“Transforming Ethnographic Data and Analytical Problems into Network Data Suitable for Complementary Analysis and Theory”

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**Abstract**. The paper is designed to serve as a guide for integrating network analysis into major research institutes in social anthropology and related fields Although written from a broadly integrative anthropological sciences perspective, the eightfold organization of the paper is quite general:

I **Foundations for Ethnography and Network Analysis**
II **A Generalized Ontology**
III **A Generalized Framework for Data Analyses**
IV **Software and Methods for Network Analyses**
V **Visualizations, Integration of GIS, Dynamical Representation**
VI **Examples and Outcomes: Some studies and hypotheses**
VII **Assessments of Ethnography and Network Analysis**
VIII **Epilogue: Collaborative Research Communities**

The general idea is that a network framework is not limited to special methods of analysis, but can be used, once data are transformed so as to bring out their relational elements, to study many different problems and types of data characteristic to them. It allows researchers to choose whichever historical, humanistic and social science approaches they wish to combine. It does not require that new forms of data be collected, but allows us to transform existing data into forms appropriate to the study of relations, and explore our hypotheses in that framework, one that is complementary to rather than incompatible with existing approaches.

An ontology of networks – that things, including people, relate – and an open-field network epistemology, for finding how they relate and affect one another, are sufficiently general and eclectic to accommodate a diversity of approaches, hypotheses and theoretical frameworks. It accommodates not only such data as are collected in fieldwork, interviews, historical studies, and/or surveys, but also, where desired, georeferenced and temporally coded data. Given that there are always further relational concepts to be invented, the field is open-ended, and there are few if any limitations in this approach to add to our comprehension of the richness of the ecological, social, political and other fields in which humans are embedded. Embeddedness and the study of network embeddedness (including concepts that vary from levels of organization to decentralized processes) are one example of one of the core contributions of anthropologists to network representation, theory and explanation, along with others to be discussed.

Finally, network concepts and measures can be as precise, or as fuzzy and probabilistic, even relativistic, as the researcher judges to be appropriate for the data, the interactions that are studied, the hypotheses or models to be mobilized. There is no concept here of "the" scientific method, but a host of methods that may be brought to bear in testing hypotheses and discovering phenomena and relationships that might otherwise be imperceptible.

Network studies have their limits, of course, but these may depend on research design not only in terms of how the data were collected before the network coding, but how they are to be coded.

Some institute-level inputs are proposed here to support researchers in their generative use and contributions to the fields of network analysis. A general approach to network frameworks for theory and analysis needs to be reintroduced into social anthropology, and introduced to neighboring disciplines such as demography, political science, and social history in ways that are better grounded ethnographically. The approaches already undertaken by physicists, economists (econonophysics), computer and complexity scientists to problems in the social scientists also need far better grounding and less reliance on ready-made computerized datasets. A network of research institutes can play a crucial role in the process while enhancing the opportunities for researchers to expand their productivity with approaches that are complementary to those of their core disciplines.

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Transforming Ethnographic Data and Analytical Problems into Network Data Suitable for Complementary Analysis and Theory[1]

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June 2005
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# I **Foundations for Ethnography and Network Analysis**

*¶1 The Complementarity of Ethnography and Network Analysis*

Imagine for a time that anthropologists, in addition to their books and articles in social anthropology, published auxiliary studies using network representations of their data and network analyses. Even using the same data, new results will often emerge.

Ethnographer Ulla Johansen and White (2002) have performed this experiment, now in the form of a book on *Network Analysis and Ethnographic Problems* (2004) that treats exclusively the data on a case study for which Johansen (2005) has now published an ethnography. The common element of the two studies is the existence of a systematic transcript of her work on the genealogies of a nomad clan in SE Turkey. These data are a relatively complete account of memory culture, compiled from interviews. On the genealogies themselves are annotated the birthplaces, towns and tribal origins, as well as the marriages and migration of individuals, plus notable differences about the identities of individuals – ethnic, occupational, political, lineage and clan and other affiliations.

The two accounts are complementary rather than redundant. From the ethnography we get photos, context, customs, beliefs, norms, histories, stories, and a wealth of other data. The systematic genealogies are not included but form a fundamental part of the knowledge base from which the ethnographer writes. The network analysis extracts as much of the systemic data as encoded in the ethnography as possible, and adds dimensions of the ethnography necessary for interpreting the common and variant meanings and understandings of the terms and relations (family, lineage, clan, tribe, marriage, marriage payments, kinship, many of the norms, etcetera) and the contexts in which they occur and vary spatially and historically. Many of the relations are external links outside the clan and the territories its members occupy. A huge number of findings emerge from the network analysis that are not found in the ethnography. The introductory chapter explains why this will necessarily be the case: while individuals experience events and relations that occur in what we might call their network neighborhoods, learn about events and relations on a larger scale, form ideas and speak about larger patterns, the patterns we see in the network analysis cannot possibly be discerned and described accurately,

[1] This paper was intended as a basis of dialogue with MPI researchers. Comments and Suggestions are welcomed. With Patrick Heady joining the first author in this iteration, we expect additional transformation, editing, additions and deletions prior to eventual publication beyond the Working Paper series.

and neither can they be described by extrapolation by ethnographies from their field experience (except in intuitions or metaphors) without the aid of network analysis. As Marx was fond of saying, “history is formed behind our backs,” out of sight, but in interactions that are equally real to those experienced by individuals, if only because they occur in a network of interconnected individuals, no one of which has either perfect oversight or the language to describe such patterns.

This usage of an anthropological network framework for community, institutional, and historical studies that grew out of the Manchester school (e.g., Turner 1957) represents nonetheless a very different approach than that of Mitchell (1969), Barnes (1954) and others who viewed networks as a very specialized and limited approach. In their view it was unsuited for institutional or community studies, where institutional analysis and structure-functionalism were the methods of choice because of the supposed stability of institutions. This was a surprisingly narrow view given that Turner (1957) in *Schism and Continuity* had used an historical networks approach that drew on genealogies to show causes and consequences of institutional crises in an African village. Perhaps it was the complexity of large networks that drew Mitchell (1969) and others who used more formal methods to the view that network analysis was best suited to small-scale studies oriented towards viewing microscopically how people interacted in complex and fluid situations in the urban context, labor markets, and the like. Even Barnes (1954), arguing for a view of the whole of social life in terms of networks, restricted his analysis to informal interpersonal ties, and saw the “primordial relations of kinship, friendship and neighboring as constituting a relatively distinct and integrated sphere” rather than also show “how networks constituted and linked into a variety of economic, political and other institutions,” including those of the larger society (White and Johansen 2004:49).

