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POETICS

Poetics 28 (2001) 307–329

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Douglas D. Heckathorn[a], Joan Jeffri[b,*]

[a] *Department of Sociology, Cornell University, Ithaca, NY 14853, USA*
[b] *Program in Arts Administration, Teachers College Columbia University, 525 W.120th Street, Box 78, New York, NY 10027, USA*

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POETICS

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Abstract

This paper describes the use of respondent-driven sampling (RDS) to identify and survey jazz musicians in four U.S. cities – Detroit, New Orleans, New York and San Francisco. RDS has been used previously to sample injection drug users as part of a study of HIV prevention education and services. Through a mechanism of long referral chains and modest incentives, RDS will help to identify the social structure of the jazz musicians' community in the four study cities and their patterns of affiliation. It will also help to document everyday practice and to identify areas of greatest need for living jazz musicians.

"All art is only done by the individual."
Ernest Hemingway

1. Introduction

A traditional problem in identifying artists in surveys independent of the census is the assumption that artists who are located through institutions are representative of the universe of artists – a sociologist's challenge, an economist's nightmare and an

☆ The original research for Respondent-driven Sampling was made possible by grants from the Centers for Disease Control and Prevention (U62/CCU114816-01) and the National Institute on Drug Abuse (RO1 DA08014). The current research on jazz musicians is made possible by the National Endowment for the Arts under a cooperative agreement with the San Francisco Study Center, with additional support from the Lucille Packard Foundation and the Louisiana Jazz and Heritage Foundation.

* E-mail: ddh22@cornell.edu; jj64@columbia.edu

0304-422X/01/$ – see front matter
PII: S0304-433X(00)00031-0

arts administrator's reality. The challenge becomes even greater when faced with artists who do not join institutions, or who join only institutions unrelated to the arts – community groups, religious organizations, civic clubs. Investigators who have undertaken surveys based on information culled from membership lists and other organizational documents have gathered important and valuable information (Jeffri, 1989; Jeffri et al., 1990a,b,c; Jeffri and Greenblatt, 1998; Throsby, 1983; Throsby and Mills, 1989; Wassall and Alper, 1983 among others). But they have also clearly understood the limitations of such approaches to identifying samples and have sought ways to learn more about the networks to which artists belong and the interaction of those networks with one another.

There is perhaps no artist that better exemplifies these challenges than the jazz musician. Known for collegiality, for seeking opportunities to play with peers, and not known for membership in arts-related organizations, the jazz musician has a distinctly American legacy. This legacy and the development of jazz around the United States is intimately tied to issues of freedom, race, expression, hardship and joy. Because of the way jazz artists work – often free lance, sometimes affiliated, with varying degrees of formal education and great strengths in self-teaching, apprenticeships, improvisation in living as well as working, the communication mechanism is largely an oral one, by word of mouth and personal referrals.

Jazz musicians fall into the category of 'hidden populations' in that (1) no sampling frame exists, so the size and boundaries of the population are unknown, (2) there are strong privacy concerns, not because of illegal or stigmatized behavior, but because of the tight but informal networks which outsiders find hard to penetrate, and (3) the population constitutes a small proportion of the general population.

Great attention has been devoted recently to the problems involved in sampling hidden populations because of two recent events, the AIDS epidemic (Watters and Biernacki, 1989; Laumann et al., 1989) and decreases in the accuracy of the U.S. census (Brown et al., 1999). Efforts to address both problems have focused attention on problems in sampling hidden populations. The primary focus has been on injection drug users, men who have sex with men, and the homeless. Though these groups differ profoundly in social and legal status from jazz musicians, methods developed for studying stigmatized hidden populations may be adaptable to study non-stigmatized hidden populations. That is the premise of the study described in this article.

Given its small size, using traditional methods to sample a hidden population would be prohibitively expensive. For example, if a general population survey were used to study jazz musicians, a colossal sample would be required to ensure that even a modest number of jazz musicians had been sampled. Furthermore, when a hidden population has privacy concerns, it cannot be reached by methods such as household surveys or random digit dialing, nor can these methods reach those with unstable living arrangements as when several families live in an apartment although only one name appears on the lease (Sudman and Kalton, 1986).

Three methods currently dominate studies of hidden populations. First, location sampling involves identifying locations where members of the population can be found, and then deploying interviewers. A problem is that location sampling is

practical only for locations that are large and public. However, such large public scenes tend not to draw a representative sample of any hidden population. For example, not all jazz musicians attend jazz clubs and festivals.

Institutional samples are a second method for sampling hidden populations. In the case of drug injectors, samples are drawn from drug-treatment programs and prisons. Here, the researcher relies on the institution to draw the sample. The problem is that only a select group of subjects enters drug treatment programs, prisons, and other institutional settings. For a study of jazz musicians, relevant institutions include musicians' unions. However, many jazz musicians are not union members, and there are good reasons to believe that those who are members do not resemble non-members in terms of professional development and other factors.

The third method for sampling hidden populations is chain-referral sampling, the best known form of which is snowball sampling (Goodman, 1961). This has traditionally been considered a form of convenience sampling about which no claims of representativeness can be made. In a now-classic article, Erickson (1979: 299) argued that the sample begins with a bias because when sampling a hidden population the choice of initial subjects cannot be random, and further biases of an unknown nature are added as the sample expands during subsequent waves. Subsequent to Erickson's analysis, additional biases have been identified, so sources of bias in chain-referral samples include:

(1) nonrandom choice of initial subjects, that is, the choice of "seeds";
(2) volunteerism, in which more cooperative subjects agree to participate in larger numbers, or masking, in which less cooperative subjects are under represented;
(3) differentials in recruitment, in which some groups recruit more peers into the study than others;
(4) differentials in network size, because referrals occur through network links so groups with larger personal networks will be over sampled; and
(5) differentials in homophily, or tendency toward in-group recruitment, because groups with greater homophily will be over sampled.

Because of these problems, chain-referral samples have traditionally been seen merely as a form of convenience sample, suitable only for pilot studies and formative research.

Despite this recognition of bias, there has been a resurgence of interest in chain-referral methods because of their unique ability to reach those who would be missed by other methods, including those who shun public gatherings and institutional affiliations. Research on the 'small world problem' suggests that any two people in the country are connected by no more than six network links, the now famous 'six degrees of separation'. The implication is that everyone could be reached by a maximally expansive chain-referral sample after only a handful of waves.

A prerequisite for the use of chain-referral samples to study hidden populations is that the population be linked by a 'contact pattern'. That is, members of the population must know one another. These contact patterns are robust in the populations upon which HIV-prevention research has focused. Injectors form contacts when they

buy drugs, and these are strengthened because regular users cultivate multiple sources to ensure continuity of supply. These bonds are further strengthened because drugs are often purchased jointly and shared. The robustness of its contact patterns makes this population ideally suited to chain-referral sampling. Therefore, the best sources of information about injectors in any community are the injectors.

Though for very different reasons, jazz musicians have equivalently robust contact patterns. Jazz is typically performed in ensembles (IJdens, 1999), thereby creating contact patterns among the performers. Music education programs and informal apprenticeships are a further source of bonds, linking students to one another. Practitioners work in both the commercial and the non-profit sectors where mentorship and collegiality are common. Given the lack of comprehensive institutional data on jazz musicians and their robust contact patterns, a chain-referral-based study of jazz musicians employs the best source of information about the jazz community – that possessed by the jazz musicians themselves.

