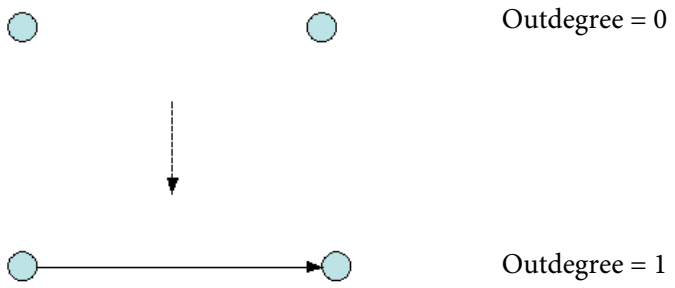

Figure 1. Network transition indicating a preference for a tie to another

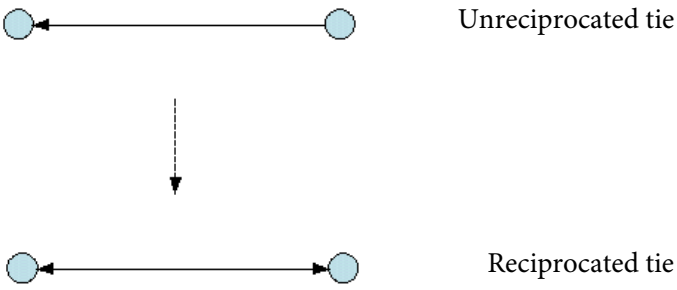

Figure 2. Network transition indicating a preference for reciprocated ties

There are, in fact, for just two actors, four possible dyadic configurations depending on the way in which the relationship is expressed. As we increase the number of network actors the number of possible network configurations rises exponentially, thus dramatically increasing the size of the state space. The modelling of these changes from one network configuration to another is carried out by formulating transition probabilities from one state to another. These probabilities are then used to simulate realisations of the process. The outcomes of such realisations are compared with the actual results observed in the panel data to identify the best fitting model parameters as explained in Snijders (2001).

Another possible formulation for a change in network configuration over time is the transition probability associated with a change from having a close link with another actor to that of having an indirect tie (i.e. link at distance two or more away). This is illustrated in Figure 3 where a preference is expressed over time for keeping others at social distance two (or more) and thus avoiding many

direct links with other individuals. A negative coefficient associated with this parameter would therefore indicate the opposite tendency and a desire for network closure.

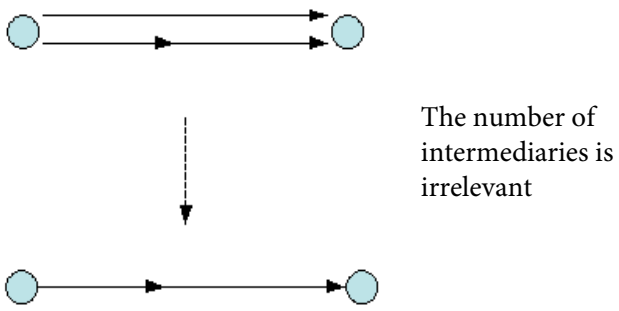

Figure 3. Network transition indicating a preference for keeping others at social distance two

The model for the joint evolution of the friendship network and the various behavioural variables, described in more detail in Snijders (2001) and Steglich, Snijders and Pearson (2004), is based on the following principles. First, the evolution of network and behavior proceeds in steps of small changes, unobserved, between the panel observations. The small changes consist of either a change in one relational variable between two pupils, or a change in one behavioural variable of one pupil. Second, these changes are made in dependence upon the current network-behavioural configuration, but – given this dependence – without coordination between the pupils. This means, e.g., that a friendship group cannot suddenly spring into being, but can only grow as the result of the gradual coalescence of friendship ties. Third, the changes are considered as resulting from a limited goal pursuit process, the goal being the local improvement of the evaluation by the pupils of their network position and their behaviour. The network position is evaluated also in view of the behaviour of self and of one's friends; the behaviour is evaluated also in view of the behaviour of friends. The precise specification of the model according to these principles is given in the above references. To give a plausible but also parsimonious representation of the network-behaviour co-evolution, the assessment of the network position is based on a limited list of aspects. Each of these aspects has a weight in the overall assessment; these weights are parameters of which the estimates, based on the observed data, are given in the tables below. The following aspects are considered:

- Out-degree, which is the term used in social network analysis for the number of friendship choices made by the pupil (Figure 1).
- Reciprocity, the number of reciprocated choices for the pupil (Figure 2).
- Indirect ties, the number of 'friends of friends' of the pupil who are not his or her direct friends. The general tendency in networks of positive affect towards network closure, also called transitivity of choices, implies that friends of friends will tend to become friends, so that the number of indirect ties will be lower than expected under random patterns of ties. Thus, a negative weight for the number of indirect ties will reflect a positive tendency toward network closure (Figure 3).
- Homophily for the variables under consideration (gender, smoking, behavior etc.) expressing the preference for friends with the same value on this variable (Figure 4).
- The value of a variable under consideration for the 'sender' of a friendship tie ('ego').
- The value of a variable under consideration for the 'receiver' of a friendship tie ('alter').

The last three of this list make it clear that any single individual variable, e.g., smoking behaviour, is assumed to potentially have three types of effect on friendship choices, and thereby on the network dynamics. A positive homophily effect would mean that pupils prefer friendships with others having a similar smoking behaviour, which will drive the dynamics to friendship groups being preferentially homogeneous in smoking behaviour (although in actual practice this homogeneity will be not at all perfect, due to other influences that also operate on the friendship process); a positive 'ego' effect would mean that those with a higher value on smoking behaviour attach a higher value to friendships, and thus will tend to increase their number of friends more strongly over time; and a positive 'alter' effect would mean that those who smoke more are more attractive as friends, and therefore will tend to receive more friendship nominations. Although a variable such as smoking behaviour, due to its changing nature over time, operates differently on the network dynamics than a variable such as gender which is constant over time, the representation of their impact on the network evolution, indicated by the homophily, ego, and alter effects, is the same.

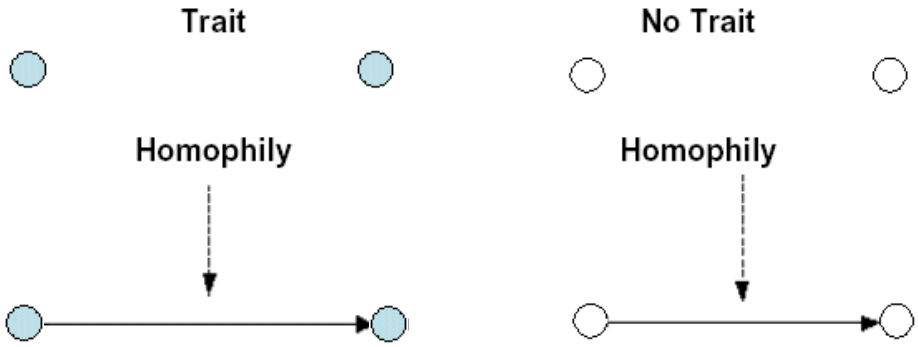

Figure 4. Network transition indicating a preference for ties to similar others (Homophily)

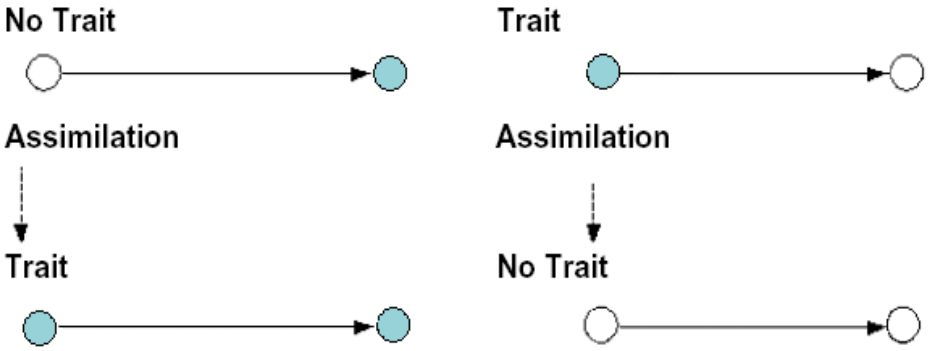

Figure 5. Behavioural transition indicating assimilation to friends(Assimilation)

The modelling process is given greater scope by the addition of the behavioural variables, which in this paper include the substance-use and sporting behaviours. The assessment by the individuals of their behaviour, e.g., smoking, and hence the direction of the dynamics of this behaviour, is based on the following list of aspects.

- The basic tendency to perform this behaviour, or to have a high value on it. A higher tendency parameter will lead to a more positive trend in the average of this behaviour. Since it is assumed that there are also random influences operating on the dynamical process, a zero weight for the tendency effect would imply that the average behaviour is not necessarily constant, but will tend toward the middle value in its range and

stabilize there. Hence, e.g., to maintain the behaviour at a low stable level, it is necessary that the weight of the tendency effect is negative.

- The assimilation to the average value of one's friends on this particular behavioural variable (trait) (Figure 5).
- Other individual variables (traits), which can themselves be changing (e.g., representing the effect of sporting behaviour on smoking behaviour) or non-changing (e.g., the effect of gender on smoking behaviour).

Fitting the statistical model produces not only the weights for these effects, but also the rate of change. Due to the definition of the model (cf. Snijders, 2001; Steglich et al., 2004), the rate of change is not identical to the average number of observed changes between successive panel waves, but will be slightly higher, representing that there can be unobserved up-and-down changes cancelling each other, and also that the individuals may have had opportunities to change their network ties or their behaviour but chose not to do so. Such non-utilized opportunities for change are considered in the model definition also to contribute to the rate of change.

In this paper we will pay particular attention to the mechanisms of homophily and assimilation. Figure 4 illustrates homophily (McPherson et al., 2001) occurring in the network model. According to this principle individuals tend to form relationships with others, who have similar rather than dissimilar behavioural characteristics or traits. Figure 5, on the other hand, illustrates assimilation whereby individuals undergo a behavioural transition to match the trait of their already existing friends (Friedkin, 1998). More generally, we will use the mechanisms illustrated in Figures 1-5 to analyse the panel data and record the results in Tables 2-4.

The SIENA program (Snijders et al., 2005) is used to analyse the panel data. This program estimates the parameters in the model sketched above. The parameters can be tested by testing the t-ratios (parameter estimate divided by standard error) in the standard normal distribution (Snijders, 2001). The results enable us to test the way in which sporting activity and substance use evolve for different substances, and also the hypotheses that increased sporting activity leads to decreased substance use or that increased substance use leads to decreased sporting activity over time. We do not in this paper address the way in which sporting activity and substance use evolve for different sporting activities; although data on differing types of sporting activities were gathered (the main out of school sporting activity for 13 year old boys at that time was football, while for girls it was dancing). We concentrate here on observing and identifying the dynamic interaction between sporting activity (defined in general) and substance use for particular substances.

3.2 Study design and sample data

The social network data were collected in the Teenage Friends and Lifestyle Study (Michell and West 1996, Pearson and Michell 2000, Pearson and West 2003). Friendship network data and substance use were recorded for a cohort of pupils in the West of Scotland. The panel data were recorded over a three year period starting in 1995, when the pupils were aged 13, and ending in 1997. A total of 160 pupils took part in the study, 129 of whom were present at all three measurement points. The friendship networks were formed by allowing the pupils to name up to twelve best friends.

Pupils were also asked about substance use and adolescent behaviour associated with, for instance, lifestyle, sporting behaviour and tobacco, alcohol and cannabis consumption. The question on sporting activity asked if the pupil regularly took part in any sport, or go training for sport, out of school (e.g. football, gymnastics, skating, mountain biking). The school was representative of others in the region in terms of social class composition (Pearson and West 2003).

The behavioural variables were coded as follows:

Smoking: 1(non), 2(occasional) and 3(Regular i.e. more than once per week)

Cannabis: 1(non), 2(tried once), 3(occasional) and 4(Regular)

Alcohol: 1(non), 2(once or twice a year), 3(once a month), 4(once a week) and 5(more than once a week)

Sport: 1(not regular) and 2(regular)

The data set investigated in this paper has been analysed in other publications. Other analyses using NEGOPY (Richards, 1989) were carried out by Michell and Amos (1997), Pearson and Michell (2000) and Pearson and West (2003). The cohesiveness and influence of larger groups and the investigation of sociograms was of special interest in these papers (at present SIENA does not analyse large cohesive groups). In particular the second of these publications has detailed sociograms for the complete data set at the first two time points. Pearson and West used a Markov process to model transitions between network and behavioural states and identify sojourn times in these states. Steglich, Snijders and Pearson (2004) extended SIENA to model processes of selection and influence among adolescent smokers and alcohol-users. Steglich, Snijders and West (2006) illustrated the analysis of the co-evolution of adolescents' friendship networks, taste in music and alcohol consumption. In this publication we extend the earlier work of Steglich, Snijders and Pearson (2004) by including three substance-use traits as well as sporting activity to explore the mechanisms of homophily and assimilation.

4. RESULTS

Table 1 summarises each of the behavioural and sporting activity traits at each age by gender. Gender and age appear to play an important role in the determination of these traits, with a general pattern of increased substance use and decreased sporting activity among older females. We investigate these tendencies in the context of co-evolving network and behavioural mechanisms.

4.1 Results on network evolution: selection of friends

Estimation of a reference model was carried out containing only network information on selection of friends together with gender. The results for outdegree, reciprocity, number of actors at distance 2, gender homophily, gender ego and gender alter are shown in Table 3 ('Network'), where the significant results are shown in italics. Hence a negative outdegree effect (Figure 1 and Table 2; 'Network: outdegree) indicates that friendship with other pupils is unlikely and unstable unless there is some additional property added to the desired friendship such as reciprocity (Figure 2 and Table 2; 'Network: reciprocity'). Other desirable properties are possible. One such is the benefit of having mainly direct ties in a friendship network. This would result in a strong preference against having school friends at social distance 2 (Figure 3 and Table 2; 'Network: distance-2').

Another desirable property which adds to the value of a friendship is being of the same gender. (Figure 4 and Table 2; 'Network: gender: homophily'). There is strong gender homophily in friendship selection. Girls significantly prefer to have more friendship ties than boys, and are significantly less attractive as friends. (Table 2; 'Network: gender: ego and alter').