Granovetter (1990) also argues against the myth of networks as a special method. Mitchell (in Schweizer 1989d) had by that time also a partial change of mind on the subject, opening his article with “ethnography—or better good ethnography—is the basis of social anthropology. By ethnography is meant the detailed recording of the statements, interaction and behavior of those people who are the subjects of study of the social anthropologist,” and concluding with

> It has been my object to illustrate to you how techniques of analysis developed in respect of network analysis can be used in making the patterns in ethnographic data apparent. Note that the elements in network analysis are relations not [only] the attributes of actors. Network analysis deals much more directly with the material which normally finds its way into the ethnographer’s notebooks. The techniques of analysis allow the very complex sets of relationships to be simplified to the extent that their patterns—if they exist—may more easily be seen. But the essential process is that of moving from ethnography to analysis and then back to the ethnography in order to seek interpretations of these patterns.

On the subject of theory, however, Mitchell (1989:78) writes:

> The question raised here is whether the techniques which have recently been developed in connection with network analysis can be of any use to anthropologists confronted with a mass of ethnographic data. The answer

> … depends on whether the theoretical questions you want to answer can be presented a form for which the techniques are relevant. This raises the question whether network analysis is in itself theoretical or merely a technique. I hope to argue that the techniques involve certain assumptions which may have theoretical implications.

Mitchell's argument is valid, and a step forward from 1969, giving a useful place to network analysis. But given the development since then of network theory in its own right, it does not go nearly far enough. In the book with Johansen, we took *all* the network and attribute data that we could find in readily accessible form, organized these data longitudinally (Johansen and White 2002), and wrote a 500 page book that examined every aspect of social anthropology for this case study to which those data were relevant, always moving from network analysis to ethnography and back again. The results included a new set of theories about complexity in marriage systems that was sufficiently powerful to supersede but subsume that of Lévi-Strauss, and a theory of self-organization in particular types of kinship and marriage systems. We further developed and used a new form of marriage census, critiqued and replaced the older systems of counting cousin marriages frequencies only. We were able to develop an ethnographically grounded theory of a form of decentralized leadership and another that served as the basis for discriminating a new form of clan (dubbed "the endoconical") from others in its genre. We demonstrated the concept of relational cognition (see also White 2005a) to give an account of shifting signifiers of meaning with respect to variable and shifting – self-scaling or scalable – units of social grouping. None of these findings would be possible without the network analysis that we were able to do simply with one systematic slice of the ethnographic field materials: the clan genealogies and all the attributes and identities that we could attach to the individuals therein. In addition, we were able to validate a general theory of predictive social cohesion, give an account in this context for ethnogenesis of the society and the indicators of its present dissolution and changing form, and to give an account of the factors that precipitate the extensive outmigration that this micro-society generates. We were able to test a prediction from general principles as to which structural positions in this network are the ones that generate out-migration. Neither he or Barnes had in mind, judging from personal knowledge as well as their publications, that such work was possible when they set out, in using a networks approach, by "identifying a concept which we at the time felt was needed to deepen our analysis of the social life of the people we were studying" (Mitchell 1989:78). The changes in the network approach since 1969 (see Schweizer 1996b) have been in the development of general network theories that extend and sometimes subsume in their generality and precision a variety of core theories in our disciplines, in the ability to analyze large and complicated networks with multiple relations and levels of analysis, and the ability to link core network concepts, capable of measurement, with core concepts in the social sciences. In addition, some of these concepts have close links with complexity theory, which had hardly begun to exist in the 1960s. Finally, we have through the vehicle of network analysis the ability to track changes through time, visualize changing structures, model the processes that produce them, and study feedback and feedforward in dynamical terms through the study of network processes.

¶2 *Attainability of Generalizable Comparative Theory, Models and Measures*

Comparative analysis in anthropology faltered in its earliest days because of failure to take into account the fact that societies, communities or cultures, once posited, cannot be conceptualized and analyzed statistically as if they were independent entities. More than any other species, interconnection and diffusion, the contagions sometimes made possible by the spread of ideas, make it mandatory that interaction be included as part of the phenomena. Other sciences have come to realize that interaction is often channeled, and hence the interdisciplinary understanding of dynamics has turned to networks – whether in physics, biology, biochemistry, ethology, or ecology. Anthropologists were the first to understand and model this problem of interaction and nonindependence, but the social sciences, in general, are the last to understand it. The exception is network sociology, now considered one of its basic theory-groups (Mullins 1973), one which was largely effected by Harrison White and a myriad of his well-trained and diverse students. In Germany Thomas Schweizer (1996b, 1997, 1998; Schweizer and White 1998), as did others in the context of social anthropology, effected an independent school of anthropological network analysis, which atrophied after his death.

A second problem in comparative analysis in the social sciences, now largely rejected in anthropology, was the reliance on categorical typology, classifying traits by type (assuming as well that the traits represented the shared features of relatively homogeneous and bounded cultures). The assumption that humans necessarily think in categories also invaded cognitive anthropology under the initial guise of such theories of meaning as componential analysis, which is largely based on an Aristotelian worldview (as opposed for example to relative product views of meaning). Although there has been a benignly motivated retreat in anthropology to the view that categories are socially constructed, and rejection of the translatability of such constructs (because their 'components' will not always match), only a minority of anthropologists have begun to work with the possibility that humans also think relationally, and that their cognition may not be embedded exclusively in the head, but in links to the world, or that the world as experienced forms part of our relational cognition (White 2005a). Relational thinking – as an extremely common thought process – has been extensively studied in educational and cognitive psychology, and network concepts about bundles of relationships that form the basis of analogical recognition and thinking are now in circulation in cognitive sciences (e.g., connectionism). No longer tenable is the idea, expressed by Lévi-Strauss and early structuralists of mental and mythic processes, that people (and analysts alike) *cannot* comprehend the complexity of multiple and dynamical relations, nor a justification on this basis that people *must* think in terms of simplified rules and categories. Instead, we have network theories today such as those of Harrison White, in *Identity and Control* (1992), which challenge the formerly dominant theories "that social action comes from individual biological creatures—humans—as a consequence of their nature and consciousness as persons" as well as its mirror image: "This mirage of the person as atom breeds an obverse mirage of society as an entity" (1992:3).

Graph theory and its extensions, for the study of relations, is a neutral language for describing relations and for showing, by formal proof, some of the consequences of their diverse forms of concatenation.

Training in relational and dynamical analysis is an antidote to our educational system, where training is still in analytical thinking that is primarily categorical, classificatory, and static. Back to Harrison White: There is “no tidy atom, no embracing world … the real riddle … is that anyone can effect action by intention in social contexts” (1992:4) ….: “goals and preferences, being so changeable, are not causes but are spun after the fact as accountings of what has already happened” (1992:8).