2. Respondent-driven sampling

Respondent-driven sampling (RDS) is a new form of chain-referral sampling that was developed to overcome the biases traditionally associated with this method (Heckathorn, 1997, 1999). It has also served as the recruitment mechanism for an intervention that targets active injection drug users for HIV prevention education and services (Broadhead et al., 1998; Heckathorn et al., 1999). The design principle of respondent-driven sampling is simple. If the biases associated with chain-referral methods are understood, it is possible to redesign the sampling process to eliminate those biases that are not inherent in the method, and to quantify and control those that are inherent in the method. Therefore, RDS includes both a specific method for structuring the chain-referral process to reduce one set of biases, and analytic procedures to weight the sample to compensate for others. In this way, chain-referral sampling can be made into a statistically valid sampling method.

The first source of bias is due to the selection of initial subjects. Fig. 1 depicts the recruitment tree generated by RDS beginning with a single seed. Over the course of many waves, the sample expanded to include more than one hundred recruits.

An examination of recruitment patterns by ethnicity confirms that the choice of initial subjects does indeed introduce a bias into the sample (see Table 1). Recruitment reflects *homophily*, a tendency to recruit persons like oneself. For example, in a study of injectors in New London, Connecticut, non-Hispanic white injectors recruited, on average, 74% other non-Hispanic whites; Hispanics recruited 58% Hispanics; and non-Hispanic blacks recruited 51% blacks. Only the very small group in the Other category failed to recruit differentially from within.

It might seem that homophily would make chain-referral samples irrevocably biased. For example, a group that had been over represented among the seeds with which recruitment began might seem as though it would remain over represented in the sample. The manner in which homophily affects recruitment as the chain-referral sample expands from wave to wave can be identified by modeling the process as

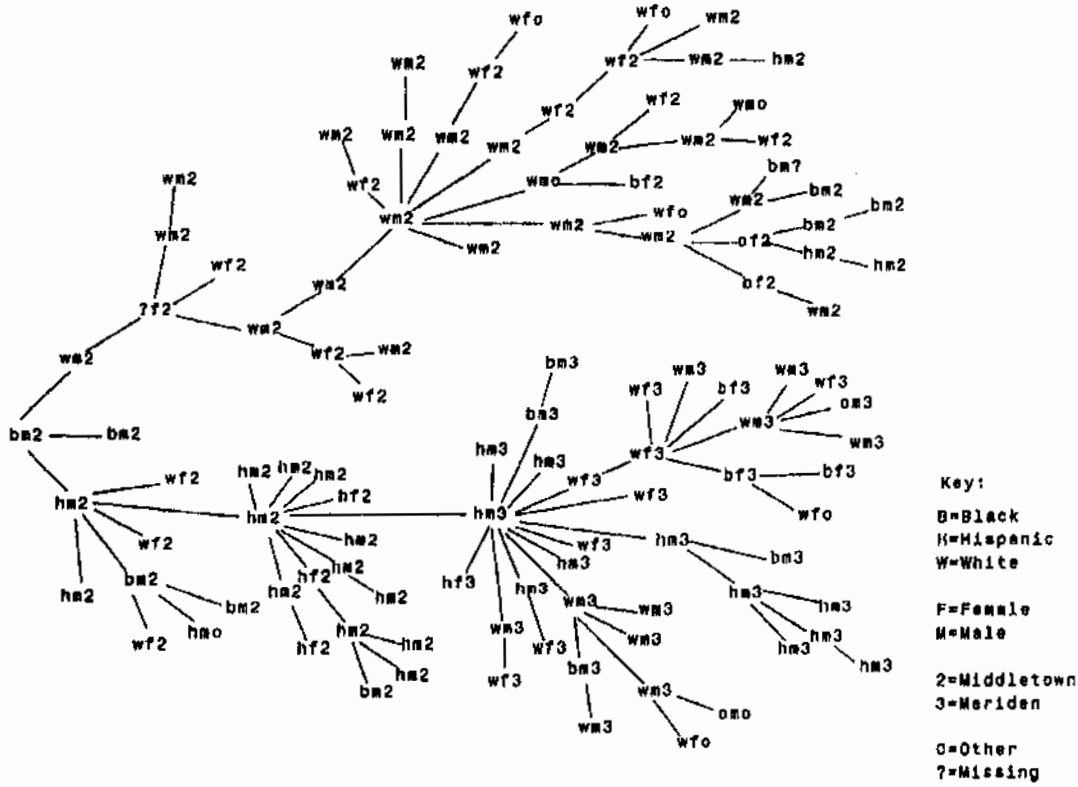


Fig. 1. Peer recruitment network beginning from a single seed.

Table 1
Race and ethnicity of recruits, by race and ethnicity of recruiter

Race/ethnicity of person who recruited	Race/ethnicity of recruit				Total
	W	B	H	O	
Non-Hispanic white (W) (n = 65)	73.9%	13.9%	7.7%	4.6%	100%
Non-Hispanic black (B) (n = 39)	33.3%	51.3%	10.3%	5.1%	100%
Hispanic (H) (n = 19)	31.6%	10.5%	57.9%	0%	100%
Other (O) (n = 7)	28.6%	42.9%	28.6%	0%	100%

a form of stochastic model known as a Markov chain (see Fig. 2). A Markov chain consists of a set of two or more finite states (e.g., subject characteristics such as gender or ethnicity), and transition probabilities from state to state (i.e., probabilities that a subject with a given set of characteristics will recruit a subject with each other possible set of characteristics). As an illustration of a Markov chain, see Fig. 2A, which depicts Table 1's data on recruitment by race and ethnicity. The four states correspond to the recruiter's race and ethnicity (i.e., Hispanic, non-Hispanic black or