Male

Trait/Age	Age 13	Age 14	Age 15	Total
Occasional and Regular Smoking	6 (8.2%)	10 (13.7%)	14 (19.2%)	16.0%
Occasional and Regular Cannabis	8 (11%)	12 (16.5%)	26 (35.6%)	21.0%
Alcohol (once or more per week)	8 (10.9%)	14 (19.1%)	27(36.9%)	20.0%
Regular Sport (Any Sport)	64 (87.7%)	60 (82.2%)	56 (76.7%)	82.2%

Female

Trait/Age	Age 13	Age 14	Age 15	Total
Occasional and Regular Smoking	14 (25%)	19 (33.9%)	22 (39.3%)	22.0%
Occasional and Regular Cannabis	8 (14.3%)	10 (17.9%)	19 (33.9%)	22.0%
Alcohol (once or more per week)	18 (32.2%)	20 (35.7%)	26(46.4%)	38.1%
Regular Sport (Any Sport)	39 (69.6%)	33 (58.9%)	19 (33.9%)	54.1%

Male and Female

Trait/Age	Age 13	Age 14	Age 15	Total
Occasional and Regular Smoking	20 (15.6%)	29 (22.5%)	36 (28%)	22%
Occasional and Regular Cannabis	16 (12.5%)	22 (17.1%)	45 (34.9%)	21.4%
Alcohol (once or more per week)	26 (20.2%)	34 (26.3%)	53(41.1%)	29.2%
Regular Sport (Any Sport)	103 (79.8%)	93 (72.1%)	75 (58.1%)	70%

Table 1. Numbers and Percentages of Pupils with Traits at each Age

Network Evolution

Model	Parameter	Estimate	St. Error	p-value	Interpretation
Network	outdegree	-1.89	0.057	<0.001	*Costly friendship ties*
	reciprocity	2.34	0.084	<0.001	*Prefer reciprocation*
	distance-2	-1.12	0.063	<0.001	*Prefer network closure*
	gender homophily	0.77	0.093	<0.001	*Prefer same sex friends*
	ego	0.18	0.091	0.04	*Girls prefer more friends*
	alter	-0.25	0.100	0.01	*Girl less attractive as friend*
	rate period 1	12.62	1.061		Rate of network change (1)
	rate period 2	9.49	0.805		Rate of network change (2)

Table 2. SIENA estimation results for the model. Effects labelled in italics indicate significance at $\alpha = 0.05$ (two-sided)

If we extend our study to include the behavioural effects of smoking, cannabis and alcohol use some of these effects display reduced significance levels. For instance, girls do not significantly prefer to have more friendship ties than boys, nor are they significantly less attractive as friends. (Table 3; 'Network: gender: ego and alter'). Furthermore this is also displayed in an earlier study (Steglich et al., 2004) using the same data set, but without cannabis use, where some significance was identified with regard to the ego and alter effects of gender. We will discuss this finding in the conclusion. The rates of network change are high during both time periods one and two (Table 3; 'Network: rate period 1: rate period 2'). This means that the average number of occasions per time period which each actor gets for applying a small change to his network neighbourhood (i.e., erasing an existing tie or creating a new one) is high, indicating a highly active dynamic evolution in the formation of friendship ties.

4.2 Results of the behaviour-related effects on network evolution

The results about the behaviour-based selection of friends are also summarised in Table 3. The first significant result is that smokers name more friends than non-smokers (Table 3; 'Network: smoking: ego'). It is also the case that smokers are less attractive as friends than non-smokers (Table 3; 'Network: smoking: alter'), although this is of borderline significance. There are no significant ($p<0.05$) network effects associated with cannabis use, although there is a marginal cannabis-ego effect ($p<0.1$), indicating that cannabis users do appear to name fewer friends than non-users (Table 3; 'Network: cannabis: ego'). The alcohol-based selection effect is the strongest behaviour-based effect. Adolescents appear to prefer friends with the same drinking behaviour (Table 3; 'Network: alcohol: homophily').

4.2.1 Smoking

The low smoking tendency (-3.36) shows that pupils in general have a preference not to smoke. Gender acts as a borderline significant effect on smoking (Table 3; 'Smoking: gender'), suggesting that girls have a higher preference for smoking than boys. Cannabis has a highly significant behavioural effect on smoking (Table 3; 'Smoking: cannabis'), cannabis users being far more likely to smoke than non-users.

4.2.2 Cannabis

The negative tendency of cannabis (Table 3; 'Cannabis: tendency') is a weak effect indicating that pupils in general have a tendency not to use cannabis. The most significant effect is a positive influence effect of friends on cannabis use (Table 3; 'Cannabis; assimilation). A non cannabis user with a friend who uses cannabis (or a cannabis user who has non-user friends) is more likely to assimilate (change) his behaviour to match that of his friends. There is a mild, but not significant, gender effect on cannabis use (Table 3; 'Cannabis; gender'), suggesting that contrary to the smoking effect, girls may have a stronger dislike for cannabis than boys. Cannabis use changes slowly at first, but more rapidly later (Table 3; 'Cannabis: rate period 1: rate period 2').

4.2.3 Alcohol

Alcohol use seems more popular than either smoking or cannabis use (Table 3; 'Alcohol: tendency'). The most significant effect is a positive influence effect of friends on alcohol use ($p < 0.001$). A non-drinker who has drinking friends (or a drinker who has non-drinking friends) is more likely to assimilate (change) his behaviour to match that of the friends. Gender, smoking and cannabis use do not appear to significantly affect alcohol use. The rate parameters indicate that changes on the alcohol dimension increase over time, which means that alcohol dynamics speed up.

4.3 Sporting Activity

We repeated our analysis including the sporting behaviour of the pupils as an additional dependent variable. The results for the two dependent variables smoking and sports behaviour are shown in Table 4a. The network effects show homophily occurring in the cases of gender and smoking (without alcohol and cannabis) behaviour, but very weak negative effects for sporting behaviour. Pupils seem to prefer friends with different sporting behaviours. Sporting pupils also name fewer friends. Neither do the behavioural effects show assimilation occurring among sporting pupils. The main effect appears to be the causal relationship between smoking and sporting activity (in addition to the effect of gender on sporting activity). Smoking reduces sporting activity and girls engage in less sports activity.

The analysis was repeated for cannabis and alcohol use (Tables 4b and 4c) but the effects were not significant. The analysis was extended for sporting activity and all substance uses as dependent variables and the results (not displayed), were very similar to Table 3 and 4a, b and c.

Finally, we observe an interesting gender effect from Table 3 that girls smoke more (p=0.05), which vanishes in Table 4a (p=0.23) after controlling for sport. This occurs because of the combined effects of girls sporting less and smokers engaging in less sporting activity.

5. CONCLUSIONS

The first question we address is the degree to which influence/homophily and selection/assimilation mechanisms account for the observed co-evolution of substance-use and friendship ties in our data. The answer is that we observe both mechanisms occurring in the data set. There are strong selection effects occurring in the choice of friendship ties. Preference for same sex reciprocated relationships in closed networks predominates. There is quite strong assimilation and influence and also a degree of homophily and selection associated with some of the substance use behaviour.

The second question relates to the difference between the three substance-use behaviours. If we regard these substance use behaviours as dimensions, then assimilation occurs on only two dimensions (cannabis and alcohol) and not on the third (smoking), (Table 3; 'Alcohol: assimilation' and 'Cannabis: assimilation'). Pupils are therefore more likely to assimilate their behaviour to match that of their friends with regard to drinking and cannabis use, but not with regard to smoking behaviour.

Selection, on the other hand is most noticeable among drinkers (Table 3; 'Network: alcohol homophily') and smokers (Table 3; 'Network: smoking: ego and alter'). Drinkers prefer friends with the same drinking behaviour. Smokers name more friends but are less attractive as friends.

The third question concerns the causal relationships between tobacco, alcohol and cannabis consumption. There is an effect of cannabis use on smoking behaviour. Cannabis users smoke more tobacco. This is not perhaps a very surprising result, since much cannabis is smoked together with tobacco. There are also weak effects of other substances on each other (drinkers smoke more and cannabis users drink more). There is a mild gender effect on smoking and cannabis use (girls smoke more but use less cannabis).

The fourth question introduces the dependent behavioural variable 'sporting activity'. Tables 4a, 4b, 4c all show that homophily and assimilation are not significant mechanisms with regard to sporting activity for any of the substances. What is apparent, however, is that there is a significant causal relationship between substance use and sporting activity which results in a significant reduction of sporting activity among smokers and a mild (less significant) reduction among cannabis users. The results of alcohol consumption are inconclusive, but seem to indicate an increase (not significant) among sports activists. We also found that sporting activity was highly gendered, with girls engaging in less sport than boys. The apparent increased smoking levels among girls could be partly accounted for by their reduced sporting activity, since sports active pupils smoke less.

The fifth question relates to the implications for health intervention programmes. The programmes need to address the likely effect of any intervention by taking into account the different ways that friendship networks, substance use and sporting activity co-evolve.

Insights into these patterns of co-evolution can help, first, to focus interventions on certain groups or developmental phases; second, to pinpoint particularly adverse links in the processes leading to substance abuse and attempt to break or weaken them. As an example of focussing interventions on certain groups or developmental phases we note that friendships appear to be less stable among the younger children, who are also most vulnerable to increasing smoking rates. The fact that smokers name more friends, while appear less attractive as friends suggests a simple message targeting younger pupils. The message 'Choosing to smoke won't win you friends' needs to be emphasised, especially among young and vulnerable pupils. As an example of pinpointing particularly adverse links in the

processes leading to substance abuse we propose that peer group based programmes would be better targeted at the substance uses of drinking and cannabis, since assimilation is strongest among these users (Table 3). Accordingly an example of this type of intervention is promoting the message 'Don't be coerced by peers into drinking and cannabis use' as more appropriate for drinking and cannabis. Programmes would also benefit by addressing gender issues. Girls are more likely to smoke (Table 3) and prefer more friends (Table 2). The message 'Choosing to smoke won't win you friends' could be particularly apt for them. The fact that girls network more strongly than boys (Table 2) may also indicate an ability to exercise greater influence, but this effect becomes weaker when the substance use behaviours are taken into account (Table 3).

If we consider only the network effects girls appear to be more socially active than boys, since they prefer to have more friendship ties (Table 2). They are also less attractive as friends (Table 2). These effects are not significant, however, when we include the co-evolutionary behavioural effects (Table 3; 'Network: gender: ego and alter'). In the current analysis we may be tempted to attribute this to the gender-specific effect of smoking. Table 3 indicates that girls smoke more than boys ($p = 0.053$), a result which is corroborated elsewhere (Pearson et al., 2005). The table also indicates that smokers name more friends and are less attractive as friends. We might therefore suppose that girls prefer more friendship ties and are less attractive as friends largely because of their smoking tendency. However, an earlier study (Steglich et al., 2004) using the same data set, but without cannabis use, did find some significance with regard to the ego and alter effects of gender, as well as similar gender-specific results for smoking. In our current analysis this gender-specific ego and alter effect is better explained by seemingly gender-specific cannabis consumption patterns. There is a marginally significant negative cannabis-ego effect (Table 3; $p = 0.096 < 0.1$) indicating that cannabis users do appear to name fewer friends than non users. Girls also appear to consume less cannabis. Although this is not a significant result in this study (Table 3; $p = 0.12$), the result is significant in a larger study carried out in the West coast of Scotland (Pearson et al., 2005). We might therefore conclude that the earlier result (that girls appear to be more socially active) can now be explained by their lower cannabis consumption and the marginally significant negative cannabis-ego effect.

The cannabis-ego effect whereby cannabis users tend to name fewer friends also implies that cannabis use tends to make people less socially active. This could tie in with the frequent portrayal of drug-takers as being lethargic. It also ties in with the level of sports activity of cannabis users, which is marginally lower (Table 4b; $p = 0.08$). When we take into account all the behavioural effects this direct effect disappears (not shown), and is replaced with the combination of two effects. Firstly that cannabis users smoke more (Table 3, $p < 0.01$) and secondly that smokers sport less (Table 4a, $p = 0.01$). We might therefore target our intervention program more efficiently at anti-smoking than anti-cannabis use when attempting to increase sports involvement. We may also wish to exploit the higher assimilation effect of cannabis compared with smoking. Initially this could mean separating the activities of smoking and cannabis use by encouraging cannabis users not to smoke their cannabis in order that they might become more involved and improve their performance in sport.

Other interesting effects appear in Tables 3 and 4a, b and c. These are that the strongest homophily, as well as the strongest assimilation, effects associated with substance use are the effects of alcohol. Drinkers prefer the same drinking behaviour friends, as well as exercising a strong influence on the drinking behaviour of their friends. The effects are not surprising when we consider the social dimensions of alcohol use. The challenge for health intervention programs is to reduce drinking choice opportunities among adolescents in order to control the homophily effect. The assimilation effect requires more careful control of the environment in which drinking occurs among adolescents. Drinking often occurs outside of the school environment and so the importance of out of school networks should be taken into consideration (Dolcini, Harper, Watson, Catania and Ellen, 2005).