Many anthropologies write within an understanding of this new ontology, one that does not take structures or categories for granted, which challenges rational action theory, the idea that historical dynamics has always arrived at an equilibrium, or that people make rational decisions independent of their social context. We come to recognize the usefulness of ideas like those of White, that “behaviors begin to cohere not out of some large agentive goals, but simply out of everyday adaptive responses to one’s own actions and those of others,” so that “identities get formed out of the interaction of behavior and control actions,” and “a menu of narratives are available to explain them” (anonymous quotes).

Yet, it is difficult to get beyond the new metaphors that are put at stake in these new conceptions. How do we formulate and test such theories, ones which in White’s case come out of long and deep thinking about network processes? Even the text of White’s book is often ambiguous, multilayered, suggestive yet vague.

To make new discoveries, as White and others have done in this domain, and to test theories, we can turn to case studies, and begin to recode our data to see people, events, interactions and outcomes in a temporal perspective. When coded relationally, these data lend themselves to measurement of changing structures through time, emergence and dissolution of groups, potentials for new identities and their erasure, changing patterns of emergent roles that may become encoded in language or may disintegrate while the language for them remains.

The beauty of a network framework for case studies is that it restores the idea of comparability that has not been possible in most approaches in the social sciences. Because patterns of structure, position, cohesion, centrality and a host of other concepts become measurable when translated into graphs, multigraphs and longitudinal series of graphs, the network variables that apply to particular cases can be applied across cases if careful attention is paid to content and process. Attention to contexts is already a built in potential in network studies.

## II **A Generalized Ontology**

### ¶3 *Transforming Ethnographic Data*

The proposition is that standard ethnographic data that are genealogical, inheritance cases, conflict cases, census, observational, or text-based are readily transformed into multirelational, multiattribute network data by simple but appropriate coding operations. These data can be time or event-coded. They can involve only one type of *node* (e.g., people) and their interactions on multiple dimensions (coding of *edges* between nodes, undirected or directed as *arcs*, labeled and/or ranked by intensity) or multiple types of nodes (e.g., people, groups) and the relations between (e.g., group memberships, hierarchical relations) as well as among them. All data can be time-stamped, temporal ordered, or unpacked for implicit time-ordering as with undated genealogical data. Times may be metric, coded by periods, or for successive events. In Pajek software (Batagelj and Mrvar 2002), an alternative time-coding language is available that controls the entry, offstage, and exit of nodes and edges, and controls their shape, size, properties as indicated by various fill and border colors, dimensionality, and the like. Documentation is found in the exploratory analysis introduction to Pajek (de Nooy, Mrvar and Batagelj 2005) and the on-line manual.

The EHESS in Paris (LDH), for example, implemented software written in Access that collects network and attribute data in researcher spreadsheets by collating unique ID numbers, and outputs data in the form of network and attribute files for Pajek and other network software. The system is written in French and would be useful to replicate in English, German, Spanish, Italian or other languages. It is not well documented, and usage depends on the CNRS programmer who customized it to the needs of his departmental faculty and students. The existence and accessibility of this system in the LDH research laboratory, however, has greatly augmented the use of network approaches in French historical demography.

*¶4 Analytical Problems in Anthropology and Implicit Networks/Network Theory*

Applicability of network theory and analysis to anthropological problems can be found in the chapters of White and Johansen (2005) for many of these and other topics:

Agency
Conflict
Decentralized political organization
Demography
Emergence, maintenance, dissolution of groups and potential identities
Exchange
Genealogies of property flows and things
Identity
Institutional analysis
Marriage and kinship
Migration
Robustness and resilience
Self-organization, fractality, small world structure, navigability
Sexuality
Social security
Succession
Transmission of disease, epidemiology (e.g., Moody 2002a,b)

Network theory and intuitive description of network structure and processes, of course, are implicit in most writing on anthropological, historical, political and in general, social topics, but is best developed in sociology (see Mullins 1973;

H. White 1992, 2002a,b; Emirbayer and Goodwin 1994) and, more recently, by physicists and computer scientists (see Chapter 1, White and Johansen 2004; numerous reviews are available e.g., by Barabási, Watts and many others).

¶5 *The Importance of Time*

Andrew Abbott (2000) gives us not only some tools for identifying the multiple temporal taken by sequences of changing configurations or structures, but also an important treatise on *Time Matters* (2001). It is fundamental not to regard network structure aggregated over different time periods, or at one point in time, as representing something stable. Structures can be measured at points in time but they are changing, and these changes can be key to understanding dynamics, and thus to providing hypotheses to be tested concerning explanation.

Powell et al. (2005) give one of the first explanatory network accounts of changes in industry. White, Powell, Owen-Smith, and Moody (2004) extend this account to give an understanding how networks as fields of interaction operate on larger scales within which are embedded organizations as networks that are both more cohesive in their parts and more complicated in they ways that their parts intersect.

## III **A Generalized Framework for Data Analyses**

¶6 *Multiple Relations among Multiple Types of Elements through Multiple Times*

There is no technical limit to the types of multiple relations that may be coded in a network. The key elements of a network research design, even after the data have been collected, involve identification of significant types of interactions, relations, how they differ, and what system to use for coding them. Variations in a single relation can be indexed by quantities or rankings assigned to edges or arcs. Smith and White (1992), before doing their analysis of patterns and changes in world trade, for example, had studied the relative equivalences of the 2-digit classification of commodities in international trade, and reduced the 95 quantities of commodity flows to 15 aggregated relations for classes of similar commodities. Because there is more random variation in smaller subsets of observations, aggregation of this sort in network studies leads to more robust findings.

Qualitative types of ties, however, if their contents are roughly equivalent, often quite sufficient to support a network study. Even for qualitative data, methods of discrete structure analysis (White and McCann 1988, White 2000a, Degenne and Lebeaux 1996) are appropriate for discovery of the structure of embedding of multiple types of ties over the dyads in a network and other possibilities subsumed under the analysis of multiplex networks. The question is how certain types of relation are embedded in others or how they overlap with others, and how this relates to social process, behavior, and social identity. Discrete structure analysis is also appropriate for finding the overlap structure of intersecting cliques (Freeman 1996), the overlap structure of groups in 2-mode networks (Freeman and White 1993), and a variety of other questions subsumed under the embeddings of individuals and groups in other groups or other kinds of groups.

*¶7 Discovery of Structure (and structure at different points in time) and network baselines*

Structural characteristics of networks can be discovered by any of the methods listed in Part IV (¶11), but it may prove important, depending of what emphasis is placed on them, to compare these characteristics to network baselines: What would be the probabilistic expectations for these characteristics given a network generated by certain processes, having certain constraints, or having certain other properties? Examples are given in White (1999). One may find that these characteristics are the result of other, prior, or nonindependent features or processes of the network. As with other studies, correlations among characteristics do not establish a causal or effectual relation between them. Their relation may be random given certain baselines for hypothesis testing. Conversely, the absence of correlation between two characteristics is not sufficient evidence that they are not dynamically interactive, each affecting the other with a time-lag that wipes out the synchronous correlation between them.