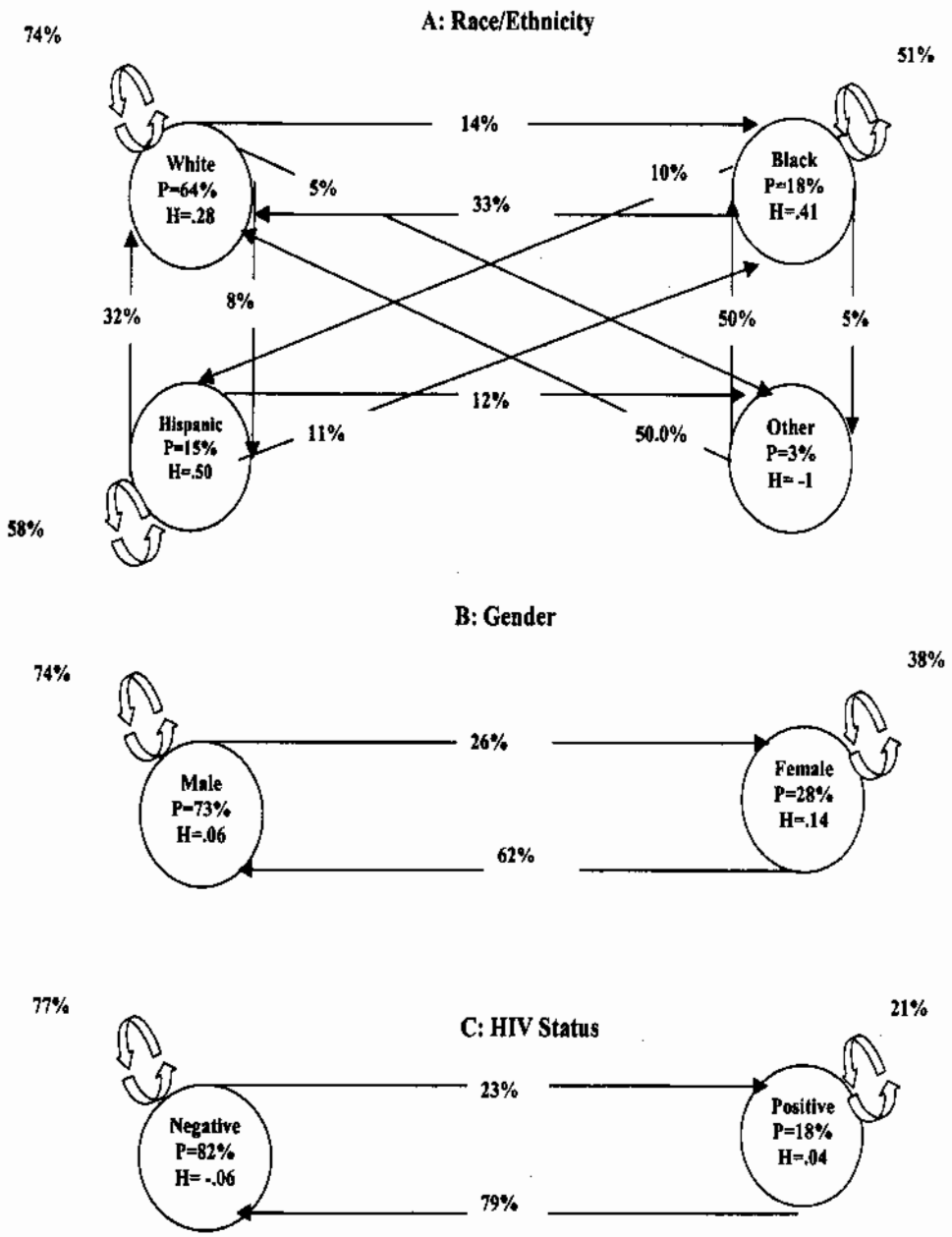
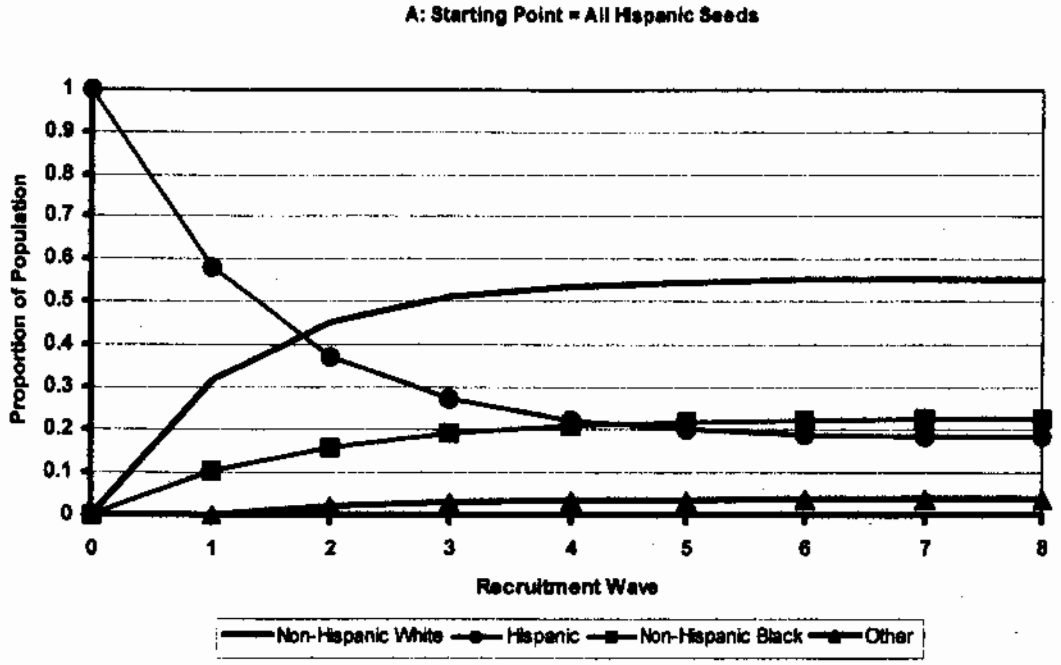


Fig. 2. Network structures of drug injectors. Patterns of association show varying degrees of homophily (New London, CT (N = 130); 'P' is population size estimated by the reciprocity model; 'H' is homophily estimated by the reciprocity and homophily models).

white, and other), and the double line arrows depict the transition probabilities within and single line arrows depict transition probabilities across states. Recruitment is a stochastic process and can be visualized as a point whose location corresponds to the state of the most recent recruit, cross-state recruitment moves the point to a different state by following the arrows, and within-state recruitment keeps the point at the same location.



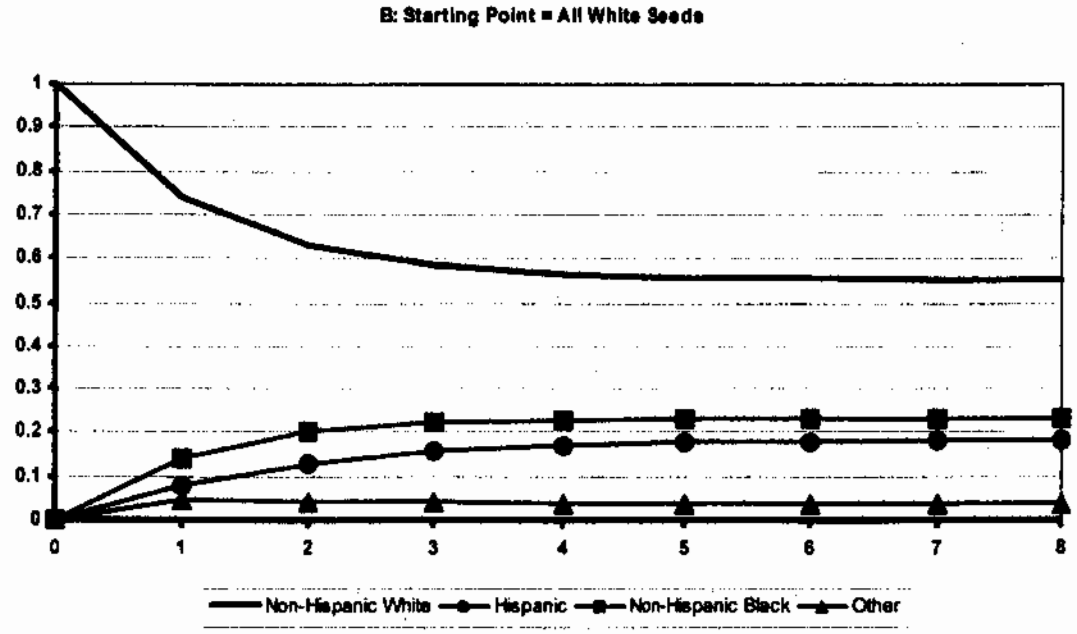


Fig. 3. Two simulations of recruitment in a respondent-driven sample: Race and ethnicity of recruits in a respondent-driven sample, beginning with all Hispanic or non-Hispanic white seeds.