Co-evolution of Network and Substance Use

Model	Parameter	Estimate	St. Error	*p*-value	Interpretation
Network	*outdegree*	-1.98	0.22	<0.001	*Costly friendship ties*
	reciprocity	2.29	0.11	<0.001	*Prefer reciprocation*
	distance-2	-1.08	0.07	<0.001	*Prefer network closure*
	gender homophily	0.78	0.11	<0.001	*Prefer same sex friends*
	ego	0.12	0.12	0.32	Girls prefer more friends
	alter	-0.17	0.13	0.19	Girls less attractive as friend
	smoking homophily	0.42	0.34	0.22	Prefer same smoke friends
	ego	0.28	0.13	0.03	*Smokers name more friends*
	alter	-0.25	0.13	0.05	*Smokers less attractive*
	cannabis homophily	0.18	0.51	0.72	Prefer same hash friends
	ego	-0.15	0.09	0.10	Hashers name less friends
	alter	0.09	0.10	0.37	Hashers more attractive
	alcohol homophily	0.96	0.38	0.01	*Prefer same drink friends*
	ego	-0.04	0.04	0.32	Drinkers name less friends
	alter	0.06	0.05	0.23	Drinkers more attractive
	rate period 1	12.72	1.49		Rate of network change (1)
	rate period 2	9.65	1.33		Rate of network change (2)
Smoking	tendency	-3.36	1.19	0.004	*Low smoking tendency*
	assimilation	0.39	0.37	0.29	Some smoking influence
	gender	0.91	0.47	0.05	Girls smoke more
	cannabis	1.09	0.38	<0.01	*Hashers smoke more*
	alcohol	0.33	0.25	0.19	Drinkers smoke more
	rate period 1	2.01	0.87		Rate of smoking change (1)
	rate period 2	1.31	0.35		Rate of smoking change (2)
Cannabis	tendency	-1.02	0.93	0.27	Low hashing tendency
	assimilation	3.54	1.43	0.01	*High hash influence*
	gender	-0.99	0.64	0.12	Girls hash less
	smoking	0.60	0.47	0.20	Smokers hash more
	alcohol	0.42	0.41	0.31	Drinkers hash more
	rate period 1	0.61	0.17		Rate of hash change (1)
	rate period 2	1.53	0.40		Rate of hash change (2)
Alcohol	tendency	0.25	0.30	0.41	High drinking tendency
	assimilation	1.63	0.43	<0.001	*High drinking influence*
	gender	0.23	0.22	0.30	Girls drink more
	smoking	-0.50	0.44	0.26	Smokers drink less
	cannabis	0.51	0.37	0.17	Hashers drink more
	rate period 1	1.67	0.31		Rate of drinking change (1)
	rate period 2	2.33	0.47		Rate of drinking change (2)

Table 3. SIENA estimation results for the model. Effects labelled in italics indicate significance at $\alpha = 0.05$ (two-sided)

Co-evolution of Network, Smoking and Sport Activity

Model	Parameter	Estimate	St. Error	*p*-value	Interpretation
Network	*outdegree*	-1.64	0.38	<0.001	*Costly friendship ties*
	reciprocity	2.31	0.10	<0.001	*Prefer reciprocation*
	distance-2	-1.11	0.07	<0.001	*Prefer network closure*
	gender homophily	0.80	0.12	<0.001	*Prefer same sex friends*
	ego	0.12	0.12	0.32	Girls prefer more friends
	alter	-0.20	0.14	0.16	Girls less attractive as friend
	smoking homophily	0.57	0.22	0.01	*Prefer same smoke friends*
	ego	0.12	0.08	0.13	Smokers name more friends
	alter	-0.14	0.07	0.05	Smokers less attractive
	sport homophily	-0.17	0.17	0.31	Prefer different sport friends
	ego	-0.15	0.11	0.16	Sports name less friends
	alter	-0.01	0.14	0.96	Sports neutral attractive
	rate period 1	12.55	1.48		Rate of network change (1)
	rate period 2	9.56	0.98		Rate of network change (2)
Smoking	tendency	0.18	1.19	0.88	Low smoking tendency
	assimilation	0.63	0.38	0.10	High smoking influence
	gender	0.52	0.43	0.23	Girls smoke more
	sport	-0.05	0.67	0.94	Sports smoke less
	rate period 1	0.88	0.27		Rate of smoking change (1)
	rate period 2	0.88	0.21		Rate of smoking change (2)
Sport	*tendency*	2.12	0.80	0.01	*High sports tendency*
	assimilation	-0.05	0.20	0.81	Low sports influence
	gender	-1.73	0.52	<0.001	*Girls sport less*
	smoke	-1.20	0.49	0.01	*Smokers sport less*
	rate period 1	0.88	0.22		Rate of sport change (1)
	rate period 2	1.03	0.29		Rate of sport change (2)

Table 4a. SIENA estimation results for the model. Effects labelled in italics indicate significance at $\alpha = 0.05$ (two-sided)

Co-evolution of Network, Cannabis and Sport Activity

Model	Parameter	Estimate	St. Error	*p*-value	Interpretation
Network	*outdegree*	-1.58	0.71	0.03	*Costly friendship ties*
	reciprocity	2.30	0.11	<0.001	*Prefer reciprocation*
	distance-2	-1.10	0.08	<0.001	*Prefer network closure*
	gender homophily	0.81	0.11	<0.001	*Prefer same sex friends*
	ego	0.11	0.12	0.34	Girls prefer more friends
	alter	-0.27	0.17	0.12	Girls less attractive as friend
	cannabis homophily	0.81	0.48	0.09	Prefer same hash friends
	ego	-0.05	0.05	0.28	Hashers name more friends
	alter	-0.02	0.07	0.80	Hashers less attractive
	sport homophily	-0.11	0.21	0.60	Prefer different sport friends
	ego	-0.18	0.15	0.26	Sports name less friends
	alter	0.03	0.20	0.87	Sports neutral attractive
	rate period 1	12.61	1.73		Rate of network change (1)
	rate period 2	9.78	1.40		Rate of network change (2)
Cannabis	tendency	-0.89	1.84	0.63	Low cannabis tendency
	assimilation	3.37	2.06	0.10	High cannabis influence
	gender	-0.24	0.47	0.61	Girls hash less
	sport	1.21	1.56	0.44	Sports hash less
	rate period 1	0.53	0.15		Rate of cannabis change (1)
	rate period 2	1.37	0.39		Rate of cannabis change (2)
Sport	tendency	1.32	0.73	0.07	High sports tendency
	assimilation	0.05	0.21	0.81	Low sports influence
	gender	-1.91	0.51	<0.001	*Girls sport less*
	cannabis	-0.64	0.37	0.08	Hashers sport less
	rate period 1	0.85	0.24		Rate of sport change (1)
	rate period 2	0.94	0.25		Rate of sport change (2)

Table 4b. SIENA estimation results for the model. Effects labelled in italics indicate significance at $\alpha = 0.05$ (two-sided)

Co-evolution of Network, Alcohol and Sport Activity

Model	Parameter	Estimate	St. Error	*p*-value	Interpretation
Network	*outdegree*	-1.55	0.44	<0.001	*Costly friendship ties*
	reciprocity	2.32	0.11	<0.001	*Prefer reciprocation*
	distance-2	-1.10	0.07	<0.001	*Prefer network closure*
	gender homophily	0.81	0.10	<0.001	*Prefer same sex friends*
	ego	0.15	0.11	0.17	Girls prefer more friends
	alter	-0.22	0.12	0.06	Girls less attractive as friend
	alcohol homophily	1.14	0.32	<0.001	*Prefer same drink friends*
	ego	-0.06	0.03	0.06	Drinkers name more friends
	alter	-0.01	0.03	0.86	Drinkers less attractive
	sport homophily	-0.09	0.22	0.67	Prefer different sport friends
	ego	-0.17	0.13	0.19	Sports name less friends
	alter	0.04	0.14	0.76	Sports neutral attractive
	rate period 1	12.57	1.29		Rate of network change (1)
	rate period 2	9.49	1.22		Rate of network change (2)
Alcohol	tendency	0.19	0.54	0.73	Low alcohol tendency
	assimilation	1.44	0.31	<0.001	*High alcohol influence*
	gender	0.03	0.17	0.86	Girls drink more
	sport	0.10	0.35	0.77	Sports drink more
	rate period 1	0.82	0.22		Rate of drinking change (1)
	rate period 2	0.96	0.27		Rate of drinking change (2)
Sport	tendency	0.68	0.67	0.32	High sports tendency
	assimilation	0.06	0.23	0.79	Low sports influence
	gender	-1.66	0.52	0.001	*Girls sport less*
	alcohol	-0.15	0.23	0.51	Drinkers sport less
	rate period 1	0.85	0.24		Rate of sport change (1)
	rate period 2	0.94	0.25		Rate of sport change (2)

Table 4c. SIENA estimation results for the model. Effects labelled in italics indicate significance at $\alpha = 0.05$ (two-sided)

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A 45-year Retrospective on Doing Networks[1]

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INTRODUCTORY REMARKS

There is little reason to expect any of you to be familiar with the particulars of my career, and especially with those aspects of it that have much bearing on my intellectual development as it pertains to my abiding interest in social network analysis. Certainly you will not know about the war stories that have come to have such an important bearing in furthering my understanding of the fundamental dynamics animating social networks. I have written extensively on a wide range of topics, notably, about organizations, elites, power and influence, politics, social stratification, health, sex and disease, but very much from a network point of view. In addition to this academic work, I have had an extensive career in academic administration, rising from Associate Chair to Editor of the American Journal of Sociology to Departmental Chair to Dean of the Social Sciences Division to Provost of the University of Chicago. With the benefit of 20/20 hindsight, one might imagine that this career is the direct result of a coherent intellectual perspective and strategy that was full born at the outset of my scholarly endeavors. But this would be woefully wrong and misleading.

My own experience strongly suggests that academic life is an unanticipated sequence of opportunities that lack definition and clarity as to what is really at stake at the time decisions are being made, e.g., whether to move or stay at an institution. For the purposes of understanding the following narrative, you need to know that some regard me as having made some useful contributions to social network approaches to the study of society. My academic focus on how people and other entities form, maintain, and dissolve relationships with others and the impact of such networks on the identity and behavior of individuals and groups have been a recurrent theme in my research over the past 45 years. It has spurred my many research endeavors, but it has, in important measure, informed the strategies I employed in advancing my research agenda and its public presentation, and it has also informed the implementation of my administrative responsibilities, plans, and schemes. I must take this opportunity to acknowledge my enormous intellectual and personal debt to the many teachers, colleagues, students and friends who have so unfailingly helped me in pursuing my myriad interests. In drawing

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up this list, I realize that they are many others that fully deserve recognition but your patience would be most sorely tried if I did so: Talcott Parsons, George C. Homans, Harrison White, Louis Guttman, J. Clyde Mitchell, Franz Pappi, James Coleman, Joel Levine, Stephen Berkowitz, Barry Wellman,Tom Fararo, John P. Heinz, David Knoke, Lois Verbrugge, Peter Marsden, Joseph Galaskiewicz, Ron Burt, Yong Hak Kim, Tony Tam, Phil Schumm, Martina Morris, Yoosik Youm, Ron Breiger, Lin Freeman, Phil Bonacich, Noah Friedkin, Toby Stuart, Roger Gould, and Anthony Paik.

To provide an overview of the narrative flow of my intellectual life course, I have listed in Table 1 the fourteen principal projects I have directed that gathered data on diverse sorts of social networks. The rows refer to the year and sites in which the data-gathering effort was launched and the columns provide information indicating the empirical focus of the study, whether it followed a probability-based, ego-centered survey sample design or a sociocentric, complete population-enumeration design, and finally some key citations to books and articles reporting the data analysis. Please note that we draw a key distinction in this table between ego-centric research designs in which the analytic focus is on a focal actor and his / her set of alters who are connected to ego by some personal linkage or tie and a socio-centric research design in which the analyst stipulates a boundary-specifying rule for inclusion in or exclusion from the network and all included entities are explicitly studied for a complete enumeration of all ties among the included actors. Differences between ego-centered and socio-centered designs pose serious methodological challenges in the analysis and interpretation of the entities under study.

THE FIRST DECADE: 1963-1973

My earliest work on personal networks begins at the very outset of my scholarly career, with my dissertation work at Harvard in 1963 when I conducted an urban survey (N = 422) of the social stratification of Cambridge and Belmont, Massachusetts, that led to Prestige and Association in an Urban Community (1966). My inspiration was a passage in Urban Social Structure (1962) a book by sociologist James Beshers, which introduced me to the notion of social distance a la Emory S. Bogardus and Robert Park of the Chicago School of Sociology, which flourished in the 1920s and 1930s. I focused attention on occupational subjective social distance (as opposed to ethnic social distance, which was the dominant theme of Chicago School sociology). Social distance directs attention to the arrangement of personal relationships along a scale of personal access to the ego, ranging, at one extreme, in a subjective willingness to kill a despised group member (maximum subjective social distance), warming sympathetic understanding to a willingness to accord citizenship to a particular group, then moving to a willingness to be a neighbor or to be a co-worker with a person from that group, to finally, being willing to form a close friendship and even marry a group member (the closest form of intimacy in a freely forming relationship—at least in the United States).

I proposed the existence of a dynamic tension between the "like-me hypothesis" (which postulates that people subjectively prefer to associate informally with people just like themselves on key status attributes) vs. the "prestige hypothesis" (which postulates that people would subjectively prefer to associate informally with persons of higher status than themselves because, among other things, higher-status persons control more useful and desirable resources than ego controls). The resolution of these contradictory impulses in a particular society constitute the basis of corporate vs. competitive class and/or status consciousness in that society (cf. Laumann 1966; Laumann and Senter 1976) (At that time no one had elaborated social networks as an analytic notion, not even the anthropologists who had only begun to speak metaphorically about social networks in the late 1940s and 1950s (e.g., Radcliffe Brown, 1952; Elizabeth Bott, 1957). But Beshers and I published a paper entitled "Social Distance: A Network Approach," in the American Sociological Review in 1967 with this analytic notion very much in mind.