*¶8 Finding the Engines of Change: Modeling Dynamics in Relation to Changing Network Structure/Changing Attributes*

The way to begin in the study of dynamics is to characterize changes in variables through time, and to do so it is often necessary to detrend a longitudinal sequence before measuring change, that is, to consider changes up and down from a calculated trendline or relevant baseline. Many characteristics are autocorrelated in time simply because short-term changes are small relative to longer-term changes or trends. Autocorrelation will (by definition) produce the appearance of oscillations once a time-series is detrended. It is important not to consider these as regular cycles if these are merely random variables under some conservative constraints, such as those on population growth. Further, different kinds of growth trends will produce different patterns of oscillations in their detrended changes, as for example, superlinear growth trends producing successively shorter oscillations simply because random variation about a line that is monotonically changing its slope will produce shorter and shorter projections onto the time axis.

In any case, the way to identify dynamic interactions is to see whether changes in one oscillatory curve predict changes in another at some regular time interval (or, say, log-decreasing if raw growth is superlinear), and whether the same is true in reverse. Once oscillatory lengths are determined (constant or log-diminishing), one change variable might predict another at ¼ of the time of this oscillation, while the second variables predicts the first at ¾ the time of the oscillation, always summing to one. These fractions determine part of the strength of the dynamical interaction. If they are 0 and 1 or ½ and ½, the two variables are correlated, but not interactive, not because change in a certain direction in one does not predict the direction of change in the other (this is true of correlated variables), but because knowing the *state* of both variables does not predict the direction in which each is changing. Turchin (2003) discusses the general concept of dynamical interaction (such as between populations of foxes and hares) and applies it to the study of historical dynamics (Turchin 2005). Population peaks relative to carrying capacity (e.g., food available) in agrarian societies, for example, will typically precede peaks in sociopolitical protest and violence.

Interactive dynamics have been discovered in network phenomena. White, Kejžar, Tsallis, and Rozenblat (2005) have discovered such changes for historical urban hierarchy dynamics, which are network driven (migration into cities, communication about the attractions of cities), and Owen-Smith, Powell, and White (2005) have discovered them in the biotechnical industry in dynamical interaction between oscillations in network growth (recruiting new and diverse partners) and organizational consolidation (growth of network cohesion), the latter running in 3-year oscillations.

¶9 *Agency and Identity: Relational Embedding*

Of all the concepts in network analysis, it is possibly those of cohesive embedding of individuals and groups and relational or tie-embedding (where comes types of dyadic ties are embedded in others) that are the most powerful for understanding agency and identity. Granovetter's (1985) work on this problem has high salience, as did his work on the strength of weak ties (1973, 1982). Harrison White's (1992) theories tend to work because of embeddedness of adaptive behavior interaction, the emergence of coherence and overlap in behavior, out of which identities are formed, and how the latter occurs via agents' control attempts in the contexts of this behavioral meshing via embeddedness.

What Harrison White's theories lack, as do many theories of network dynamics, is exactly how coherence occurs, how cohesion is formed, how the boundaries of cohesion emerge out of fluid interaction, and how to understand the ways in which cohesive groups – from small groups to large communities – overlap. Cluster- and community-finding algorithms such as are commonly implemented for network analysis (as for attribute data) typically take as an assumption that communities or clusters are mutually exclusive of one another. The idea that people are *partitioned* into mutually exclusive communities or groups runs against the grain of common knowledge in the social sciences, and mitigates against examining one of our most crucial questions: given that cohesive groups may overlap, how does where are individuals located with respect to overlaps or nonoverlaps affect the ways in which behaviors cohere, identities are formed, or attempts at control are taken? Questions such as these have been a major focus of anthropological studies from Barth's (1969) relational theory of ethnicity in *Ethnic Groups and Boundaries* to contemporary studies of globalization.

"Predictive cohesion theory" develops out of the work of White and Harary (2001) in their attempt to measure the definition of cohesion that was adopted in graph theory following publication of the Menger (1927) theorem that established the equivalence between the number of node independent paths (independent meaning no common mediators) between any pairs of nodes in a network and the minimum numbers of nodes (cutset) that must be removed from the network in order to disconnect them. He also proved that the maximal k-connected subgraphs (k-components) of a network, where every pair of nodes have this double property (all connected by k or more node independent paths and not separable by cutsets of fewer than size k), are unique and possibly overlapping. Where k-components occur, however, they are by definition locally stacked into inclusive hierarchies at different levels for k from 1 to its observed maximum. From this, White and Harary defined a monotonic measure applicable to the levels of cohesion in different naturally bounded but *potentially overlapping* (but only by k-1 nodes) unique maximal subsets of graphs. They showed the ethnographic relevance of variations in cohesion to predicting the process of dissolution in a karate club resulting from a conflict between leaders and a simple rule of decision-making used by individuals linked to both leaders to break their least cohesive link first. The theory predicted the broken ties from an unweighted graph of the network, whereas the ethnographer (Zachary 1977) had to use a weighted graph to make the prediction. His method led to a host of incorrect predictions if an unweighted graph was used.

Unconvinced of the generality of this result, Moody and White (2003) tested replications of the theoretical predictions in twelve independent network studies of friendships in American high schools. Including competing attributes and network in their models, they got almost exactly the same results in each: the cohesion measure correctly predicted school attachment as the dependent variable, beating out most other competitors and controlling for all those that remained in the predictor set. They also showed that the same measure predicted similarity in business contributions to political parties in the U.S. In 2004, their paper won the annual prize for contributions to mathematical social science, and was praised not only for its findings but it exposition of structural cohesion and cohesive embedding (due to Moody's careful explication) as a core problem in sociology and in relation to other theories.

The recent test of this measure of cohesiveness as applied to the network evolution of collaborative contracts in the biotechnical industry (Powell et al. 2005) used a similar multivariate predictive framework, and found that structural cohesion beat out all other measures except for follow-the-trend and selection of partners for diversity, which were consistent with the predictive cohesion hypothesis.

In the field of kinship and identity, the same variable of structural cohesion – now applied to structural endogamy (White 1997) – predicted social class in the context of marriage and property transmission (Brudner and White 1997) and predicted migration versus staying in place in the context of the Turkish nomad clan studied by White and Johansen (2004).