The conclusion from modeling the recruitment process as a Markov chain is that biases introduced by the selection of initial respondents are progressively *weakened* with each recruitment wave. The manner in which this occurs is illustrated in Fig. 3, which depicts the results of two simulations showing how the composition of each wave would have changed had recruitment begun from either one or more Hispanic injectors (Fig. 3A) or one or more non-Hispanic white injectors (Fig. 3B), based on projections from Fig. 1A's recruitment patterns. The vertical axes represent the percentage of injectors of each type, and the horizontal axes represent the number of recruitment waves, where wave 0 refers to the seed or seeds, which in this exercise were assumed to be ethnically homogeneous. Wave 1 refers to the seeds' recruits; wave 2 refers to the recruits' recruits, and so forth. Had recruitment begun with only Hispanic seeds the percentage of Hispanics in each wave decreases from the initial value of 100%, to 58% in the first wave, 37% in the second wave, eventually stabilizing at 18%. This stable point is termed the *equilibrium*, because it does not change with later waves. When equilibrium is reached, the composition of that and each additional wave is 22.9% non-Hispanic blacks, 55.2% non-Hispanic whites, 18.2% Hispanics, and 3.7% other.

In contrast, in the simulation where recruitment began with only non-Hispanic white seeds (Fig. 3B), the percentage of Hispanics in each wave increases, from the initial value of 0%, to 8% in wave 1, 13% in wave 2, and stabilizes at 18% in wave 5 and subsequent waves. Note that after equilibrium is attained, the composition by wave in Fig. 3B is the same as in Fig. 3A. This convergence reflects an important characteristic of RDS. If sampling is allowed to proceed through a minimum number of waves, it will attain an equilibrium that is *independent of the characteristics of the respondents from which sampling began* (Heckathorn, 1997). Thus, it does not matter whether all seeds were drawn from the same group or from any mix of groups, the ultimate composition of the sample will be the same. Hence, whatever bias was introduced by the selection of initial respondents is eliminated if sampling is continued through enough waves. After the desired number of subjects is recruited, computations can be performed (see Heckathorn 1997: 186), to confirm that the composition of the sample converged with the equilibrium sample composition.

To ensure that referral chains will be lengthy, respondents receive modest financial rewards for their recruiting efforts. Rewards are kept modest both to ensure that they would be perceived as recognition for achievement rather than pay for work, and thereby strengthen rather than weaken intrinsic motivation; and to ensure that recruitment would not become coercive. Though every application of RDS has asked respondents whether excessive pressure was used by their recruiter, none has been reported (Heckathorn et al., 1999). A second means used to lengthen referral chains is a quota on recruitment rights, generally a limit of three recruits per respondent. This ensures that semiprofessional recruiters do not emerge and battle for turf, and gives all respondents the opportunity to recruit their peers. Quotas on recruitment are implemented using a coupon system, in which potential recruiters are given dollar-bill-sized coupons that they give to their recruit. The coupon includes the study name, a phone number to call to make an appointment for an interview, and a map to the interview site. The coupon also includes a unique serial number that provides

the link between the recruiter to whom it was given, and the recruit who returns it to the project.

A second form of bias arises when especially cooperative respondents volunteer for recruitment in disproportionate numbers. In previous applications of RDS, several measures were employed to reduce this bias. The first was a combination of material and social incentives. Subjects were paid for the interview, $20 for the initial interview and $30 for each follow-up interview, each of which took between 1.5 and 2.5 hours and included detailed and intrusive questions about sexual and drug-related activity. Lesser rewards would be appropriate in a study where interviews are briefer or less personally intrusive. The second and more consequential incentive was social, the exercise of influence by the peer recruiter. Using this dual system, even respondents for whom the material reward from the interview was irrelevant, could be induced to participate through the social influence of the peer recruiter. In addition to harnessing peer pressure, another means for reducing this source of bias was to ensure that the interview site was located conveniently and in neutral turf. Otherwise, subjects would be under represented for whom the location was accessible only with difficulty, or for whom the location was threatening. Third, the interview staff was trained to treat all subjects respectfully and nonjudgmentally. In addition, amenities such as free coffee were provided. This is crucial for a sampling method that relies on peer recruitment; subjects cannot be expected to recruit peers unless their own experience was positive. To assess this potential source of bias, subjects were asked about the composition of their networks, this was compared to their recruitment patterns, and no significant discrepancies were found (Heckathorn, 1999).

Volunteerism may be of special significance in studies of the arts. Artists' desire to be unique often makes them resistant to being studied, so baseline levels of cooperativeness may be low. This will make it especially important that subjects be treated with courtesy and respect and that interview sites be welcoming and easily accessible. Furthermore, when a major national event occurs, such as many of the examples in the Culture Wars, some of those very artists voice a need for advocacy and collective action, so the baseline level of cooperativeness may be subject to change. Finally, the arts are highly stratified, with elite artists commanding large incomes and public recognition, and the demands on their time are correspondingly great, so obtaining their cooperation may be especially difficult. For these reasons, assessing this source of bias may be especially important in studies of artists to determine whether the means employed in studying injectors suffices for this rather different population.

Thus, the use of material and social incentives to produce long referral chains serves to reduce the first two sources of bias, those due to the choice of initial subjects and volunteerism. The other three biases associated with chain-referral methods are inherent in the manner in which subjects are recruited into the sample. However, this does not mean that chain-referral sampling need be either invalid or unreliable. For based on a sufficiently detailed understanding of these sources of bias, the sample can be weighted to compensate exactly for them, thereby producing an unbiased sample. The procedure for compensating for each of the three source of bias relies

on the same logic. Information gathered during the recruitment process provides the means for quantitatively measuring this bias, and then controlling it through a weighting process.

The third source of bias derives from differential recruitment. This bias occurs when a group recruits especially effectively, because its distinctive recruitment pattern is thereby over represented in the sample, e.g., if this group tends to recruit more of another group's members, the latter will be over represented in the sample. The recruitment quotas reduce this form of potential bias, but given that not all subjects fulfill their quotas, variation remains. Previous applications of RDS provide evidence for recruitment differentials. For example, in a study of injectors in Meriden, Connecticut, it was found that HIV positive respondents recruited 69% more than HIV negative respondents. Of course, this greater involvement of HIV positive subjects in a HIV-prevention intervention is easily understandable. Similarly, in that town, injectors aged 26 and more recruited 20% more than did injectors aged 18–25, so the older injectors were more energetic. RDS weights the sample to compensate for these differentials, by mathematically projecting what the sample composition would have been had all groups recruited with equal effectiveness (Heckathorn, 1999).