I moved to the University of Michigan in 1964 and immediately began work on the Detroit Area Study, which was to take up ethnoreligious group differences as well as occupational differences in subjective social distance. The latter was a concern that I had gleaned from W. Lloyd Warner, an anthropologist, and his work on Social Class in America (1960) and the Yankee City Studies (1942). At Michigan, my colleagues included a group of social psychologists, Theodore Newcomb, Dorwin ("Doc") Cartwright, Arnold Tannenbaum, Stanley Seashore, Ronald Lippitt, and several quantitatively oriented mathematicians and methodologists, Louis Guttman (Guttman, 1968; Laumann and Guttman, 1966) (formulator of smallest space analysis), Otis Dudley Duncan, and Frank Harary (a mathematician who wrote with Dorwin Cartwright and Robert Norman) the highly influential book on digraph theory, Structural Models (1965). All of these people shared an absolute fascination with small group structure and interrelated social ties. Thus my interest in social relationships and social

Table 1. The Fourteen Principal Projects Containing Detailed Information on Social Networks

Year	Data– Collection	Probability–based Population Sample	Size of Primary Sample	Size of Secondary Sample	Scholarly Report
1963	Cambridge/ Belmont, MA	X	N=422		Prestige and Association in an Urban Community (1966)
1965	Detroit Area Study	X	N=820		Bonds of Pluralism (1973)
1971	Altneustadt, West Germany	X	N=820	N=46	Networks of Collective Action (1976) with Franz Pappi
1975	Chicago Lawyers	X	N=800		Chicago Lawyers (1983) with John P. Heinz
1976	2– City Illinois Elite Study	X	N=850	N=70	American Journal of Sociology
1981	National Policy Domains	X X	N=198 Energy Orgs N=135 Health Orgs		The Organizational State (1987) with David Knoke
1983	Washington Lobbyists	X X X	N=800 Lobbyists N=300 Orgs N=300 Gov Orgs		The Hollow Core (1993) with Heinz, Salisbury, and Nelson
1992	National Health and Social Life Survey	X	N=3,432		Sex in America (1994) with Gina Kolata & Others; The Social Organization of Sexuality (1994) with Gagnon, Michael, and Michaels; Sex, Love, and Health in America (2000) with Michael
1995	Chicago Health and Social Life Survey 2nd Wave Chicago Lawyers	X	N=2,200 N=800	N=72	The Sexual Organization of the City (2004) with Ellingson, Paik, Mahay, and Youm; Urban Lawyers (2005) with Heinz, Nelson and Sandefur
2000	Chinese National Sexual Practices	X	N=3,426	N=850 (clinic)	JAMA (2003), with Parish, Pan,Wang, and Cohen
2001	Global Survey of Sexual Attitudes and Beliefs Male Aging Research and Sexual Health	X X	N=27,500 N=2,200		IJIR (2005), IASR (2006), with Nicolosi, Moreira, and Glasser JSM (2006), with Paik, Glasser, and Rosen
2005	National Health, Aging and Social Life		N=3,004		In preparation, with Waite, Lindau, O'Muircheartaigh, and Levinson

ties was very much rooted in a broad reading of sociology and social psychology. I did meet J. Clyde Mitchell in 1967 as he was returning to England from his year at the Center for Advanced Studies in the Behavioral Sciences at Palo Alto. He talked to me about his recently completed book manuscript, Social Networks in Urban Situations (1969), and I shared my work with him. So I became familiar with the anthropologist contingent in network analysis fairly early, but I think it is fair to say that the network-sociometry interest in personal networks was autonomously developed out of my sociological training and contacts at Harvard and the University of Michigan.[2]

A very important theoretical point should be made here. The fundamental substantive mechanism motivating much of the work undergirding Harrison White's (and his associates') original block modeling enterprise (White, Boorman, & Breiger, 1976) was derived from Fritz Heider's (1958) theory that postulates an intrapsychic balancing dynamic between positively and negatively oriented affects which, at equilibrium, should be in balance. Typical propositions from this scheme are that a friend of a friend is a friend and an enemy of a friend is an enemy.In sharp contrast, my work and that of my colleagues has proceeded from a very different sociological starting point. Persons (or other purposive corporate entities) are understood to be unitary actors embedded in social interactional systems which possess different endowments of resources (i.e., socially based inequalities in the distributions of desired resources) and that have different stakes (equivalently, interests, or purposes) in engaging in social interaction (i.e., they possess different stakeholding interests). We ignore the intrapsychic emotional dynamics of balancing interpersonal sentiments although we readily admit that these dynamics over time are likely to be consistent with Heider's theory. The engine driving network formation in our scheme, however, is rooted in a macrostructural understanding of the differential distribution of social resources in society—i.e., the processes of social stratification and inequality, the strategic deployment of these resources in pursuit of specific ends or interests, and the structural constraints that facilitate or hinder the formation and maintenance of these ties, particularly as they contribute to the actor's autonomy.

The central analytic questions to be answered become:

- How do you define social positions?
- How do you define social differentiation among social positions?
- How do you define modes of integration among these differentiated positions?
- What is the unit of analysis? Individual vs. dyad.
- How do you define a social relationship?
- What are the ways in which they vary across social relationships with respect to the logic of their formation?

Table 2 summarizes the range of social ties that have been studied across the fourteen projects identified in Table 1. As rich as the corpus of these data sets are, I have not explored as thoroughly as I should have the comparative effects of socio-cultural contexts on pair formation (but see Laumann and Senter, 1977). And I have been remiss in gathering useful data on the dynamics or time-dependent changes in pair-bonding within the network structure. The data sets thus suffer from a strong static bias although at the time of their collection, it seemed that collection of baseline data should be our first priority.

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[2] Of course, while Harrison White ultimately chaired my dissertation final oral defense, George Homans and Talcott Parsons, both of whom were not in residence at the time I submitted my thesis, were the critical founts of my theoretical inspiration in 1964. This interest in informal social networks predates White's move into structural equivalence (Lorraine and White , 1971) and the development of block modeling by almost a decade.

Egocentric Vs. Sociocentric Approaches

Several approaches to bridging the gap between egocentric and sociocentric network approaches have been proposed. The one I shall discuss here was developed during the exploration of four major data sets: (1) the Detroit Area Study (Laumann, 1973), (2) the 1976 study of social networks among male adults living in two urban communities (Marsden and Laumann, 1979) (3) the cross-section survey of a small German city (Laumann and Pappi, 1976), and (4) a survey of the legal profession in Chicago (Heinz and Laumann, 1982). In each of these examples, the purpose of the research was first to identify and describe patterns in group-level network structures, whether among an urban community of residents or among a community of licensed professionals, and second to make inferences about the effects of these structures on the behaviors of the nodal actors (and vice versa).

The general approach seeks to develop a link between the sociometric choices made by randomly selected survey respondents and certain aspects of the global network structure in which the respondents are embedded. For this reason, it might be useful to conceive of this approach as a hybrid of both the conventional egocentric and sociocentric approaches. Specifically, it consists of "relativizing the notion of a concrete social relationship, like friendship, work partners, or marriage, into a stochastic relationship" (Laumann, 1979). This is done by focusing solely on the aggregate relations among identified population subgroups, and measuring those aggregate relationships as the probability that different groups' constituents are tied to one another by the particular relation in question. As an example, consider my first published sociomatrix of friendship ties by occupational status and the

Table 2. Social Network Ties Studied

Year of Study	1963 C	1965 C	1971 FC	1975 C	1976 C	1981 N	1983 N	1992 N	1995a C	1995b C	2000 F	2001 I	2002 N	2005 N
Kin/In-laws	X	X	X		X			X		X	X			X
Friendship	X	X	X	X	X		X	X	X	X	X			X
Neighbor	X	X	X		X			X		X	X			X
Instrumental business work/professional ties			X	X	X		X		X	X				X
Political ties/Notables			X	X	X		X		X					
Organizational Ties			X		X	X	X		X					
Sexual Partnerships:														
- Marriage								X		X	X	X	X	X
- Cohabitation								X		X	X	X	X	X
- Dating								X		X	X	X	X	X
- One-Night Stand								X		X	X	X	X	X

Legend: C = Community; N = National (US); I = Internationall; F = Foreign

comparative analysis of the variable levels of differential association across types of social relationships. Note here the classic concentration of cases on the main diagonal with rapid declines of cases as one moves to cells with increasingly status discrepant pairs (Table 5.1 below).

TABLE 5.1 *Occupational status of all friends reported, by respondents' occupational status*

FRIENDS' OCCUPATIONAL STATUS	RESPONDENTS' OCCUPATIONAL STATUS					
	Top prof., business	*Semiprof., middle bus.*	*Clerical, small bus.*	*Skilled*	*Semi- & unskilled*	TOTAL
	PER CENT DISTRIBUTION					
Top prof., business	74.2	22.9	19.0	9.0	3.9	24.4
Semiprof., middle bus.	17.1	47.9	26.3	16.2	11.1	22.4
Clerical, small bus.	2.5	13.1	19.6	13.1	12.2	11.8
Skilled	3.8	8.9	21.8	34.8	22.8	18.3
Semiskilled, unskilled	2.5	7.2	13.4	26.7	50.0	23.1
Total	100.0	100.0	100.0	100.0	100.0	100.0
	RATIO OF OBSERVED TO EXPECTED FREQUENCIES					
Top prof., business	3.0	0.9	0.8	0.4	0.2	
Semiprof., middle bus.	0.8	2.1	1.2	0.7	0.7	
Clerical, small bus.	0.2	1.1	1.7	1.1	1.0	
Skilled	0.2	0.5	1.2	1.9	1.2	
Semiskilled, unskilled	0.1	0.3	0.6	1.2	2.2	

Table 5.7 on the next page presents a variety of indicators of the asymmetries and symmetries characterizing the reporting of different social relationships.

To bring this idea down to the level of an empirical example, consider my inquiry into the social structure among religious and ethnoreligious groups in Detroit (Laumann, 1973). A central purpose of this research was to adjudicate between three rival hypotheses about how religious affiliation affects the formation and maintenance of friendships within an urban community. The three hypotheses were: (1) that all barriers to intimate social interaction created by religious differences are slowly disappearing, (2) that these barriers still exist but are largely restricted to the major divisions between Jews, Catholics, and Protestants (Herberg, 1955), and (3) that the occurrence of friendships is strongly affected by all religious distinctions, even those among individual Protestant denominations, due to difference in the values (Stark and Glock, 1968) and social composition of their memberships (Niebuhr, 1929; Demerath, 1965).

The data consisted of a probability sample of 1,013 native-born white men between the ages of 21 and 64. Relational data were collected using two different types of survey questions. The first type has subsequently been called name generators; in this case, the specific question asked respondents to enumerate their closest friends (typically three to five persons). The second type is now called name interpreters. These questions ask the respondent to describe each of the alters that he or she has previously enumerated according to various specified criteria, such as their religious affiliations. It is

through comparing respondents' own religious affiliations with the reported affiliations of their friends that I was able to measure the relative probabilities of friendships occurring between the different religious groups. And it is precisely this logic that has enabled me to use survey data from a random sample of respondents to draw inferences about the network structure that exists in a larger population.

TABLE 5.7 *Selected comparative indexes for tables of differential association of different social relationships*

		COMPARATIVE INDEXES			
SOCIAL RELATIONSHIPS	*Table*	*Diagonalization Ratio*	*Product-Moment Correlation*	*Symmetry Ratio*	*Asymmetry Test*
Respondent–all friends	(5.1)	.560	—	2.30	$p<.001$
Respondent–first friend reported		.526	.6190	1.97	$p<.01$
Respondent–father	(5.6)	.498	.5889	0.51	$p<.001$
Respondent–father-in-law	(5.5)	.463	.5345	0.37	$p<.001$
Father–father-in-law	(5.4)	.445	.5245	0.81	ns
Respondent–both neighbors	(5.3)	.423	—	0.69	$p<.001$
Respondent–first neighbor reported		.382	.5290	0.78	ns

A variety of mathematical and statistical techniques can be used to examine the global network structure using this type of relational data. My preferred method has been first to transform the individual-level data into a set of numeric scores, sometimes called proximity estimators, that describe the degree to which the friendship choices of different subgroups, such as those determined by ethnoreligious membership, differ from each other. In this research, we used an index of dissimilarity to compare the percentage distribution (by ethnoreligious group membership) of one group's choices to the distribution of choices made by another group. This index is simply the absolute difference, in percentage terms, divided by 2 between the distributions of the friendship choices made by two groups and may therefore be interpreted as the percentage of either group's choices that would have to be redistributed in order to make the two distributions equal (Duncan and Duncan, 1955). By using multidimensional scaling analysis to model the dissimilarity scores simultaneously, the set of ethnoreligious groups can be located in a three-dimensional Euclidean space according to the relative similarities in their friendship choices, illustrated in Fig 3.3d on the next page. This method revealed that the structure of intimate associations among religious groups had considerable variation, not only between Jews, Catholics, and Protestants but also between individual Protestant denominations and ethnically differentiated Catholics. In addition, one dimension of this structure was strongly correlated (.449) with the median family incomes of each group, suggesting that religious outgroup choice was at least partially structured according to socioeconomic status.

What is important here are not the specific techniques that I used to analyze these data but rather the structure and content of the data themselves, because these dictate the set of research questions to which the approach can be fruitfully applied. For example, the data-collection procedure requires that the analyst already is informed about the specific social distinctions or characteristics that are likely to be important in structuring the social interactions among the population under study. This information can come from explicit hypotheses about the way the population is socially organized, as

in my study of ethnoreligious group structure in Detroit. Information can also come from past research on similar populations or from a qualitative understanding of the population at hand. However, without prior knowledge of the potentially important social distinctions, it is clear that appropriate name interpreter questions cannot be constructed. This means that one cannot use this approach to search blindly for relevant social distinctions from among the myriad possible ones.

The boundary-specification problem

In addition to this practical limitation imposed by the data- collection procedures, there are important theoretical considerations that become transparent during the data collection and analysis but are critical to interpreting the results accurately. These have to do with the way the empirical network is specified, or, more precisely, with how both the population and the types of relations are selected for study. Laumann, Marsden, and Prensky (1983) have labeled this the boundary-specification problem in network analysis and have argued that choosing a study population and selecting specific relationships to measure are highly interdependent processes. The goal is to choose both population boundaries and a set of specific relations so that the relations are of common relevance to the population of actors defined by the boundary specification principle. This criterion of common relevance ensures that the networks of relations among the population can be treated as a relatively closed system, in which the actors are mutually oriented toward each other. My studies of the patterns

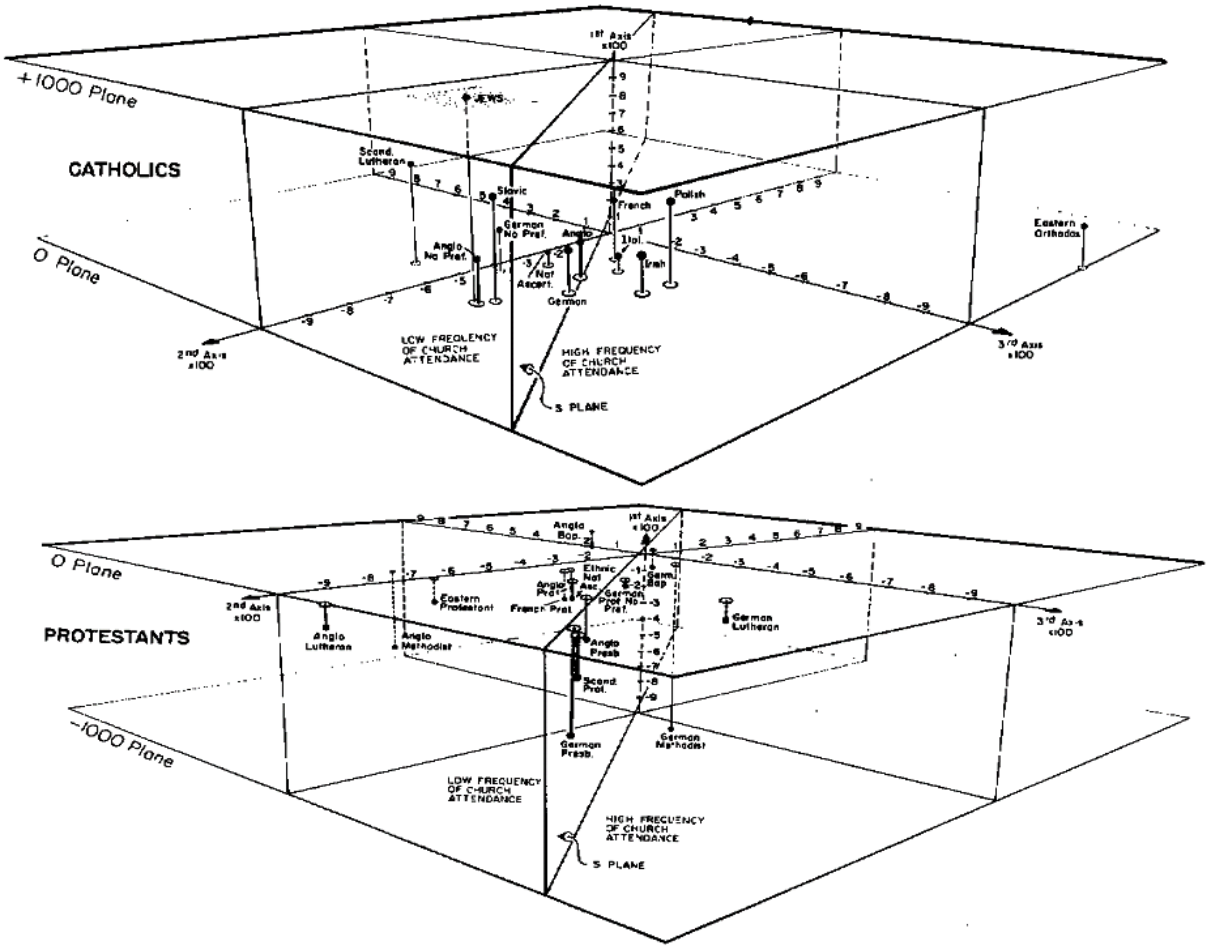


Figure 3.3d Graphic portrayal of the three-dimensional solution, based on the indexes of dissimilarity of friendship choices among 27 ethnoreligious groups. Coefficient of alienation = .132.