White (2005c) has a new paper nearly ready for submission which reviews the theories and methods for study of cohesion in small groups and for finding communities in networks, and the test of predictive cohesion theory there outperformed 21 other studies of the boundaries of cohesive groups in the classic Davis, Gardner and Gardner (1941) data on women's attendance at society-page gatherings in a southern town.

Structural cohesion is a scalable method that does not depend on the density of ties but on the structure and redundant routability of ties that make for cohesion within a group but also its resistance to disconnection coming from outside shocks. It is scalable in that it applies to the community- and group-finding problem regardless of the size of the network and the size or overlaps of the groups within it. It is also perfect for a number of anthropological problems, including the differing contexts in which identities are formed, the formation of consensus, and what we normally take as the contexts for cultural formations in hybrid as well as distinctively bounded contexts. Levels of cohesion can also serve as indicators of potentials for social support within a network. It has already been demonstrated that people who are social isolates suffer from an array of problems that stem from lack of social support that is measurable in network terms. What has yet to be shown is whether structural cohesion of a bounded but more diffuse sort benefits individual well-being, and to identify the effects of membership in multiple overlapping cohesive groups, or of membership in different levels in an embedded hierarchy of cohesive groups. All this is new terrain, given that the algorithms for measuring structural endogamy were only invented in the mid-1990s, those for measuring structural cohesion only published in 2003, and those algorithms implemented in network packages such as NetMiner (2003) only in 2004.

Moody and White (2003), however, invented a second measure, that of *cohesive embedding*, which is an extension of structural cohesion in dealing with distinctive subgroups as breakouts in potentially multiple ways (overlapping cutsets) *within* strict structurally cohesive groups. Although bounded within structurally cohesive subgroups, these overlaps may be messy, but so may social life, and some of these overlaps (which are generated along the way according to how Moody constructed our algorithm) turned out to be highly predictive, as is the case for Southern Socialite subgroups (White 2005c).

## IV **Software and Methods for Network Analyses**

*¶10 Software*

Pajek (Batagelj and Mrvar 1998, 2002, 2003) is the software of choice for (1) large network analysis—up to 1 million nodes and any number of relations, (2) visualization, (3) longitudinal analysis of networks, and (4) a very general framework for analytic operations that can be sequenced and saved as complex repetitive operations by the use of macros. It is distributed with UCINET (Borgatti, Everett and Freeman 1995a,1995b), now in version VI, which includes Pajek as its visualization software and as an input/output format. The UCINET versions of Pajek are not always up do date, however. UCINET has a number of matrix-based operations that are limited to smaller networks (e.g., up to 500) but are not found in Pajek. There are literally thousands of analytical opportunities in Pajek that cannot be found in UCINET. Pajek is closed-source software written by one programmer (Mrvar), which makes it easy for suggestions from the research community to be implemented.

JUNG (Java Universal Networks and Graphs) is open source java-based freeware designed for research groups to add their own routines to the library. The core library is programmed by computer science students at UC Irvine. Jung has features such as double sliders for node side and filtering low values on node vectors, five layout algorithms rather than the two of Pajek, control of curved lines in visualizations and pluggable rendering of properties of nodes and edges.

The Champaign IAS and University of Champaign are developing java-based network software where data can be uploaded for analysis to their web site.

Software can be found at

Pajek: `http//vlado.fmf.uni-lj.si/pub/networks/pajek`

GraphViz: `http//www.research.att.com/sw/tools/graphviz`

Yed: `http//www.yworks.com/en/products_yed_about.htm`

Combinatorica : `http//www.combinatorica.com`

Jung: `http//jung.sourceforge.net`

Combinatorica is for users of Mathematica. GraphViz is for Unix users. Jung is platform independent.

¶*11 Methods, including Simulation and Modeling*

Many of the methods of network analysis are discussed in the Glossary of White and Johansen (2005), but most are discussed in the textbooks on networks (Scott 1991, Wasserman and Faust 1994, Degenne and Forsé 1997, and de Nooy, Mrvar and Batagelj 2005), so it is unnecessary and outside the purview here to discuss these methods (only some of the newer references are given below, or in some cases examples from White's anthropological work, some of which is quite recent and not yet covered in the standard texts).

- Blockmodeling
  - Generalized blockmodeling (Doreian, Batagelj and Ferligoj 2005)
  - Structural equivalence
  - Regular equivalence (White and Reitz 1983)
- Brokerage roles
- Census of cycles, reciprocity, transitivity, hierarchy
  - Triad census (Batagelj and Mrvar 2001)
  - Marriage census (White 2005b, Hamberger et al. 2005)
- Centrality, Nodes
  - Betweenness (Freeman 1997)
  - Closeness
  - Degree
  - Flow (Freeman, Borgatti, and White 1991)
  - Random walk betweenness (Newman 2003)
  - Recursive (Eigenvalue)
- Centrality, Edges
  - Betweenness (see Newman 2004a,b)
  - Closeness
  - Degree (adjacency to other edges)
  - Flow
  - Recursive (Eigenvalue)
- Centralization
  - Betweenness (Freeman 1997)
  - Closeness
  - Degree
  - Flow
  - Recursive (Eigenvalue)
- Clustering
  - Balance in signed graphs
  - Clustering in signed graphs
  - Clustering

- Curvature
- Hierarchical clustering
- Cohesion analysis
  - Bicomponents (k-component for k=2)
  - Structural cohesion (all k-components; White and Harary 2001)
  - Structural embedding (Moody and White 2003)
  - Structural endogamy (bicomponents in marriage networks: see p-graph)
- Degree distributions
  - Exponential
  - Generalized Boltzmann-Gibbs exponential (White, Kejžar, Tsallis, Farmer, and White 2005)
  - Powerlaw
- Graph drawing
  - Eigenstructure
  - Tree structures
  - Spring Embedding: Kamada-Kawai / Fruchterman
- Marriage census or Ring Cohesion distributions
  - Exponential
  - Generalized Boltzmann-Gibbs exponential (White, Kejžar, Tsallis, and Rozenblat 2005)
  - Powerlaw
- Matrix eigenvalue/eigenvector analysis
- Navigability (Kleinberg 2002a,b; Adamic et al. 2003)
  - Successive hubs
  - Oriented search
- P-graph analysis (for analysis of structural endogamy in kinship networks)
- Small world (Watts and Strogatz 1998, Watts 1999)
  - Average distance
  - Clustering
- Strong ties (reciprocal, but in some networks, bridging clusters (White and Houseman 2002))
- Weak ties (entailed by bridging clusters? (Granovetter 1973, 1982))

Alongside these methods is the domain of simulation, which has had a huge input from the physics and computer science community in recent years. A host processes for generating baseline networks to compare with real one have been developed, but in general researchers in these fields lack an understanding of social process and a background understanding of ethnography, history, sociology and social theory. The relevance of these approaches, however, is extensively discussed in the Introductory chapter of White and Johansen (2004), supplemented by a glossary that explains many of the basic concepts involved in simulation and findings relevant to measurement, process models, and complexity theory. White, Kejžar, Tsallis, Farmer, and White (2005) have taken the step of introducing more realistic social processes (as with White 1999) into the literature in order to understand the creation and consequences of feedback and feedforward in the generation and structure of networks and the outcomes of network interaction.