Biases due to differentials in network size are controlled in a logically similar manner. When network sizes are unequal, the better connected group is over sampled. For example, in the study of several small cities in Connecticut, New London, Middletown, and Meriden, HIV positive injectors were found to have consistently larger personal networks by amounts ranging from 28% to 36% (Heckathorn, 1999). Therefore, they were reachable by a larger number of potential recruitment chains, and were hence recruited in somewhat greater numbers. The procedure for compensating for differentials in network size is based on the recognition that in RDS, the relationship between recruiter and recruit is almost always reciprocal, where this means that a tie in one direction implies a tie in the opposite direction. For example, if A is a friend to B, then B is typically also a friend to A. In previous applications of RDS, the relationships between recruit and recruiter involved some form of ongoing personal relationship in 97% to 99% of cases depending on the site. For example, in New London, the recruiter was most commonly a friend (64%), followed by an acquaintance (19%), or spouse or other sex partner (9%), and only 3% reported having been recruited by a stranger. The presence of preexisting social relationships between recruit and recruiter results from the combination of a quota on recruitment coupons and the rewards for recruiting. If recruitment coupons were available in unlimited numbers, impersonal forms of recruiting would be possible, for example, placing piles of coupons in locations were potential recruits might gather. However, given that coupons are given out only in very modest numbers, the overwhelming majority of respondents recruit persons with whom they already have a relationship rather than approaching strangers. Drawing on the *reciprocity model* (see Appendix A), the RDS weights the sample to compensate for these differentials, by mathematically projecting what the sample composition would have been had all groups had equal network sizes. Similarly, biases due to differentials in homophily are controlled through mathematically projecting what the sample composition would have

been had all groups had equal homophily. Finally, standard errors are computed based on a variant of boot-strapping (Heckathorn, 1999). For a summary of these procedures, see the appendix.

3. Using RDS to study jazz musicians

In 2000–2001 the Research Center for Arts and Culture at Teachers College Columbia University, under a cooperative agreement between the National Endowment for the Arts and the San Francisco Study Center, will conduct a survey of 1,200 jazz musicians in Detroit, New Orleans, New York and San Francisco.

After an initial orientation of a City Coordinator and staff in each location, they will then select half a dozen key jazz musicians in each city to serve as the seeds from which peer recruitment will begin. These musicians will be informed about the purposes of the study, interviewed person-to-person using a 114-question instrument, and then given the opportunity to act as recruiters for a maximum of four jazz musicians each. The recruits will then be interviewed and given the opportunity to recruit their peers. This process will continue until the goal of 300 recruitments is reached in each city. The musicians will be paid an incentive for their own interviews and for each of their recruits after the recruit has completed an interview. The responsibility for sampling, therefore, lies with the community itself.

4. Using RDS to study social structure

An advantage of RDS over standard probability sampling is that it provides information not only about the respondents, but also about their social structure. For when respondents recruit their peers they provide information about the social network in which they are embedded. Furthermore, this information is based not on self-reports, as in network sampling (Granovetter, 1975), in which respondents are asked to report on their peers. In contrast in RDS, information on network links is behavioral, having been derived from recruitment records. This is significant, not only because of issues of validity and reliability, but also because analyses need not be limited to information respondents have regarding their peers. Consider, for example, Fig. 2C's depiction of structure by HIV status, which shows that HIV positive respondents are thoroughly integrated in the injector community. That is, both HIV positive and negative respondents have near zero homophily. Such an analysis would not have been possible based only on self-reports, because many injectors do not know the HIV status of their peers, and even if they did have that information, its disclosure without the permission of the peer would be a violation of the Connecticut HIV Confidentiality Law. Such problems do not arise for RDS, because respondents need only provide information regarding themselves, and network links are established behaviorally. Therefore, in the jazz study it will be possible to analyze social structure with respect to each of the 114 interview questions, irrespective of whether that information was available to peers.

Social structure has a precise meaning when defined quantitatively (Blau, 1977; Rapoport, 1979). A system is said to lack structure if social relationships are formed randomly. In that case, individuals are indifferent between ties formed within and outside the group. Therefore, the proportion of within-group ties equals the proportional size of the group. As thus defined, structure can take either of two basic forms. First, *homophily* refers to a tendency to form within-group ties. Homophily in the formation of friendships was recognized before 1900 by Galton, and it has been found based on age, education, prestige, social class, and race and ethnicity (McPherson and Smith-Lovin, 1987). Alternatively, *heterophily* or equivalently, *negative homophily*, refers to a tendency to form out-group ties, for example, tribes with exogamous marriage systems require that marriages occur outside one's clan. As thus defined, a system is *structured* if it reflects either homophily or heterophily. Thus, homophily and heterophily are the elements out of which social structures are built. Fig. 2 provides graphic depictions of the social structure of injectors in New London, Connecticut, with respect to race/ethnicity, gender, and HIV status.

As thus defined, structure depends on both the form of relationship considered and the type of group. If a basis for group identification is socially irrelevant, it does not serve as a basis for structural differentiation, and homophily is zero. For example, whether one is born in an odd or even month is socially irrelevant, so homophily is zero based on this status. Similarly, in the United States, blood type is socially irrelevant, so homophily is presumably zero. In contrast, in Japan, where blood type is widely believed to determine interpersonal compatibility, if that belief comes to shape the formation of relationships, structure will emerge. In contrast, race and ethnicity, and other basic demographic variables, are strongly structuring. Thus, determining whether an attribute affects homophily is a way of determining its social significance.

Homophily is formally defined as follows: perfect homophily, in which all ties are formed within the group, is assigned the value +1; and no homophily, in which ties are formed without regard to group membership, is assigned the value zero. When the level of homophily is intermediate, such as 1/3, ties are formed as though one third of the time, one forms a tie within the group, and two thirds of the time, one forms a tie randomly, without regard to group membership. Perfect heterophily, in which all ties are formed outside the group, is assigned the value −1.

The structural analysis of jazz musicians will focus on identifying the patterns of homophily and heterophily by which relationships are structured. Do jazz musicians form a uniformly cohesive group? The results of a study of jazz musicians in the Netherlands (IJdens, 1999) found they formed three distinct groups, depending on whether they preferred to play contemporary improvised music, classical or neoclassical modern jazz, or rock-jazz and fusion. Our study will determine whether these or comparable differences exist among U.S. jazz musicians. There are many other bases upon which the musician community might be structured. Do the most commercially successful professionals form a core around which other musicians are arranged, or do they remain separate, each forming their own inner and outer circles? Do musicians who studied at the same school or completed the same apprenticeship form enduringly cohesive groups? What are the most significant structural

organizing principles for the musician community: musical specialty, commercial success, or the demographic factors that structure other relationships in U.S. society, including race and ethnicity, age, and socioeconomic status? For example, does musical preference trump ethnicity or does ethnicity affect musical preference? RDS provides the means for addressing these issues.

A focus will be the identification of dynasties. The family-like nature of certain art forms results in the creation of artistic lineages, sometimes resulting in actual dynasties – for example, the Marsalis Dynasty in New Orleans. Analysis will also examine the relationships between dynasties, as they are sometimes factionalized against other dynasties.

Stereotypes are common regarding the ethnic and racial backgrounds of artists in ethnicity-associated fields. The assumption in the jazz community is that it is populated largely by African Americans, although some experts would add 'and also white Jews'. Not only will RDS confirm or deny this, it will illuminate for us those important networks that people make in their daily lives – the network of people who jam together, who form ensembles together, who play other kinds of music to support their jazz habit, the jazz musicians who also teach, what part of the city they live in, and so on.

It is these networks that define the structure of the jazz community, and identifying them can provide us with a clearer understanding of the glue that holds that population together and whether that glue has the same pattern in New Orleans as it does in New York, Detroit or San Francisco.