Source: Laumann, 1973: 68-9.

of friendship and social distance within urban communities, the patterns of collegial ties within a professional community, and the assortative mating of sex partners meet this criterion. Without this type of specification beforehand, the significance of patterns found in the data are less clear. Moreover, as Laumann, Marsden, and Prensky have noted, failure to specify the network carefully may result in inaccurate and misleading characterizations of the network being studied. (See Laumann and Schumm, 1997 for an extended discussion of the methodological and theoretical issues raised with this strategy.)

Several key substantive assumptions undergird these analyses. First, social differentiation among social positions is likely to be multidimensional in character, rather than simply a unidimensional structure reflecting status distinctions of high, middle, and low. One needs measurement techniques that permit the determination of the dimensionality of the underlying social distinctions animating the social structure. To be sure, if there is only a single dimension distinguishing social positions, the technique should disclose it. Second, the social space within which social positions (status, or social locations) are located is continuous, rather than discrete or discontinuous. Finally, there is a distance-generating postulate among social positions and groups: to wit, similarities in status, attitudes, beliefs and behavior facilitate the formation of intimate (or consensual) relationships among incumbents of these positions. The corollary holds that the more dissimilar two positions are in the status of the incumbents, the less likely the formation of intimate (or consensual) relationships and, consequently, the "farther away" they are from one another in the social structure. (As you will see below, this postulate, first formulated in 1966, describes the key mechanism employed in interpreting the social organization of sexual partner choice in 1994.)

THE SECOND DECADE: Studies of the legal profession and community elites

Let us briefly consider my entry into the study of the legal profession in the mid 70s. In the spring of 1973, I was a very reluctant guest at a slide show depicting the treasures of Chicago architecture that had been designed as a get-acquainted party for newcomers to the faculty at the University of Chicago. The party was taking place in a large, lakefront apartment in Hyde Park. The co-host, a husband who evidently hadn't recalled the event and was just returning from a business trip, came in at the last minute, grabbed a drink and fell into conversation with me (where I was off nursing my own). He asked what I did at the University and I said that I studied elites. We fell into a conversation and soon he asked whether I would come to a dinner meeting at the Chicago Bar Association that was considering what empirical evidence they might need to assist them in reforming the organization of the bar. I had just received a NSF award to study community elites in several Illinois small cities (as a direct follow-up to the study of Altneustadt in West Germany described in Laumann and Pappi, 1976), and said that I really didn't think I had the time available to do it. He said that it would only cost me an evening and I would at least get a free meal. I was finally persuaded to come to the dinner where I met John Heinz, a professor of law at Northwestern University Law School who had been similarly recruited to the dinner. Before it ended, we had formed a strong mutual recognition of our respective professional strengths and began to work together to design a survey instrument for the CBA committee. Thus began a 25-year collaboration that resulted in three major studies of the urban bar, the latest book of which was published in the spring of 2005. The host for that evening, Spencer Kimball, was a professor of law at the University of Chicago and the Director of the American Bar Foundation, which ultimately funded our various studies to the tune of several million dollars. There is no way that I could have plausibly anticipated, let alone, predicted the myriad sequences of opportunities that flowed from this apparently chance encounter.

Postulates of Structural Analysis

It is worth noting that Networks of Collective Action (1976) is one of the two key places (the other is The Organizational State, 1987) in which we attempted to articulate the theoretical agenda motivating all our network analyses. In the introductory chapter, we lay out some essential definitions and then propose several postulates of structural analysis. A social position is a location in social space and is defined with respect to other social positions to which it may or may not be linked. One must maintain an analytic distinction between a social position and its incumbents or occupants that occupy that position. A social structure is defined as a persisting pattern of social relationships among social positions. A social relationship is any direct or indirect linkage between incumbents of different social positions that involves mutual, but not necessarily symmetric, orientations of a positive, neutral, or negative affectual character and/or may involve the exchange of goods, services, commands, or information. The unit of structural analysis is the specific relationship obtaining between any pair of actors, as defined above. The absence of the specified relationship between a pair is as theoretically important as its presence. Three fundamental postulates of structural analysis are the following:

- POSTULATE I (relationship-specific structures):

  > There exists a multiplicity of social structures in any complex social system that arises out of the many possible types of social relationships linking positions to one another.

(Social positions are arranged with respect to one another as a function of the patterns of social relationships directly and indirectly linking them. The reason positions are in close proximity is because they have close links with respect to a given type of social relationship relative to those positions that have less close ties to them. There is no such thing as "the true underlying social structure." Each structure reflects its own logic of social and functional constraint. One could, of course, postulate a theory of structural priority, as the Marxists do when they assert that certain types of relationships are more fundamental (in the sense of formative) than others.)

- POSTULATE II (distance-generating mechanism):

  > For any given relationship-specific structure, there exists a principle of systematic bias in channeling the formation of (or making more likely the) relationship between certain kinds of positions and the avoidance of such relationships between others.

(In other words, relationships among social positions are not formed on a chance basis, but rather in accord with some principle of differentiation among positions. An example of a distance-generating mechanism is the principle of "equal status contact"—the famous homophily principle in network analysis—which breeds liking and mutual attraction among incumbents of similar-status positions. Another example is George Homans' aphorism, "love flees jural authority"—i.e., positions exercising control/power/command over others generate an avoidance of intimate ties with subordinates.)

- POSTULATE III (structural contradictions):

  > Given a plurality of relationship-specific structures predicated on different principles of organization, structural contradictions are possible features of any complex social system.

Observing a negative correlation between two relationship-specific structures denotes a structural contradiction; whereas a positive correlation indicates structural crystallization. Two fundamental implications of structural differentiation of large-scale social systems with regard to integrative problems:

1. Structural differentiation is the basis of the objective differentiation of interests.
2. Structural differentiation is likely to lead to differentiation of evaluative standards (values) in the population because social positions embedded in distinctive, localized communication settings with associated constraints on access to information, experiences, and other resources.

As an empirical example of these principles, we can look at Figure 12.2 depicting the three-dimensional representation of the community-elite interface in Altneustadt (Laumann and Pappi, 1976: 225) Two types of social positions are embedded in this space, members of the community elite (and the relationships they report they have among themselves) and population subgroups (defined by socioeconomic status and religious affiliation (Protestant or Catholic), who have indicated whom they know and trust in the community elite.

THE THIRD DECADE: Organizational networks

Several sets of studies on elite social networks were generalized to a study of national policy domains in Washington, D.C., conducted in 1980, with a focus on health and energy policy. In this case, David Knoke and I shifted focus from individual members of the elite to organizations like the Edison Electric Institute, Mobil Oil, the American Medical Association, the American Hospital Association, etc., and the networks of confidential communication that they maintained in their efforts to

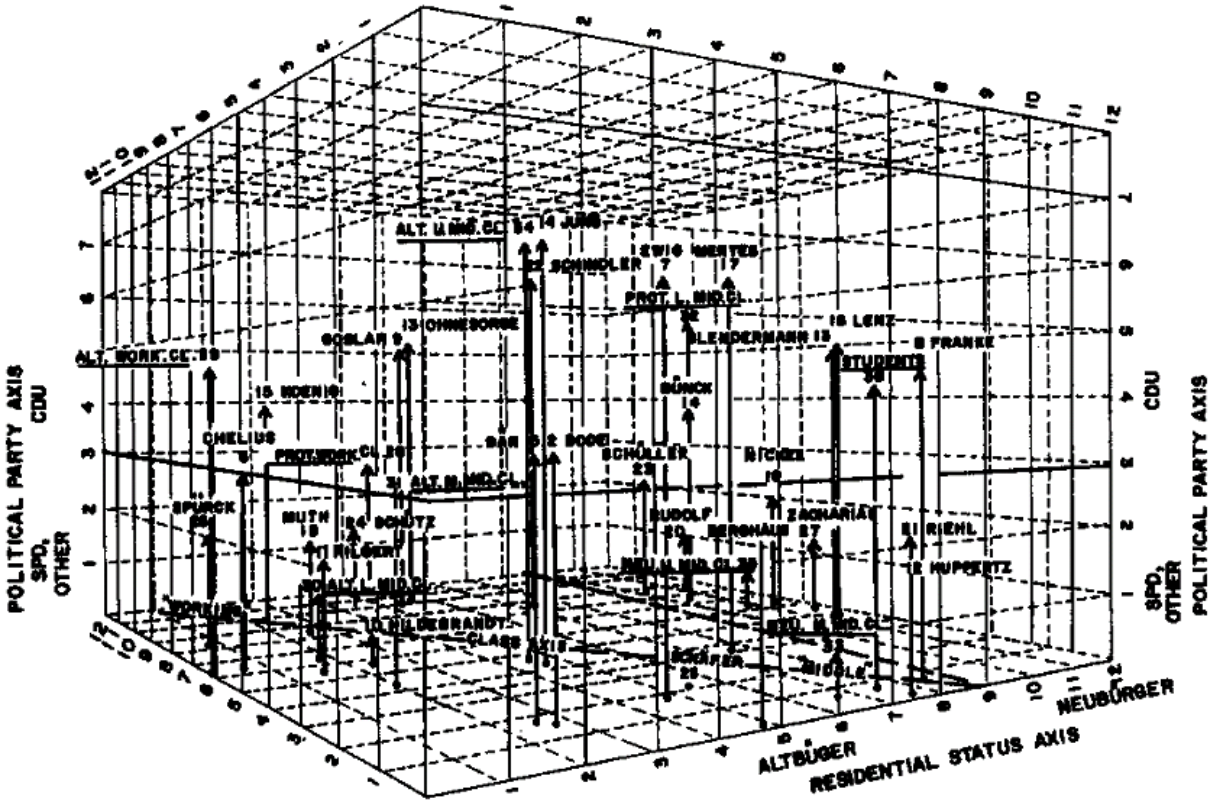


Figure 12.2 Three-dimensional representation of the community–elite interface, based on a monotone distance analysis, partitioned unconditional, coefficient of alienation = .087.

Source: Laumann and Pappi, 1976: 225.

formulate and influence national governmental policy-making in the Congress, executive branch, and judiciary. The study resulted in several major books, The Organizational State (Laumann and Knoke, 1987) and The Hollow Core (Heinz, Laumann, Nelson, and Salisbury, 1993). For the purposes of the next story, it is important to note that these studies involved me in personally conducting extensive interviews with many of the key actors on national health policy. This is the stage setting for the war story I describe below.

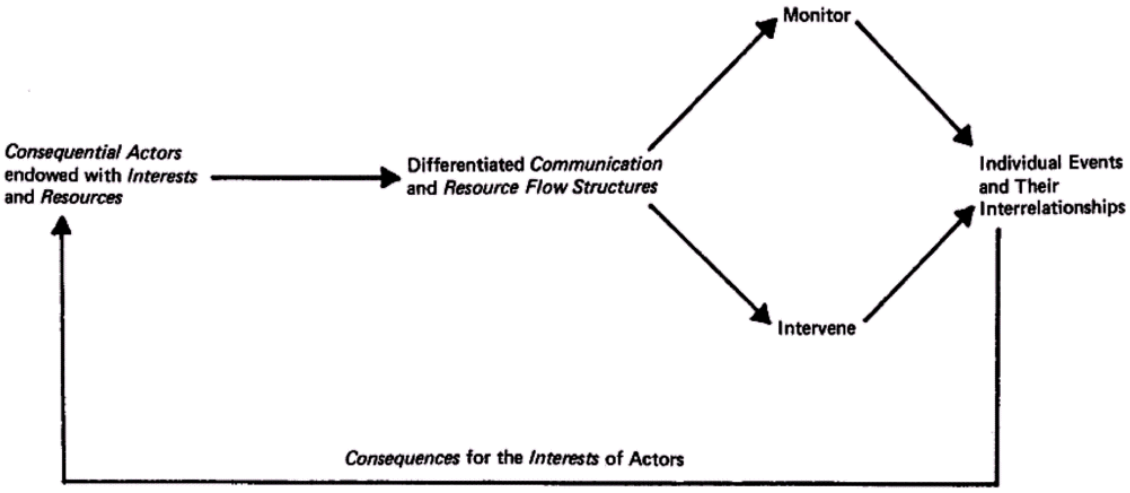


Figure 1.1. The General Model
Source: Laumann and Knoke, 1987: 4.