Because Pajek is a network calculator with far greater possibilities for sequential analysis and menus for unary (one input → one output) and binary (two inputs → one output) operations for networks, partitions, permutations and vectors, and each of its ten calculator menus has an extensive pull-down menu, Pajek is relatively complex and takes some time to learn. The new textbook (de Nooy, Batagelj and Mrvar 2005), *Exploratory Social Network Analysis with Pajek*, comes equipped with 30+ sample datasets available from the WWW, subsets of which are discussed to exemplify Pajek procedures in each chapter, and with exercises for students at the end of each chapter. For a method or problem of choice, such as genealogies and citation networks (chapter 12—grouped because these networks have similar types of links to genitor nodes that are implicitly ordered in time), working through a chapter provides a researcher with practice and clear instructions for the needed operations.

Pajek is freeware, so it can be downloaded, along with lists of operations and their definitions (including citations to the original works where they are explicated), examples of formats, and sample datasets. Output can be routed to UCINET, to the R statistical language system for further analysis and statistical graphs, directly to Pajek graphics, and from Pajek graphics to a variety of outputs for internet display, graphical inserts to articles, and powerful display formats such as SVG, which also allows preset images of nodes and edges to execute motion through time.

Basically, then, while aspects of Pajek can be easily learned by researchers, there are so many advanced features that someone in IT (the information technology department) should take charge of coordinating the efforts of researchers to utilize these features. Some one or two specialists in the institute, for example, should be fluent in R and the usage of R to take network and attribute data from Pajek into R for further analysis and preparation of graphics for printing and insertion in publications.

One or more specialists in the institute should become familiar with the graphical output formats and their potential uses – SVG, for example. There is also a special menu of options for controlling the features of graphic output inside the Graphics Menu screen of Pajek.

Genealogical analysis and visualization of results (White, Batagelj and Mrvar 1999, Mrvar and Batagelj 2004) has many possibilities that go far beyond what is available in Chapter 12 of de Nooy, Mrvar and Batagelj (2005). This also requires help from specialists.

Methods for marriage census analysis (White 2005b, Hamberger, Houseman, Daillant, White and Barry 2005) also require specialist training and help. These methods utilize macros within Pajek, but the setup and understanding of the procedures and the output requires some practice, training, and familiarization with the methods employed.

Because Pajek is the engine for large network and analysis, including the majority of network algorithms, and for visualization, it would be advisable to invite Andrej Mrvar to the institute for 1-2 months to (1) teach Pajek usage to research teams (2) train IT personnel in advanced techniques (3) answer questions of relevance to research goals and where needed to add functionality to Pajek for new capability, and (4) to explain and write macros for institute research needs. It would be optimal as well to hire a young PhD for the IT staff to deal with network analysis and its extensions, help apply network analysis to institute projects, help with research design for data coding, and to train with Andrej Mrvar while he is at the institute. While Pajek is designed by Batagelj and Mrvar, Mrvar is the principal programmer, but he works closely with anthropologists, sociologists, and many others concerned with networks.

## V **Visualizations, Integration of GIS, Dynamical Representation**

### ¶*13 Graphical Representation*

Graphical representations for kinship include ordering genealogies in time, clickable images to follow evolution of a kinship and marriage structure in time, and movie visualizations that follow changes in time by fading older ties for deceased individuals and bringing in new ties. Changes in sizes of nodes can be made proportional to numbers of children, wives, brothers and brothers-in-law, number of remembered ancestors or numbers of descendants, etcetera. Nodes and lines may be of different shapes (triangles, circles for m/f), colors (e.g., by lineage or other groupings) or size (e.g., edge betweenness importance of ties that link to other ties).

Advanced visualizations running in overlay on a genealogy may show the flows of property through the network, the subsets of ties mobilized by each marriage, or the marriages that reciprocate ties between groups marked in bold, for example.

The most advanced options at this time for marriage analysis (White 2005b, Hamberger, Houseman, Daillant, White and Barry 2005) find all the marriages that relink in any possible way up to a certain depth of ancestry (e.g., types of cousin and second marriages, types of marriages with in-laws, types of 3- or more family relinkings), and then construct a marriage census graph that shows the frequency of each type by a proportionally sized node for that type, shows the co-occurrence of marriages that are simultaneously of two types by the thickness of lines between those types, and so forth. Statistical frequency analysis is also provided in the output, and which marriages or individuals link to which marriage types may be included in the graphs or statistical output.

For studies of friendship, one of the useful visualizations is to thicken the lines that show reciprocal dyads and transitive triples, utilizing the results of a triad census. Those results are ideal to discovery of the different kinds of network structures that occur with friendships or exchanges in different contexts, case studies, or time periods. Often, looking at longitudinal data, the people who occupy certain structural positions at one time in a network will migrate not only to other groups, but to other positions in the structure (Moody, 1999a), so it is important to record and analyze such data through time.

### ¶*14 Integrating GIS*

Batagelj and White discussed in 2005 (and he and a student have since developed) a system for integrating network representations exported from Pajek to SVG format with basemaps drawn from GIS. Times-series maps can be made to animate changes in a GIS-populated physical environment (terrain, rivers, lakes, oceans, seas and other ecological features) with overlay data in

GIS (e.g., cities, attributes of places, population sizes) in the basemap but with node-to-node network links overlaid on these maps. The technique is to make the network SVG transparent in its background, and to embed the GIS map(s) underneath. Within the SVG there may also be placed dynamical elements, such as routes that change through time, or agents that are seen to traverse these routes.

This approach to integrating GIS, with its control over landscapes and network representations and ability to superpose attributes of places or zones on that landscape, can provide powerful visualizations of structure and dynamics from communities at a relatively small-scale up to world systems at a regional or global scale. White and Spufford (2005) are currently finishing a book with integrates the Eurasian data on city networks and trade in the Medieval period from 1175-1500, taking 25 year coding intervals as their time periods.

*¶15 Dynamical Representation*

There is a new visualization package currently under design by Batagelj, with input from our research community, and implementation by one of his students. It allows elements of graphics output to possess continuous motion through time (nodes and their edges, for example), much like a movie. The representation of network and attribute changes over time can be made into movies that will play on the net, or that can be converted to a form that will play in a slide from a PC. As a corollary and addition to ¶13, an institute specialist would need to take charge of how to help researchers with this possibility. There are other possibilities at this level of complexity (GIS, and other software for dynamical visualization) that can occupy a specialist as an aide to researchers.