5. Identifying population boundaries

A boundary of special theoretic and practical importance in any study using RDS is that of defining the population upon which the study focuses and thereby the criteria for recruitment into the study. If resources were unlimited, one could conduct a general population survey, e.g., anyone within the study area could be recruited. In this way, the social embeddedness of the group of interest could be analyzed. For example, in the study of jazz musicians one could analyze their relationships to other types of musicians, other types of artists, non-musician members of the music industry such as producers and club owners, non-musician friends, family members, and the general public. Of course, given that jazz musicians make up a tiny part of any city's population, such an approach would be inefficient in that a huge sample would be needed for even a modest number of jazz musicians to be included.

Under realistic conditions, limits in recruitment are essential in any application of RDS. If the population of interest is clearly defined, the criteria governing recruitment are not problematic. For example, in a study of professional actors, membership in Actors' Equity could serve as a criterion. If the population is less clearly defined, some form of screening protocol is needed. For example, in the study of Connecticut injectors, the criterion for participating in the study was having injected drugs during the last 30 days. Subjects were screened using an eight-step protocol. The first step consisted of looking for fresh track marks, and 80% of subjects were

admitted at this step. The additional steps involved demonstrating detailed knowledge of injection techniques. Similarly, a study of jazz musicians could use a set of criteria, such as being recognized by other musicians as a jazz musician, defining oneself as a jazz musician, or publicly performing jazz compositions, where satisfying any one criterion would qualify for inclusion in the study. Such inclusion criteria should be inclusive rather than exclusive. That is, they should be broad enough to capture the population of interest, even at the cost of including some whose membership in the population is dubious. Inclusive criteria are important because it is always possible to remove inappropriate subjects during analysis, and if the number of such subjects is small, the reduction in sample size is minor. However, it is generally not feasible to go back and add groups to the sample who were missed.

Previous research on artists provides the basis for defining an inclusive set of criteria. Traditional categories of artist definition most often return to Frey and Pommerehne's (1989: 146–147) list of eight characteristics:

(1) the amount of time spent on artistic work
(2) the amount of income derived from artistic work
(3) the reputation as an artist among the general public
(4) the recognition among other artists
(5) the quality of artistic work
(6) membership of a professional artists' group or association
(7) professional qualifications (graduation from art schools)
(8) the subjective self-evaluation of being an artist

Work done by Jeffri and colleagues (1989, 1990a,b,c, 1998) and Throsby and Jeffri (1994) on artists in the United States and on visual artists in the U.S. and Australia expanded and refined these characteristics in a series of surveys and comparisons, to ask artists to self-define professionalism.

In three separate studies, two questions asked artists for their definitions of professional artists, as applied first to themselves and then to someone else using the following categories:

(1) *The marketplace definition*
    (i) The person makes his/her living as an artist.
    (ii) The person receives some income from his/her work as an artist.
    (iii) The person intends to make a living as an artist.
(2) *The education and affiliation definition*
    (i) The person belongs to an artists' association (discussion group, artist's co-op, etc.).
    (ii) The person belongs to an artists' union or guild.
    (iii) The person has been formally educated in the arts.
(3) *The self and peer definition*
    (i) The person is recognized by his/her peers as an artist.
    (ii) The person considers him/herself to be an artist.
    (iii) The person spends a substantial amount of time working at art.

(iv) The person has a special talent.
(v) The person has an inner drive to make art.
(vi) The person receives some public recognition for his/her art.

In all three studies, the majority of artists answered consistently in the self and peer definition categories, both for themselves and for someone else. This suggests that social boundaries defining artists may depend more on self and peer definitions than on education, affiliation, and the market. This was true for performing as well as visual artists, suggesting that artists orient more toward professional peers than toward market or institutional acceptance (Jeffri, 1989; Jeffri et al., 1990a,b,c; Jeffri and Greenblatt, 1998). For example, according to Nassir (1997):

> We played more hours in jam sessions than we did on gigs. We only needed gigs to pay the rent and food so we could continue to try things that we learned in the university of the jam session.

The challenge for the investigators was to create appropriate screening criteria that were broad enough to be inclusive and that did not require every local interviewer to be a jazz expert. Members of the jazz community, through focus groups and an advisory board, helped to develop a set of criteria such that possessing one or more qualifies the respondent for inclusion in the study. Consistent with the previous research indicating that social boundaries defining artists depends most on self and peer definition, the criteria included self-definition as a jazz musician. The term jazz is used in diverse ways, e.g., blues artists generally do not define themselves as playing jazz, though blues is considered a form of jazz by musicologists. There are generational differences as well, with some older musicians reacting negatively to the word 'jazz' to describe what they play. Definitional problems are compounded because jazz has combined with many other forms of music, thereby creating various hybrid forms. Therefore, the criteria included a list of musical forms, including jazz, blues, fusion, funk, Latin, ragtime and many others. The aim was to ensure that an expansive definition of jazz would be used to define the population of jazz artists, and thereby include even those artists who might object to being defined as jazz artists. Other criteria included income from work as a jazz musician, engagement in jazz, number of jazz performances and production of a documented body of jazz work.

6. When quantity becomes quality

Artists vary on many dimensions, as acknowledged in the Frey and Pommerehne criteria, most of which are quantitative. However, they give no guidance regarding how much time one must spend on artistic work to qualify as an artist, or how much income, reputation, or recognition is required. The issue arising in the analysis of these terms is, when does a quantitative difference matter socially, or equivalently, when does quantity become quality? For example, if professional musicians form a socially distinct group, how much professional activity suffices for someone to enter the group of professionals?

RDS provides a rigorous means for identifying socially significant breakpoints in quantitative variables. A study of injectors in Connecticut shows how this can be done. In Middletown, younger injectors formed an identifiable subgroup, as reflected in substantial homophily, H = 0.56. Therefore, they formed social ties as though 56% of the time, they formed a tie to another younger injector, and 44% of the time, they formed a tie irrespective of age. Younger injectors were defined as age 25 or younger. Such breakpoints can be identified by a clustering rule: *choose the breakpoint to maximize homophily*. It is important to recognize that these boundaries vary across groups, e.g., in New London, younger injectors as defined by the age 25 breakpoint exhibited near zero homophily, H = 0.07. This may be related to the number of younger injectors; whereas in Middletown younger injectors constituted 19% of the injector population, in New London they constituted only 9%, a number that may have been too small for the development of a distinct group of younger injectors.

Quantitative variables can become the basis for several types of social boundaries. The simplest, as illustrated by the case of younger Middletown injectors, is a binary separation. However, quantitative variations could become the basis for three or more socially distinct groups. These more complex patterns can be identified by an extension of the above clustering rule: *the optimal set of breakpoints is the set that maximizes the mean of groups' homophily*. For, if mean homophily is maximized by two breakpoints, then the clustering rule suggests that the system contains three distinct subgroups.

Another possible pattern occurs when, as in what is termed a *scalar stratification system*, the system does not contain any distinct subgroups, but individuals associate with those whose value on the graduated parameter is similar to their own (Blau, 1994). For example, if individuals primarily associate with those who are within five years of their own age, there would not be a distinct younger group and older group, but age would nonetheless be an important basis for association, in that ages of associates would be highly correlated.