But first I want to quickly highlight the theoretical development advanced in the first chapter of The Organizational State (Laumann and Knoke, 1987). The main innovation is the systematic introduction of events as an analytic object in developing the notion of the interface between actors and events. Let us first consider the general model used to characterize the social system/environment interface (Figure 1.1). Succinctly put, our orienting framework is a set of consequential corporate actors, each possessing (1) variable interests in a range of issues in a national policy domain and (2) relevant mobilizable resources. These actors are embedded within communication and resource-exchange networks (Granovetter, 1985; Marsden and Laumann, 1977). The flows of specialized communications and resources among the actors enable them to monitor, and to communicate their concerns and intentions in, relevant decis-ion-making events that, in turn, have consequences for their interests. These events, both in themselves, as unique historical occurrences, and in their interrelationships, have critical import for explaining the behavior of individual actors and their interaction.

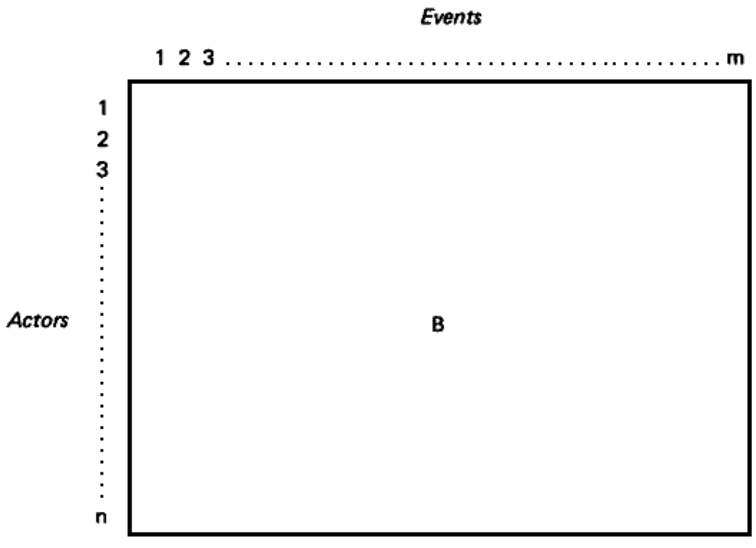


Figure 1.4. The Rectangular Matrix of Actors by Events
Source: Laumann and Knoke, 1987: 26.

To start, we define a rectangular matrix in which the rows are a set of actors (I) and the columns are a set of events (j) in a system of action, as depicted in Figure 1.4. Entries in the cells of the matrix indicate the nature

of the relationship between each actor and event. For example, a 1 might indicate that the actor participated in some way in the event, and a 0, that it did not. The critical question is what is the boundary-specifying principle that defines the set of actors belonging to the joint space of actors/events and what is the boundary-specifying principle that defines the set of events belonging to the joint space of actors/events? There are, of course, a multitude of "valid" framing rules for any given system of action, each of which may treat the set and subsets or rows and columns in fundamentally different ways. Each alternative has profound implications for selecting the method-ology appropriate for empirical analysis.

It is useful to form a triangular matrix out of the rectangular matrix depicted in the figure by taking into account the interrelationships among events and among actors. In Figure 1.5 (p. 28, Organizational State), we have added an events-by-events triangular matrix, A, that refers to the interrelationships among events (m) and an actor-by-actor triangular matrix, C, that defines the (dyadic) interrelationships among the actors (n). The third-dimensional column indicates the absolute properties of events and actors stacked together, which includes variables such as the preferences or amounts of resources of the actor and the public visibility of events. The entries in the matrix itself represent information about the ways actors and events are related to one another in three modalities: within events, within actors, and between actors and events. This is our specification of the individual versus relational level of analysis in a given system of action.

Matrix C is familiar to social network analysts who study links among actors. What is new for us to think about is the event-by-event matrix, which raises all-too-often-neglected questions about the organization of events and the resulting impact of that organization on the actor-event interface, B. This framework is deployed in analyzing the national health and energy policy domains. What we shall now see is how this perspective was translated into a framework for analyzing sexual networks in the adult population of the United States. But first I need to tell you the story of how I got involved in sex studies.

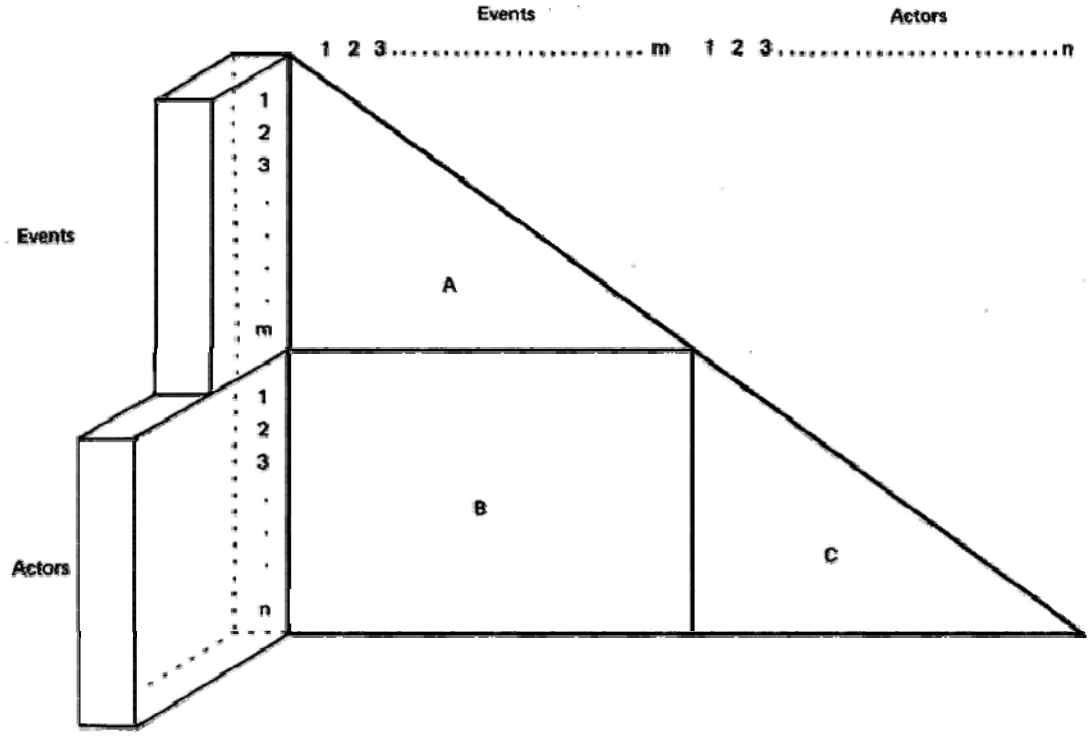


Figure 1.5. A Matrix Representation of the Interface among Events, Actors, and Actors/Events
Source: Laumann and Knoke. 1987: 28.

THE NATIONAL SEX STUDIES

In 1985, I was appointed Dean of the Social Science Division at the University of Chicago. I was interested in encouraging the formation of more social ties across different units of the University, and particularly the medical school. Dr. Mark Siegler, then and now director of the top-ranked Clinical Medical Ethics program in the country and my regular squash partner, began to discuss the planning for a year-long workshop on "AIDS and Society" that would bring together the faculties in the social sciences and the medical school to discuss the diverse challenges arising from an epidemic that was at the time doubling every 10 months. In the course of this riveting series of presentations, I became convinced that there was not going to be a magic bullet that would stop the spread of the epidemic through immunization—the answer appeared to lie in behavioral interventions and here we lacked critical information on the sexual practices of the population at large that were placing us all in jeopardy. Robert Michael, an economic demographer and director of NORC at the time, and I began to talk and soon concluded that Chicago should undertake another Manhattan Project which would pool our strengths in survey and sample design at NORC to mount a national survey of sexual practices. Having been editor of the AJS, I had been at the intersection of professional communication networks about all sorts of topics and had acquired knowledge of large numbers of professional colleagues scattered throughout the U.S. Tapping these widely ramifying networks quickly helped me identify the key researchers in sexuality and assess their potential for collaborative work. This is a field that mainstream researchers have avoided because of the disrepute and social disapproval of such topics in "legitimate" social scientific circles. I quickly identified John Gagnon, a Ph.D. sociologist from the U of C and one of the most prominent and respected sexologists in the country, and arranged to meet him and recruit him to our research team. We then responded to a call issued by the NICHD (NIH) for research proposals to design the national sex survey. In winning the competition, with the invaluable assistance of Martina Morris, we proposed a research strategy and survey instrument that was designed to comprehensively inquire about people's sexual behavior and the sexual networks in which it was expressed in all their complexity.

The OMB fiasco

Because of certain technicalities in issuing the award as a contract rather than a scientific grant, the Office of Management and the Budget (OMB), a key bureau in the Office of the White House, had formal responsibility for approving the use of the interview instrument. By this point (1988), it was widely recognized in the scientific and medical community that such a survey was a necessity if we were going to be able to design effective public interventions in persuading people to take appropriate defensive measures to assist in containing the spread of the disease. But the survey was going to be controversial. Right-wing religious groups had from the days of the Kinsey Reports (1948, 1953) in the late 40s and early 50s strenuously objected to such inquiries because, in their view, sex reports had the manifest effect of naturalizing or normalizing immoral sexual behavior, such as masturbation, anal and oral sex, premarital and extramarital sex. Moreover, the government had no business in invading people's private lives, even if it were ostensibly for reasons of the public's health.

Science magazine reported in late January 1989 that the national sex survey was under review at OMB, and we could look forward to having the much-needed data soon. Someone in the copy-editing department at Science chose, quite incredibly, to illustrate the news story with the picture from the 1970 cult film, Bob and Carol and Ted and Alice, ostensibly about married couples' mate swapping. The Washington Times, a conservative newspaper, picked the story up with screaming headlines, and within a few days, there was a 17-page White Paper prepared by Representative William Dannemeyer (Orange County, CA) circulated to every member of the House and Senate decrying the study, accusing Michael and me of being mere figureheads and fronts for a cabal of homophiles (Gagnon and

Michaels) who were attempting to legitimate the extensiveness of gay sex in the nation. Thus began an annual cycle of House and Senate Appropriation committees recommending support (Senate) or not (House) for the national survey. Since the joint conference committee on appropriations could not agree, funding for the study was deferred each year. I suddenly thought of myself as a playwright who had stumbled into his own play (rather like Luigi Pirandello's famous play of the late 1920s "Six characters in search of an author"). All the tactics of strategic networking that I had talked about in The Hollow Core and The Organizational State were to be fully deployed in the years ahead.

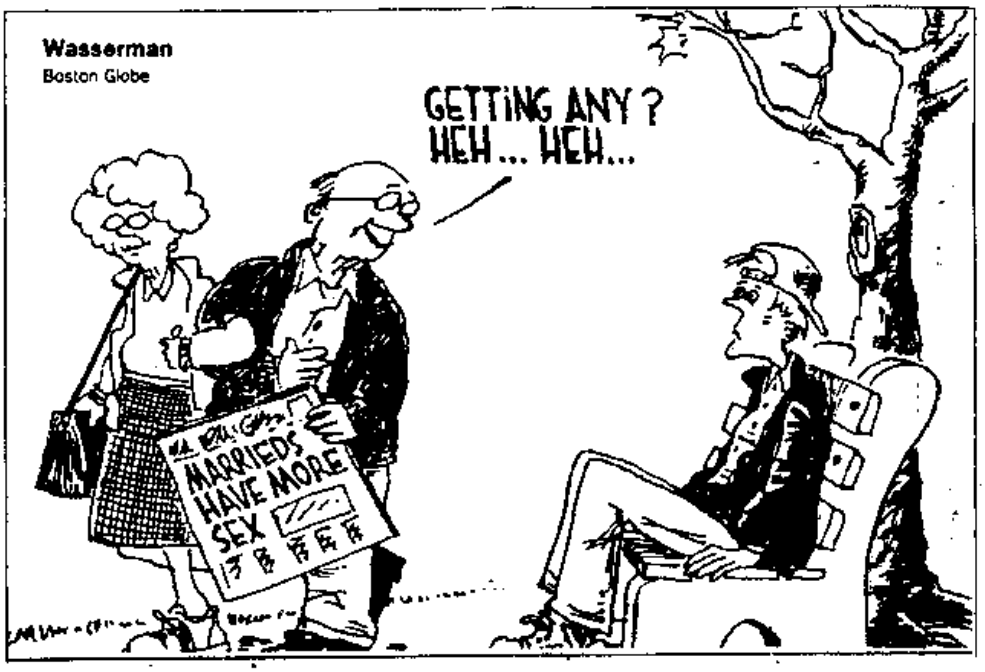
It was imperative that we mobilize Congressional support for the initiative. I remembered that my close friend, regular squash partner, and colleague, James S. Coleman, one of the University's distinguished University Professors, had close ties to the Democratic Senator from New York, Daniel Patrick Moynihan, just recently deceased, who was Chair of one of the key appropriation committees concerned with welfare and education. The Senate at the time was under Democratic control and thus had some leverage with the White House and Executive Branch. Jim effected an introduction and we three principals of the study flew to Washington to meet Moynihan in the summer of 1989. On entering the office, I was ushered to a leather wing-backed chair, next to which was a full-size papier mache statue of John Hancock standing with quill pen in hand about to make a key point during the deliberations about the Declaration of Independence. He hovered over my right shoulder throughout the conversation, looming over me as a most disconcerting presence. The Senator and three or four of his key staff members, were arrayed on one side of a room furnished to look like a Harvard faculty office (which Moynihan had once been). I was asked at the outset why we had come, and I was a bit taken aback since we had told his Chief of Staff what we wanted and were hoping for a quick "in and out" visit. Thus began a hour-long conversation jumping with no apparent rhyme or reason across a wide range of topics, few having anything much to do with our quest, and including the Senator's touching story about visiting a hospital in a poor section of New York and being told that he should not handle a low-birth weight baby who was dying of AIDS for fear of contracting the fatal illness. At one point he glanced at the boots John Gagnon was wearing and said, "Oh, you must be the Devil Incarnate." It was Gagnon who had been especially pilloried for his unacceptable political views by the religious right (among his sins, he had served as a faculty advisor to a college group which had some 20 years before advocated the legalization of marijuana). All of us had been subjected to a detailed investigation of our political affiliations and activities. At the conclusion of this remarkable, and I can only say, bizarre encounter, the Senator instructed his Chief of Staff to assist us in making connections on the Hill and to keep him informed of developments. Gagnon remarked once we were outside that now we knew what it meant to "rock and roll with the stars." As follow-up, I returned to Washington a number of times to meet various congressional staffers, Senators, and Representatives to urge their support for funding the study. In these ventures, Bill Bailey, the chief lobbyist for the American Psychological Association who was especially well connected on the Hill, usually accompanied me and coached me on what to say to various target officials. I knew that Bill was dying of AIDS, but it was his wish (expressed through third parties) not to have this acknowledged in any way. He knew that I knew and I knew that he knew that I knew, but we could not reveal this mutual knowledge in any way. One day he took me on a particularly grueling trip to visit a number of people in the old Senate Office Building, with seemingly endless corridors that separate the clusters of offices associated with each Senator. We literally raced from one appointment to an other, as scheduling was of the essence in meeting all the critical people involved in an upcoming vote. Though he looked more emaciated than I had seen him in some time, neither of us could make a move to make the effort less strenuous, or even to excuse him from accompanying me. He felt it was crucial that he be there to provide suitable guidance to help garner the support we so desperately needed. Two weeks later he died of complications from a rare form of pneumonia that characteristically afflicted persons infected with HIV.