*¶16 Links to Complexity Theory and Interdisciplinary Approaches*

A review of complexity theory in relation to social anthropology, together with findings that link the two domains of theory, is found in White and Johansen (2005; see also the Glossary). As a member of several of the working groups at the Santa Fe Institute, White (2000c) was the editor of the special crossdisciplinary issue on Networks, which contains equal numbers of hard science and social science contributors. These are links that may require specialist services within our institutes, and we as social scientists can benefit from attention paid to some of the mathematical and statistical methods used by physicists (e.g., White, Kejžar, Tsallis, and Rozenblat 2005, White, Kejžar, Tsallis, Farmer, and White 2005).

## VI **Examples and Outcomes: Some finished studies and hypotheses**

These examples are best shown in powerpoint visualizations that are complementary to this paper. The powerpoint will be posted to the web, under conference papers, at http://eclectic.ss.uci.edu/~drwhite.

¶17 Brudner and White (1997), Social Class and the Genealogy of Things *for a single summary image: a relinking genealogy, similar to a DNA strand, spinning off currency and valuables while dynamically recombining landed and productive property*

¶18 White and Johansen (2004), Self-Organization in Middle Eastern Endo-Clan Systems

*for a single summary image: an endoconical clan, in this case a network with a temporally expanding conical shape that is cohesively interwoven, spinning off an exodus of migrants to towns and cities*

¶19 Houseman and White (1998a,b; Denham and White (2004); Houseman 1997: Unsuspected Dual Organization and its Structural Flexibility and Dynamics (Pul Eliya, Amazonia, Australia)

*for a single summary image: Pul Eliyan sidedness, property transfers and political succession in an instantiated dual organization of balanced exchange that is not globally labeled or coded in local language, but exists in conformity with egocentric kinship 2-sided division of people into marriagables and unmarriagables. The instantiated quality of this structure, which is not otherwise culturally expressed in categorical terms, operates as an indexical portion of the cognitive process of 'counting' sidedness.*

¶20 White and Spufford (2005), Civilizations as Dynamic Networks: Monetization and Organizational Change from Medieval to Modern

*for a single summary image: a network/GIS overlay of a global trade network that by cursor motion applied to the image at a URL allows flyover and zoom capabilities; eventually this image will change dynamically in time and be modeled in parallel by a set of flow and other equations that express the interactive dynamics between population pressure, sociopolitical reaction (cooperation or violence), trade and warfare, agency spaces, etcetera (there is a lot more to the etcetera).*

¶21 White and Schweizer (1998), Identity and Behavior in Loose Social Structure (SE Asia).

*Verbal image: The basic idea is that what appears to be different behavior on the part of elites is a function of isogamous marriage by status with options narrowing for elites because their shrinking size narrows the people available for marriage. See the publication for graphic network images.*

## VII **Assessments of Ethnography and Network Analysis**

Some of the greatest progress in theory and social anthropology came out of the Manchester School, which moved beyond structure-functionalism through incisive critiques by Gluckman, Turner, Leach, Colson, T. S. Epstein, and a variety of others, with new problems and methodologies that marked a break with tradition by Gluckman, Turner, Mitchell, A. L. Epstein and others, including contributions from the Malinowskian camp as those of Nadel and others. Leach's (1954, 1961) two ethnographically-based critiques were the death-knell of British structure-functionalism, the latter an ethnography of genealogical identities and property transmission. Taking social networks to an analytic phase (Mitchell 1969) produced data that opened to view the fluidity of social structure and organization. Soon, analytically minded anthropologists turned to transactional and then to symbolic theories. Few in anthropology have continued to work the interface between networks and anthropology both analytically and substantively. Even while Harrison White's diverse and highly creative students established an expanding theory group in sociology (Mullins 1973), contributions of anthropology to networks and networks to anthropology in D. White´s and subsequent generations of students have been remarkably productive.

White has worked the network/anthropology interface for some 36 years, as did Thomas Schweizer from 1988-1999, so illustrations here draw on White's work as well as a sample from others' contributions to findings and new developments in the interface between networks and anthropology. Looking at the contributions over just the last 15 years, it is remarkable how the relatively few anthropologists working this interface—Bernard, Boster, Johnson, Mitchell, Schweizer, myself and Wolfe, for example, and not including thousands of anthropologists who use the term network without any specific network analysis—have made such a difference, in both directions of the network/anthropology interface, given the impressive number of sociologists who have turned to networks as their primary framework. But even such organizations as the annual Sunbelt networks conference was originally organized by anthropologists (Bernard and Wolfe), and we have made more than our share of contributions. The point being that by enhancing our capabilities to perform network analysis of ethnographic data, which can most easily done first in large research institutes, there are still plenty of discoveries to be made in this area and the enhancement of our productivity on diverse topics in this commensurate approach is likely to yield major returns to investment.

¶22 Contributions of Anthropology to Network Analysis (examples)

- Cohesive embeddedness (Moody and White 2003)
- Consensus analysis (Batchelder and Romney 1988, 1989, Romney, Weller and Batchelder 1986)
- Edge-cohesion models of conflict and fission (Zachary 1977)
- Entailment analysis (White and McCann 1988)
- Flow centrality (Freeman, Borgatti and White 1991)
- Informant Accuracy: the gap between network memory and behavior (Bernard et al. 1984)
- Material culture lattices (Schweizer 1993a,b)
- Networks and cognition (Boster 1986)
- Regular equivalence (White and Reitz 1983)
- Reverse small world experiments (Killworth and Bernard 1978)
- Structural cohesion (White and Harary 2001)
- Structural equivalence (Lorrain 1968, Lorrain and H. White 1971)
- Structure of the world economy (Smith and White 1992)

*¶23 Contributions of Network Analysis by Anthropologists to Ethnography and Social Anthropology*

Conical clan (Hage and Harary 1996)
Dual ordering analysis of possessions (Schweizer 1993c)
Endoconical clan (White and Johansen 2004)
Ethnographic embeddedness (Schweizer 1997)
Identity and control, network theory (H. White 1992)
Graph theoretic applications (Hage and Harary 1983, 1991, 1996)
Ethnic Identity and genealogy (Johansen 2000)
P-graphs (White and Jorion 1992, 1996)
P-systems (Harary and White 1991)
Positional analysis (White and Reitz 1983, Schweizer 1988)
Redefining complexity in marriage systems (White and Houseman 2002, White and Johansen 2004, White 2005b)
Relational cognition (White 2005a)
Resolution of the Natchez paradox (White et al., 1971)
Resolution of the Fischer-Goodenough residence debate (Skyhorse 2003)
Sidedness (Houseman and White 1998a,b, presaged by Mitchell's 1989:77-78 finding of residential sidedness in genealogical age classes, Mitchell gave no name to this structure, but it is discussed for other ethnographic examples by Hage and Harary under 'balance')
Structural Endogamy (White 1997, Brudner and White 1997)
Structurally defined social class boundaries (Brudner and White 1997, Fitzgerald 2004)
Two-mode analysis, ritual (Schweizer 1991, et al. 1993)