7. Estimating the size of hidden populations

A sampling method such as RDS provides information about population composition, but only in proportional terms. For example, it provides the proportional distribution of the population by demographic category and other variables. However, unless the target population is sampled to exhaustion, the sample does not compose a census. Therefore, additional information is needed to estimate the size of the hidden population. A technique termed capture-recapture provides a suitable method that bases the population estimate on the overlap between two different samples. A study of injectors in Meriden, Connecticut, illustrates how this can be done. One sample of injectors was drawn by police, where the police definition of an injector included arrest for possession of drugs or injection paraphernalia, acknowledging injection drug use, or associating with injectors. The police official who provided the data stated that the 86 injectors identified by the police constituted in his judgment

almost all of the injectors in Meriden. However, a sample drawn using RDS yielded 386 injectors in Meriden. The computation of the overlap between the two samples was based on gender, ethnicity, and exact birth date for each of the injectors. This identified 32 overlaps. By capture-recapture methods (Wittes and Sidel, 1968), the injector population can therefore be estimated as (86/32)*386 = 1,037, a figure eleven times larger than the police estimate of the number of injectors. This population therefore proved rather successful in remaining hidden.

RDS will allow us to project the size of the universe of jazz musicians in the four study cities: Detroit, New Orleans, New York and San Francisco. In addition to the survey of jazz artists using RDS, the Jazz Artists Study will survey a random sample of twenty percent of the population of the union locals of the American Federation of Musicians in each target city.

Many musicians are not union members. Artists' unions in general are not always seen as providers of a collective voice and there seems to be substantial distrust of joining the union by jazz musicians. Sometimes, joining the union deters rather than assists artists in getting certain kinds of work – unions frequently 'look the other way', for example, when indigenous companies are developing and, as soon as they see economic potential, they try to force these companies to unionize and hire only union artists.

While the universe of union musicians is known, the union cannot break out jazz musicians from other musicians. Therefore, all union musicians will be asked to respond, so that data from union jazz musicians can be compared to data from non-union jazz musicians. The capture-recapture method will estimate the number of jazz artists by comparing the overlap between the union and RDS-identified jazz artists. Specifically, where X is the number of jazz artists in the RDS sample, Y is the number of jazz artists identified in the union study, and Z is the overlap between the two, the estimated number of jazz artists in the city is X*(Y/Z).

8. Drawing a stratified respondent-driven sample

In many studies, a group of special interest is so small that a representative sample would produce too few members of this group for adequate study. Female jazz artists form such a group. They are a modest part of the universe of jazz artists. However, so little is known about them that they provide an important area of study. Each sampling method possesses a procedure for over sampling groups of special interest. In RDS, this can be done in several ways, including bonuses for recruiting members of the target group. In a study of younger injectors in Meriden, this proved to be an effective strategy. A disadvantage of this procedure is that recruitment of the target group is sensitive to the size of the bonus. If the bonus is too small, recruitment of the target group is inadequate, and if too large, other groups are neglected, so calibration problems arise. Therefore, in the Jazz Artists Study, we will use a complementary procedure, in which respondents are given two types of recruitment coupons, one that can only be used to recruit a female jazz artist, and three that can be used to recruit any jazz artist, irrespective of gender, for a total of four coupons.

To assess the relative size of the male and female jazz artist populations, each respondent will also be asked how many they know personally from each group.

9. Using RDS to study social inequality

All social systems are stratified to some extent but stratification among artists is especially steep. For example, though highly prominent actors and directors have enormous incomes, their median income was only $22,000 in 1989 according to the 1990 census. Figures from Actors' Equity Association give the median income from all sources including work as an actor as $30,000 in 1997. Income distributions are similarly stratified for musicians. Stratification involves multiple dimensions, including not merely income, but also prestige and influence within the profession. Generally, these multiple dimensions are strongly correlated, such that those with great prestige tend also to have large incomes and great influence. Patterns of association usually reflect stratification, so contacts are most frequent among those of approximately equal status. This study will determine whether these generalizations hold among jazz musicians.

The key to using RDS to analyze structured social inequality is the recognition that homophily may reflect not merely social differentiation (i.e., separate but equal), but also social inequality (i.e., separate but unequal). For example, consider a hypothetical system composed of masters who perform with one another, and novices who perform together while each aspires to join the ranks of the masters. The novices exemplify *exclusion homophily* based on their exclusion from the ranks of the masters. The masters exemplify *power homophily* based on their gatekeeper role, their power to determine who will be included and excluded.

The study of jazz musicians will include a study of both status differences and the means by which status is changed. All professions possess some form of career ladder. For example, the roles within each opera and the opera companies themselves are stratified, and a starring role at La Scala is proof that one has reached the top of the profession. Jazz musicians do not appear to have such a universally recognized means for signaling status, but commonalities with other performing arts may exist. For example, performing with a master confers status, so status is often signaled through a list of the master performers with whom one has played.

10. Conclusion

Studies of the arts can benefit from methodological developments in other areas, including areas dealing with profoundly different types of populations. However, much research may be required to determine how these methods can best be applied in the arts. For example, the incentives appropriate to a study of artists may be quite different from those appropriate to a study of injectors.

However, commonalities are also important. The RDS methodology itself signals both knowledge of and respect for the subjects being studied. Peer recruitment is a

much more friendly methodology than an academic mail survey, for example. Also, artists, although approached frequently for advice, are unaccustomed to being offered incentives for sharing their expertise. While the study's incentives do not pay as well as a 'gig', they do send a message of respect to the jazz community.

The significance of the study includes: showing that the boundaries of this population can be precisely determined, and therefore programs designed to foster the development of this art form can be more precisely targeted and the effects of such programs can be more precisely documented; providing reliable and consistent data to funders, advocates, policy makers and the artists themselves about their conditions and needs. Finally, given an answer to the 'how many jazz musicians' question, these constituents can have a solid idea of the amount and cost of resources that are needed.

The study will also document the continuities and differences between jazz artists and other artists, and other professionals. For example, every profession includes some form of professional socialization, stratification system, institutionalized means for moving up or down, and the like. Respondent-driven sampling may provide a richer measure of artists' situations than simple demographics by assessing patterns of who hangs out with whom and what sub-communities form bonds. This can provide new insights into the needs of jazz musicians as groups of highly singular individuals with clear and present needs. Even though many jazz musicians like what Billy Taylor calls 'America's classical music' to speak for them, this study is a beginning in letting us hear directly from the artists themselves.

Appendix: A technical summary of respondent-driven sampling

Respondent-driven sampling has three analytic components. These consist of procedures for computing: (1) the composition of the equilibrium sample and the number of waves required to reach equilibrium, (2) the estimated population composition while controlling for the effects of differentials in network size, homophily, and recruitment effectiveness, and (3) the homophily level of each group. This appendix summarizes each of these elements.