In September 1991, two years after these lobbying efforts had been pursued without much result, Senator Jesse Helms submitted an amendment to an appropriations bill that effectively transferred the funding intended for the national sex survey to a "say no to sex" campaign. I thus have the dubious distinction of having an act of Congress passed to stop my research (the Senate voted 66 to 34 in favor of the amendment). Of course, this was what we had been hoping for—the demonstration that the Congress was incapable of supporting the necessary research initiative to fund the survey. We immediately went to the private foundations, notably the Robert Wood Johnson Foundation, Henry Kaiser, Ford, Rockefeller, and McArthur, to get funding for the survey at a much-diminished level and we were in the field in February 1992. A particularly important consequence of the private funding was that we could revert to our original survey instrument. In the effort to make it more palatable to unspecified opponents, we had gutted the study by dropping many questions about sex that would prove to be its most important and useful lines of inquiry. We decided to get the results out as soon as possible—that is, no later than the fall of 1994-- and to make them accessible to the public as well as to the research community. To this end, we arranged for Gina Kolata, a New York Times reporter who specializes in covering science and health news stories, to write in collaboration with us a companion volume, Sex in America (1994), for the lay world as we prepared the more technical volume, The Social Organization of Sexuality (1994). Here we began to transgress yet another boundary of academic community discourse that sharply demarcates "real academic scholarship" intended for scholarly peers from publications intended to attract widespread popular attention. We felt strongly that the public needed to be fully informed about what we had discovered and we wanted to have a hand in framing the public's understanding rather than leaving it to others to do so, and with what distortions and misdirection we didn't want to contemplate.

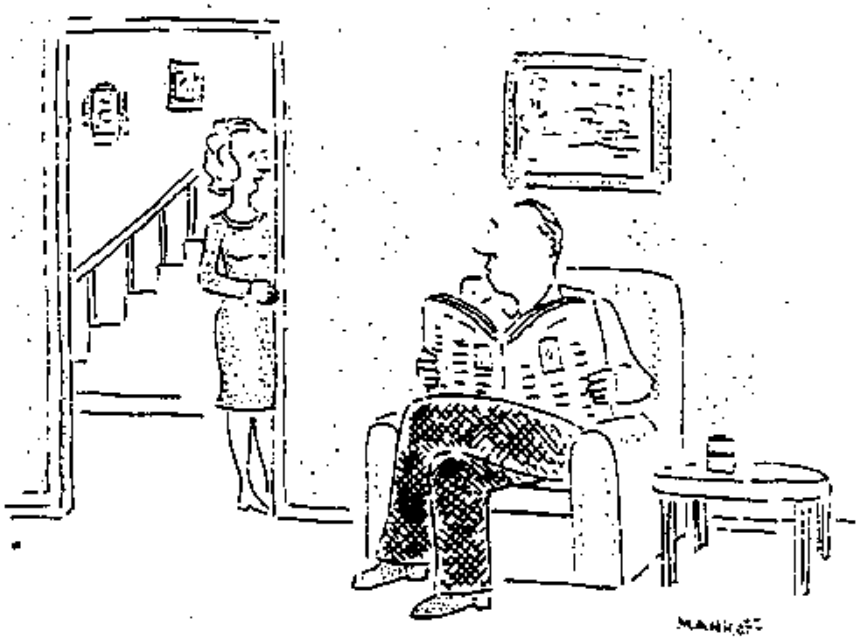
In the light of the prolonged political struggles over funding the study, the Ford Foundation became convinced that we needed to prepare ourselves for a hostile reception and thus provided funding to have us all receive professional media training. We were all taken to New York for a weekend of intensive training at a large TV studio so that we could cope with "attack" journalists on television and radio who might want to disrupt or distort our message. An attack journalist interviewed each of us on camera in supervised practice sessions and the video was then played back with professional coaches pointing out our weaknesses in response and the tactics we needed to use in order to take charge under these circumstances.

The public release of the books involved months of planning and preparation, with an elaborate collaboration among the news organizations of the University and our two publishers, an academic press and a commercial press. Great care was expended in devising news releases that would effectively channel the media take on the findings—that is, we were learning to be spin-doctors. I discovered that there are four independent editorial departments in most major metropolitan papers, the front page, the editorial page, the book review section, and the tempo/ lifestyle/women's/health section. In the rollout of the campaign, each of these departments were independently targeted and we counted ourselves successful if we got stories placed in all four sections, even if not on the same day! Here is a sampling of the media response to the release of Sex in America and The Social Organization of Sexuality on October 12, 1994 — newspaper headlines, cartoons. During the course of the following week, we were covered in over 300 metropolitan newspapers across the country, made the cover of TIME magazine, and were lead articles in many other magazines. Notice that we were successful in pitching the story as "sexual practices in the U.S. are not 'kinky'" — partially in the hope of knocking the wind out of the sails of the right-wing opposition who were convinced that our agenda was to spread liberated and pleasure-seeking sex to the masses. That is, as one critic remarked in the New Yorker magazine, Laumann and his colleagues' discourse on human sexuality is "sperm-ingly chilling." Only at Chicago could we have so thoroughly managed to take the fun out of sex.

Chicago Tribune, Saturday, October 22, 1994 Section 1 27



THE NEW YORKER, OCTOBER 24, 1994



"Hi. You've been randomly selected to participate in a sex survey upstairs in fifteen minutes."

Chicago Tribune
Thursday, October 6, 1994

Sex study shatters kinky assumptions

By Peter Gorner
Tribune Staff Writer

DAILY NEWS EXCLUSIVE

DAILY NEWS • Thursday, October 6, 1994

Marrieds do it more

New sex study reveals Americans' co-habits

WASHINGTON POST
OCTOBER 7, 1994

Survey Finds Most Adults Sexually Staid

Americans' Average Is Once Per Week

By Barbara Vobejda
Washington Post Staff Writer

THE MOST COMPREHENSIVE, REVEALING REPORT ON OUR SEXUAL BEHAVIOR TODAY AND ITS SURPRISING IMPLICATIONS

SEX in America

A DEFINITIVE SURVEY

ROBERT T. MICHAEL, JOHN H. GAGNON, EDWARD O. LAUMANN, AND GINA KOLATA

VER of new sex study.

DAVE SALTONSTALL
News Staff Writer

In preparing for the media event for the release of the two books, we briefed many organizations and professionals who could serve as outside commentators on the merits of the work. This is called "salting." Included in the briefings was a daylong presentation at the National Institutes of Health, which readily embraced the work as their own. We had assumed that they would notify other interested parties in their umbrella organization, including the Centers for Disease Control (CDC) in Atlanta. But organizational politics interfered with the communication link and the chief spokesperson at the Centers for Disease Control for the AIDS effort, was suddenly confronted in his regular Monday morning press briefing with a host of questions from journalists talking about the Sunday media blitz on our study. I had asked one of his staff (lately of the National Center for Health Statistics which has just been amalgamated into the CDC), a sociologist, to have the NCHS do a critical read of our chapter on sexually transmitted diseases. They gave us very helpful feedback and were generally very supportive of the line our analysis had taken. The spokesperson had been heard to remark on his way to the podium that "The Chicago study had more findings than they had respondents." After the press conference, he convened his staff and ordered them to prepare a press release condemning the study as just "another untrustworthy sex report." One of the persons assigned to the task was my contact in the NCHS, who called me to tell me of this development. I told him that he should inform his boss that if they chose to "rain on our parade," I would use the microphone in hand from the vast amount of media attention directed toward our study to do battle with them on some issues we had chosen not to feature in the press release. Moreover, I pointed out that we would win that war because of the unique data of high quality we had in hand. The CDC press release came out muttering that they welcomed any new information to help them in the war on AIDS and promptly dropped the matter.

Now what was this contretemps really all about? Relying on the network data we had on the patterns of sexual partnering across population subgroups, we had concluded that there was literally no possibility of an AIDS epidemic in the heterosexual population of the United States, as it was then

making its devastating progress in the "homosexual" subpopulation. But this flew in the face of an emerging mantra of the CDC and the AIDS-prevention community that "everyone was at risk for HIV." This position had been developed as a political tactic in the public health community to mobilize broad public support for AIDS intervention efforts. Acknowledging the need to get more government funding behind the AIDS prevention effort, we had "buried" our discussion in the middle chapters of The Social Organization of Sexuality, which analyzed sexual networks and the epidemiology of sexually transmitted infections. Before our study, it was most certainly reasonable to have made such claims due to the lack of comprehensive, reliable empirical data to indicate anything to the contrary. Let us now turn to a brief consideration of the pertinent data.

THE FOURTH DECADE: Further developments of research on sexual matters

The fruition of the theoretical strategies developed in the 1970s and 1980s may be seen in the following schematic outline of the model of sexual exchange, which organized The Social Organization of Sexuality (1994). The National Health and Social Life Survey of the adult population aged 18 to 60 (N = 3,169) was a remarkably successful national probability-sample survey which achieved nearly an 80 percent completion rate. It was a ninety-minute private, in-person interview in the home. Careful examination of the data suggests that sampling biases were minimal and that we were successful in eliciting high levels of candor from our respondents. A central thrust of the analysis was to demonstrate the extent of status homophily on sexual partner choice, and the substantively critical but unexpected finding that one-night stands are almost as homophilous as marriages. Note here that we are following our dictum that we need to explore the differing social and functional logics that power the mechanisms generating ties in different relational settings. A common intuition would have it that one-night stands involve strangers, by definition, and that such pairings should be much more apt to cross social barriers than pairings leading to marriage. This does not appear to be the case. It is also worth noting how high the levels of homophilous choice are. This relates to my early work talking about "social entitivity", or the variable tendency to self-target on a particular status attribute, denoting then the variable degree to which status groups are separated from one another by in-group preferences.

Table 6.4 **Percentage Homophilous, by Relationship Type: Percentage Distributions (includes only those marriages and cohabitational relationships that began during the past ten years)**

	Type of Relationship			
Type of Homophily	Marriages	Cohabitations	Long-Term Partnerships	Short-Term Partnerships
Racial/ethnic	93[a]	88	89	91
Age[b]	78	75	76	83
Educational[c]	82	87	83	87
Religious[d]	72	53	56	60

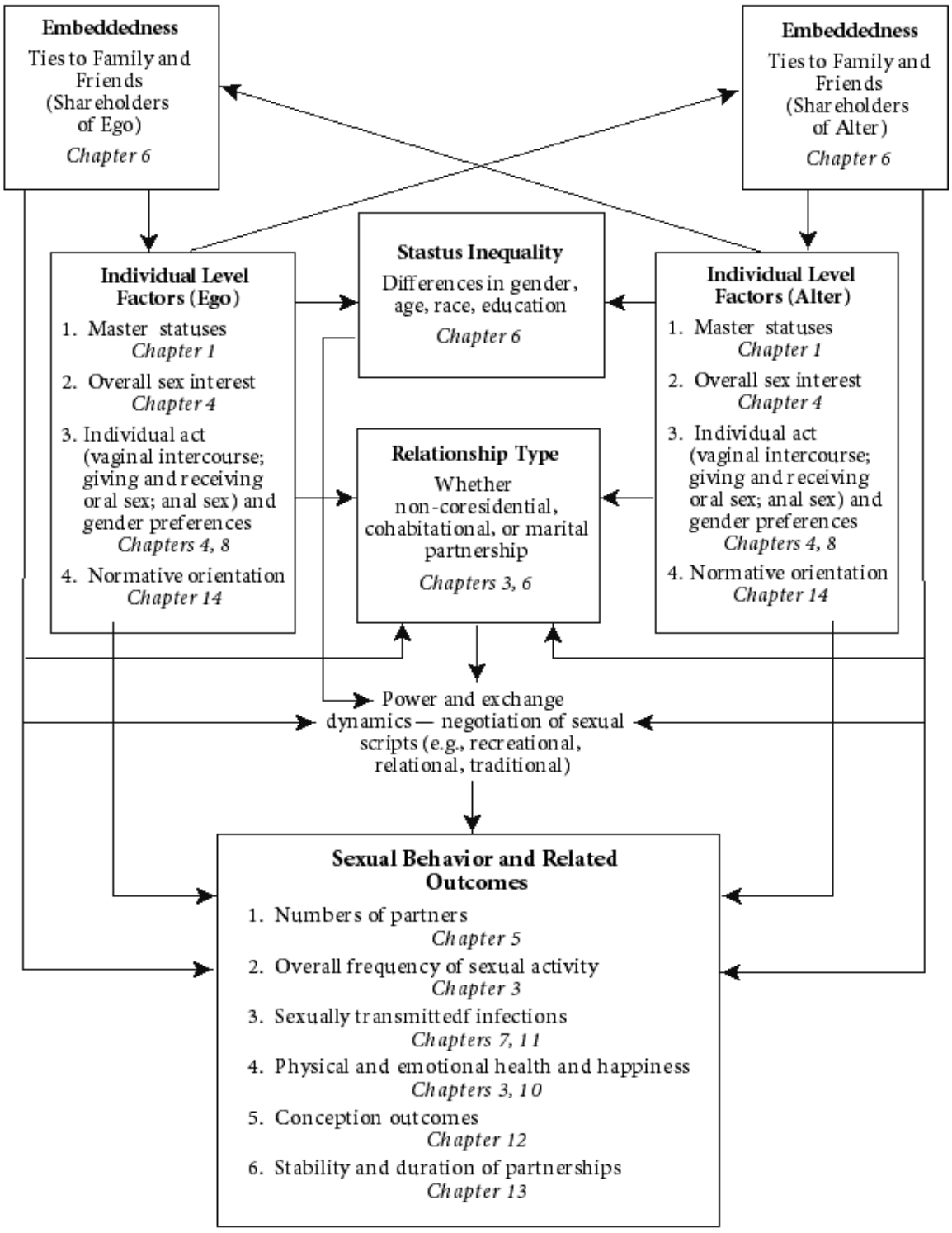
[a]Indicates weighted percentage of marriages that began within the past ten years and involved two people of the same race/ethnicity. Cases in which either partner was reported as Native American or "other" or had missing data are omitted.