Computing the composition of the equilibrium sample

Respondent-driven samples attain a stable composition after a modest number of recruitment waves. Computing this equilibrium requires solving a system of n linear equations, where n is the number of groups into which respondents are divided (Heckathorn, 1997). Where respondents are divided into groups a, b, ..., n; S_{xy} is the selection proportion, that is, the proportion of members of group X recruited by members of group Y, and E_x is the proportion of members of group X in the equilibrium sample $E = (E_a, E_b, \ldots E_n)$, the system of linear equations is:

$$
\begin{aligned}
1 &= E_a + E_b + \ldots + E_n \\
E_a &= S_{aa} E_a + S_{ba} E_b + \ldots + S_{na} E_n \\
E_b &= S_{ab} E_a + S_{bb} E_b + \ldots + S_{nb} E_n \\
&\ldots \\
E_{n-1} &= S_{a\,n-1} E_a + S_{b\,n-1} E_b + \ldots + S_{n\,n-2} E_n
\end{aligned}
$$

For example, the composition of the equilibrium sample can be computed from Fig. 2B: n = 2, because respondents are divided into two groups, female (a) and male (b) ; S_{aa} = 0.38, because the proportion of female injectors recruited by female injectors is .38; similarly, S_{ab} = 0.62; S_{ba} = 0.26, and S_{bb} = 0.74. Therefore, the composition of the equilibrium sample can be computed by solving the following equations:

$$1 = E_a + E_b$$
$$E_1 = S_{aa} E_a + S_{ba} E_b$$

Substituting 0.37 for S_{aa} and 0.26 for S_{ba} yields

$$1 = E_a + E_b$$
$$E_a = 0.37 E_a + 0.26 E_b$$

By algebraic manipulation, this equation system reduces to

$$E_a = 0.29$$

Finally, given that the equilibrium proportions must sum to 1 (i.e., $1 = E_a + E_a$), the equilibrium proportion of members of group b is 1 less the proportion in group 1, (i.e., $E_b = 1 - E_a = 1 - 0.29 = 0.71$). Thus, the equilibrium composition of the sample is E = (0.29, 0.71).

Computing the number of recruitment waves required to approximate equilibrium

To compute the number of waves required to approximate the composition of the equilibrium sample, it is necessary first to identify the way in which the composition of the sample changes from wave to wave. Where X_a^i is the proportion of group a recruited during wave i, the proportional distribution of the n groups of respondents during any wave i is defined by the vector, $X^i = (X_a^i, X_b^i, \ldots X_n^i)$. The composition of the sample during the subsequent wave, i+1, can be computed as follows:

$$X_a^{i+1} = S_{aa} X_a^i + S_{ba} X_b^i + \ldots + S_{na} X_n^i$$
$$X_b^{i+1} = S_{ab} X_a^i + S_{bb} X_b^i + \ldots + S_{nb} X_n^i$$
$$X_c^{i+1} = S_{ac} X_a^i + S_{bc} X_b^i + \ldots + S_{nc} X_n^i$$
$$\ldots$$
$$X_n^{i+1} = S_{a\,n} X_1^i + S_{b\,n} X_2^i + \ldots + S_{n\,a} X_n^i$$

Computations begin with wave 0, X^0, which specifies the seeds from which sampling began. Each subsequent wave is computed from the preceding wave. After the composition of the wave has been computed, the composition of the wave can be compared to the composition of the equilibrium sample. We consider equilibrium to have been approximated when the discrepancy is less than 2% between the equilibrium and wave-specific composition of the sample for each of the sample's n constituent groups.

Computing the estimated composition of the population

Estimates of population composition that compensate for differentials in network size, homophily, and recruitment effectiveness are based on the *reciprocity model* (Heckathorn, 1999). In RDS, respondents recruit overwhelmingly from those with whom they have

network ties, generally friends, acquaintances, or relatives. Such ties are reciprocal because a link from any individual x to y implies that a link also exists from y to x. Hence for two groups a and b, the number of links from a to b (T_{ab}) will equal the number from b to a (T_{ba}), i.e., $T_{ab} = T_{ba}$. Furthermore, the number of ties from any group x to y is the production of three terms, the size of the group (P_x), the mean network size of group members (N_x), and the proportion of ties from that go from x to y (S_{xy}), i.e., $T_{xy} = P_x N_x S_{xy}$. Hence, for two groups, a and b, $P_a N_a S_{ab} = P_b N_b S_{ba}$. When group size is expressed as a proportion, so $1–P_a$ can be substituted for P_b, this expression can be solved for group a's size, P_a as follows:

$$P_a = \frac{S_{ba}N_b}{S_{ba}N_b + S_{ab}N_a}$$

This is the estimate of group size based on the reciprocity model, and it provides the means for controlling for three sources of bias, those due to differentials in network size, homophily, and recruitment (Heckathorn, 1999). For example, consider again the case of gender. From Fig. 2B, where females are group a and males are group b, the proportion of males recruited by females was $S_{ab} = 0.62$, and the proportion of females recruited by males was $S_{ba} = 0.26$. Furthermore, the mean network size for females was $N_a = 101.4$, and $N_b = 92.4$ for males. Substituting these values into the above expression yields the estimated proportion of females in the population is:

$$\frac{0.26\ 92.4}{0.26\ 92.4 + 0.62\ 101.4} = 0.27$$

Note that the estimated proportion of females, 0.27, is slightly less than that in the equilibrium sample, i.e., 0.29. This reflects the larger networks of females, a factor that caused them to be over sampled slightly, a bias for which the reciprocity model compensates.

This solution generalizes to systems with more than two groups. The solution for a system with n groups requires solving a system of n linear equations:

$$\begin{aligned} 1 &= P_a + P_b + \ldots P_n \\ P_a N_a S_{ab} &= P_b N_b S_{ba} \\ P_a N_a S_{ac} &= P_c N_c S_{ca} \\ &\vdots \\ P_a N_a S_{an} &= P_n N_n S_{na} \end{aligned}$$

Finally, homophily is computed based on the population estimate derived from the reciprocity model (i.e., the P terms), and from the recruitment selection proportions (i.e., the S terms), e.g., in a system with two groups, a and b, where homophily is positive, $H_a = (P_a - S_{ba})/P_a$. For example, given that $P_a = 0.27$ and $S_{ba} = 0.26$, the homophily of females was $H_a = (0.27 - 0.2581)/0.27 = 0.14$. Similarly, the homophily for males was .06, so in this sample, females were slightly more homophilous than males, a differential that lead females to be over sampled slightly. The reciprocity model also controls for this source of bias.

Respondent-driven sampling software

To facilitate computation of the sampling equilibrium, number of waves required for equilibrium to be attained, estimated population size, homophily, and other relevant terms, custom software has been developed. For a free copy of this software, please write or e-mail the first author.

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Douglas Heckathorn is Professor of Sociology at Cornell University. He currently serves as the chair of the Theory Section of the *American Sociological Association*, and as the senior editor of the journal, *Rationality and Society*. In 1989, he received the *Lon Fuller Prize in Jurisprudence* for an article that appeared in the *Harvard Journal of Law and Public Policy*. Recent research has focused on HIV prevention in high-risk groups, formal theories of collective action and norm emergence, use of cognitive mapping to analyze public policy discourse, analyzing power and influence differentials in macrosocial networks, and developing more valid and reliable means for sampling hidden populations

Joan Jeffri is Director and Founder of the Research Center for Arts and Culture at Columbia University's Teachers College. She and the Center have spent 15 years researching, in systematic ways, the condition and situation of the American artist, including training and career development, economic and social conditions, and access to services and resources both in and outside the arts community. Reports such as Information on Artists I and II, the Artists Training and Career Project, and books including *Artisthelp: The artist's guide to work-related human and social services* (Neal-Schuman), *The actors speaks*, *The craftsperson speaks* and *The painter speaks* (Greenwood Press) document the Center's findings. The Center's work has been used internationally in comparative studies and reports in Portugal and Australia. Jeffri's current work includes a study of jazz artists in four U.S. cities and a study of public attitudes towards artists.

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USA POSTMASTER: Send address changes to *Poetics*, Publications Expediting Inc., 200 Meacham Ave, Elmont, NY 11003.

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Printed in The Netherlands