[b]Age homophily is defined as a difference of no more than five years between partners' ages.

[c]Educational homophily is defined as a difference of no more than one educational category. The categories used were: less than high school, high school graduate, vocational training, four-year college, and graduate degree.

[d]Cases in which either partner was reported as "other" or had missing data are omitted.

Another important feature of sexual partner choice is that there are quite modest accumulations of partners over the lifetime in the United States: the median is 2 for women and 6 for men, according to the NHSLS. This table is the sociomatrix that I sought to estimate when I first began planning for the NHSLS. It has the same format that I used in 1966 when describing friendship choices by occupational status. Now there are many important methodological and technical issues which impose



A schematic outline of the model of sexual exchange

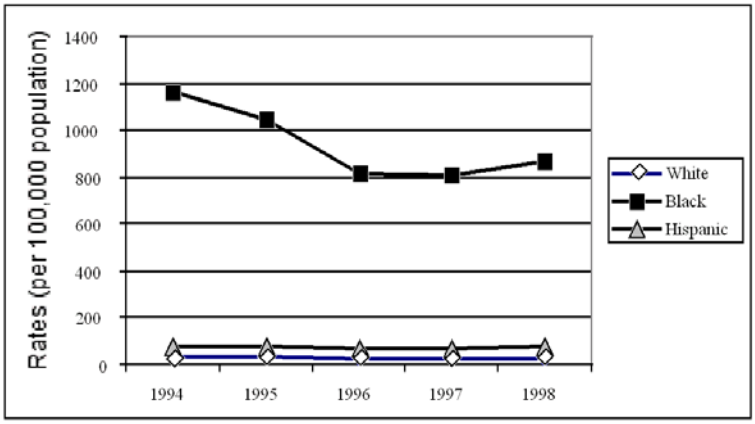
significant limitations and qualifications on how one can analyze and interpret these sorts of matrices, but for present purposes, we need only note the many empty cells in which there are no observed sexual partnerships between the two status-defined categories. In short, the U.S. adult population does not constitute a random mixing pool but a highly discontinuous set of status groupings with only the most limited, indirect sexual access to one another. Since the bridging population that has sex on several discrete, socially defined islands is extremely rare and would have, in addition, to be infected with HIV to act as a vector of infection across subpopulations, transmission dynamics are effectively stalled in their tracks. Since HIV infected persons are predominantly homosexual and bisexuality is quite rare, the principal avenue by which the infection could move into the heterosexual population is very limited. When you add to this the fact that HIV is difficult to transmit (not like gonorrhea which has an infectivity of 50/50 for each unprotected sexual encounter), you can see how we came to the conclusion we did.

Network thinking has inspired a paradigm shift in the field of sexually transmitted infections (Aral, 1999). Youm and I (Laumann and Youm, 1999) were intrigued with the observation that African Americans had 20 to 30 times higher prevalence of gonorrhea and syphilis than whites and Hispanics have. In trying to explain these discrepancies, we came to a network explanation. It is well known that in large randomly mixing populations, STDs would disappear in a few generations.

Table 7.1 **Race, Age, and Gender of Respondents and Their Sex Partners (row percentages), Nonmarital Partnerships Only (oversample included)**

	Partners																		
	White						Black						Hispanic						
	< 30		30–44		45+		< 30		30–44		45+		< 30		30–44		45+		
Respondents	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	*N*
White																			
18–29:																			
Male	2.4	79.9	1.3	10.1	. . .	. . .	.2	.2	. . .	.4	. . .	. . .	.2	1.8	. . .	. . .	. . .	. . .	552
Female	69.1	1.8	15.1	1.0	1.0	. . .	4.1	. . .	.8	. . .	. . .	. . .	3.1	. . .	1.3	. . .	. . .	. . .	392
30–44:																			
Male	1.9	21.5	4.9	60.6	1.2	3.7	. . .	.2	. . .	.5	. . .	. . .	. . .	.9	.4	1.2	.2	. . .	571
Female	7.8	1.2	60.5	4.2	15.7	. . .	.7	. . .	2.9	. . .	1.0	.2	. . .	.2	2.5	. .	.2	. . .	408
45–59:																			
Male	.7	.7	3.4	40.9	.7	46.3	. . .	. . .	. .	. . .	. . .	. . .	. . .	. . .	. . .	1.3	. . .	1.3	149
Female	. . .	. . .	21.9	1.6	64.8	4.7	.8	. . .	.8	. . .	3.1	. . .	. . .	. . .	. . .	.8	.8	. . .	128
Black																			
18–29:																			
Male	. . .	7.5	. . .	1.2	. . .	. . .	.6	77.5	. . .	5.8	. . .	. . .	. . .	5.2	. . .	.6	. . .	. . .	173
Female	. . .	. . .	.7	. . .	. . .	. . .	68.5	. . .	25.3	. . .	.7	. . .	3.4	. . .	. . .	. . .	. . .	. . .	146
30–44:																			
Male	.5	1.4	1.0	6.7	. . .	2.9	.5	14.9	2.4	51.0	. . .	5.8	. . .	1.9	. . .	2.4	. . .	.5	208
Female	. . .	. . .	1.4	. . .	.9	. . .	5.2	. . .	70.3	10 8	9.9	.9	. . .	. . .	.5	. . .	. . .	. . .	212
45–59:																			
Male	. . .	. . .	. . .	1.7	. . .	. . .	. . .	. . .	. . .	31.7	. . .	63.3	. . .	. . .	. . .	1.7	. . .	. . .	60
Female	. . .	. . .	. . .	. . .	. . .	. . .	1.8	. . .	19.3	. . .	71.9	3.5	. . .	. . .	. . .	. . .	3.5	. . .	57
Hispanic																			
18–29:																			
Male	3.7	31.7	2.4	4.9	. . .	2.4	1.2	1.2	. . .	. . .	. . .	. . .	. . .	31.7	. . .	4.9	. . .	. . .	82
Female	16.4	. . .	3.0	. . .	. . .	. . .	16.4	. . .	1.5	. . .	. . .	. . .	46.3	1.5	11.9	1.5	. . .	. . .	67
30–44:																			
Male	. . .	13.6	7.6	27.3	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.5	10.6	. . .	28.8	. . .	4.5	66
Female	4.5	. . .	23.9	. . .	7.5	1.5	. . .	. . .	. . .	. . .	. . .	. . .	6.0	. . .	34.3	1.5	16.4	. . .	67
45–59:																			
Male	. . .	. . .	. . .	21.1	. . .	15.8	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	31.6	. . .	15.8	19
Female	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	100	. . .	. . .	. . .	2

Note: Percentages may not add to 100 percent owing to partners whose racial/ethnic background was not among those listed here (these cases are included in the row totals). ". . ." indicates fewer than thirty cases.



Rates of gonorrhea by race and ethnicity, United States, 1994-98
Source: CDC 1998, Section 12, Table 12B
Note: Georgia did not report gonorrhea statistics in 1994

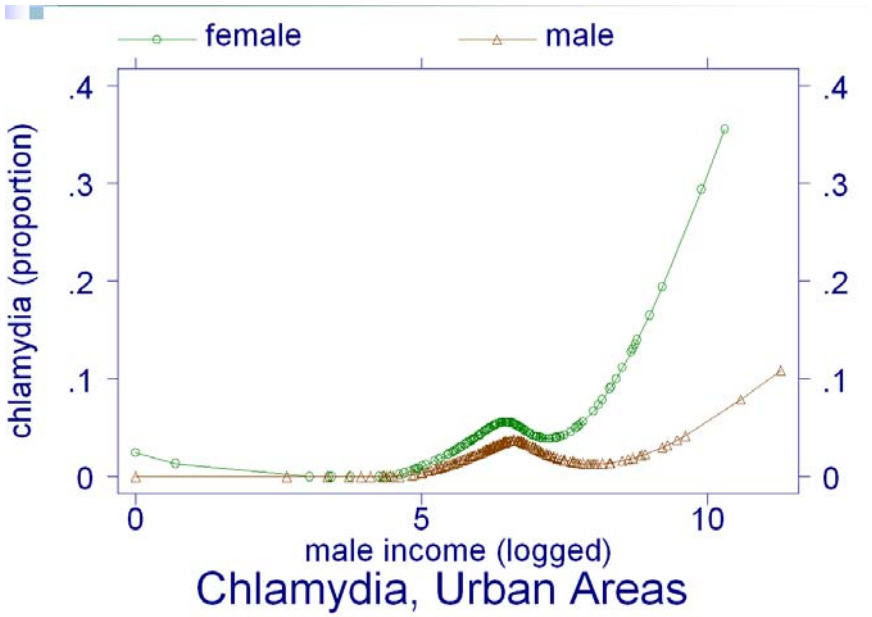
They are hypothesized to persist due to the presence of core groups, which are small groups of individuals (often running around 3 to 5 % of the total population) who have many sex partners in a short period of time, say a year, and who tend to confine their partner choices to other core group members. The NHSLS afforded the first opportunity to identify core group (4 or more partners a year), adjacent (2 or 3 partners a year), and peripheral group members (one or no partner a year). In this table, we observe the strong tendency to confine partner choice on the main diagonal. What is of special interest is the tendency to become more racially exclusive as one moves from peripheral to adjacent to core group status. In short, there is a much greater likelihood of a peripheral white to have a peripheral African American partner than for a member of the African American core group to have a partner who is a member of the white core. Thus, because African Americans for some historical reason were seeded with gonorrhea or syphilis, these infections are more or less confined to African Americans relative to the whites because there are no infected bridges between the two racial groups. We have thus constructed an exclusively sociological account for the differential distribution of selected diseases.

Table 9.3 Contact Matrix (Number of Partnerships for the Last Twelve Months)

	WP	WA	WC	AP	AA	AC	HP	HA	HC
WP	1,463.02								
WA	78.44	199.99							
WC	37.39	160.65	175.98						
AP	12.25	1.53	.86	172.16					
AA	.48	3.01	2.16	18.93	67.02				
AC	1.19	5.61	3.91	16.64	59.88	44.93			
HP	33.75	1.91	2.07	2.24	.39	.93	82.32		
HA	3.96	4.75	8.25	.14	1.00	3.66	4.86	9.67	
HC	.29	4.73	7.79	.23	2.59	4.32	3.14	13.80	10.41

Note: This table shows the estimated number of partnerships between persons in row (chooser) and column (chosen) groups, calculated according to the procedures described in app. 9.A. Since the estimated number of contacts for an ordered row/column combination is the same as for its reversed order, the matrix is symmetrical, and the upper-right-hand entries can thus be omitted to avoid redundancy.
WP = white periphery, WA = white adjacent, WC = white core, AP = African American periphery, AA = African American adjacent, AC = African American core, HP = Hispanic periphery, HA = Hispanic adjacent, HC = Hispanic core.

Another example of the powerful explanations afforded by network approaches is provided in a study of sexually transmitted diseases in China. Parish and I with a Chinese co-Principal Investigator, Professor Pan Suiming (2003), conducted a national area probability-survey of China (N = 3,828). China Family Health Survey) ironically funded by the NICHD, which had not been permitted to fund the U.S. survey, the NHSLS in 1991. There is a new wrinkle added—a collection of urine samples, biomarkers, so that we could test for the presence of several sexually transmitted diseases. Noteworthy here was the opportunity to test for an STI, Chlamydia, which is asymptomatic in 90% of the cases so that one cannot rely on self-report to tract the prevalence of the infection. The Chinese public health authorities are convinced the principal vector for the rapidly rising levels of STIs are the migrants from the countryside to the cities.



Our sample tells a very different story. First, it is true that Chlamydia prevalence approximates 9% of the female population in the south coastal region (where the principal take-off of the Chinese economic miracle occurred). Again ironically, the US at the time had no nation-wide data on Chlamydia prevalence, only some scattered city data with which to make a cross-national comparison. Second, we found that the highest risk for infection for women was being married to a man in the top quintile of the income distribution. In this subpopulation upwards to 30 percent of the men have sex with commercial sex workers (CSW), get infected, and then infect their wives (85% of women have only one lifetime sex partner). (For comparison purposes, somewhat less than 1 percent of U.S. men had sex with a paid partner last year.) Thus, we are observing a two-step transmission chain, from CSW to john to wife, which also allows us to delineate quite precisely the contours of its spread and the limited extent to which the population at large is at risk. One important public health intervention message is that one should go to airports rather than bus stops to get the message out about safe sex practices.

Four years ago, two physicians, Stacy Lindau and Wendy Levinson, Linda Waite, a demographer colleague in the Department, and I began a collaboration to design a national longitudinal survey of women and men aged 55 to 85 focusing on the interrelations among aging, selected health statuses, and social networks (including sexual partnerships). An innovative piece of the enterprise was to include a half-hour collection of biomarkers (including blood, Body Mass Index measurements, sensory function, vaginal swabs, urine and salivary samples) together with a two-hour, in-person

interview from a sample of 3,004 drawn from the sampling frame for the National Retirement and Employment Survey. The theoretical framework, the Interactive Biopsychosocial Model (IBM), was laid out in an article published in Perspectives in Biology and Medicine (Lindau, Laumann, Levinson, and Waite, 2003). It focuses particular attention on the role of social networks in fostering, maintaining, or compromising health over the aging process. We have just left the field, having achieved a sample target, with a completion rate of 74.5 percent. This will be the capstone for my research enterprise.

CONCLUDING REMARKS

I have many more war stories of more recent vintage, but I am sure that your patience has been thoroughly exhausted and the point I have been trying to make should now be clear. To wit, academic knowledge can and will command public attention from the most diverse of audiences. It is never neutral nor does it speak with only one self-evident meaning. It inevitably plays a political role, supporting some stakeholders' preferences and denigrating others. The notion that you should leave it to others to offer interpretations of what you have learned from scholarly inquiry is a serious mistake. One must take responsibility for what one discovers and must concern oneself with how it will be diversely understood. It does expose oneself to some potentially painful experiences, but it can also be fun and exhilarating.

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