## VIII. **Epilogue: Collaborative Research Communities**

*¶24 Collaborative Endeavors and Communities of Scholars*

We have proposed here some institute-level inputs to support researchers in their generative use and contributions to the fields of network analysis. Collaborative endeavors are needed and they can be implemented not only in major research institutes in social anthropology (Halle MPI) or ones support anthropology (Irvine IMBS, ASU School of Anthropological Sciences) but in related fields and institutes that have a social science component. These might include the Rostok MPI, Santa Fe SFI, Paris EHESS, Budapest IAS Collegium, Princeton IAS, Champaign IAS, Swedish SCASSS, the Wissenschftscollege zu Berlin, Netherlands NIAS, Wien IWM, Zürick Collegium Helvetica, and so forth. Such efforts need to focus, however, on institutes with resident faculty and researchers and not those that have only transient visitors – such as the MSH Paris or Stanford CASBS. The new model for research institutes to flourish involves a certain amount of mutual help in building up the new interdisciplinary frontiers in the social sciences in ways that are helpful to researchers not only in core disciplines and scientific departments, but in recognizing the value of interdisciplinary and the usefulness of infrastructural approaches across disciplines. We need to be able to train and produce new generations of anthropological and related scientists equipped with advanced methods and theory, and either place them in departments to train academics or produce research that will influence disciplinary trajectories, including in those times of governmental shortfalls in allocation of research monies.

¶25 An example: the Kinship and Social Security (KASS) Network Studies

The KASS project, directed by Patrick Heady, is investigating the role of family networks as sources of security and mutual assistance:

> "Like the state, the family provides care, education, financial support, and help in finding employment. It also influences (and occasionally controls) choices involving career and marriage. However, the role of the family is not constant over time and space. We know, from statistical sources and sociological and ethnographic studies, that it varies greatly between different parts of contemporary Europe. Changing patterns of marriage, cohabitation and divorce, declining fertility and aging populations also have implications for the family's role in social security.
>
> Although the role of kinship in social security has important implications for state and EU policies on social security, gender discrimination and social exclusion, it remains relatively little understood - despite challenging contributions in recent decades from anthropology, economics, and evolutionary theory. One reason is that conventional data sources such as censuses and surveys do not collect the full range of data needed to evaluate these theoretical developments. The only sort of data that is capable of capturing enough factual details about kinship networks, while also investigating the way these relationships are actually experienced, is ethnographic fieldwork. A central idea of this project is to use ethnographic methods, followed by both interpretative and mathematical analyses of the resulting data, to illuminate the questions above. Another central idea is that current trends need to be understood in their historical context. The fieldwork studies will be carried out in eight European countries and placed in context by historical reviews of the development of family systems and state social security. " (KASS web page, MPIAS).

The project developed its own state-of-the-art interviewing software, called KNQ, programmed by Gordon Milligan with the help of Christian Kieser, on the basis of user and certain algorithm specifications by Patrick Heady and advice of Martin Kohli. It builds on Fischer's (2000) kinship editor. It has various enhanced visual features and hangs a questionnaire structure off the individual person icons. During the interview concerning known relatives and social support, the fieldworker uses a graphic interface to construct ego's kinship network and to file answers to questions about kin and other relationships. Figure 1 shows an initial graph as the interview begins, with ego marked as E (names in this example are hypothetical and actual questionnaire results always anonymized). The equals sign in the kinship graph indicates a nuclear family unit. The graph will grow as the interview progresses.

These data will be put in a basic hierarchically structured database, nominally SPSS to begin with, and will be analyzed using methods such as hierarchical and linear regressions, looking initially at testing various economic theories such as kinship altruism and reciprocity. The analysis will subsequently be expanded to investigate theoretical ideas emerging from the qualitative fieldwork. What we should like to do here tentatively is to suggest ways in which the application of Pajek could form a bridge between the interpretive analysis of the fieldwork teams and the more aggregate statistical analysis that will be carried out as just described. In many ways Pajek and SPSS data structures are compatible.

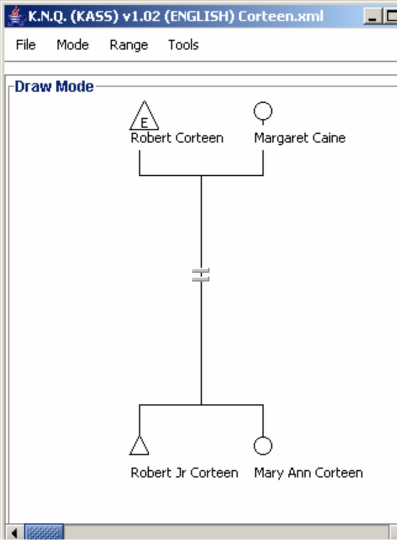

Figure 1: An ego network under construction for Robert Corteen (Hypothetical data)

Here, we consider the possibility of transforming the data saved in KNQ format not only into SPSS or other formats for statistical analysis, but also of exporting the same data into Pajek format. Figure 2 shows a graph for known kin of ego (the hypothetical Robert Corteen Sr. of this example, shown as the darkest of the triangles) in which there are four generations and square boxes that show marriages in-between the generations. This is a bipartite p-graph (White 2005) designed so that nuclear and extended family networks will typically take the form of a tree structure in which the dark lines with arrows (thick for women, thin for men) point pack either to the marriage of the parents or from each marriage to the individuals married. The thick blue arcs with downward arrows, running from Robert Corteen (senior) to his daughter Mary Ann and to her child Elinor Kerruish are coded from ego's statements about providing social support to his daughter and granddaughter.

Figure 3 shows an added analytic step taken in Pajek (menu option /Network/Components/Bi-Components) to identify the cohesive subgroups in the network. The program checks for the existence of bicomponents, which are sets of individuals (and here, any entailed marriages) of maximal size in which every pair of persons has two or more independent pathways of connection. Robert Sr. and his daughter qualify to be in such a set because they are both kin related and related here by social support. Elinor qualifies to be in the same set because she has more than one pathway both to her mother and to her grandfather. For interpretive purposes, we can note that the bicomponent evident here would be the same even if there were no direct support tie between Robert and Mary Ann, only that between Robert and Elinor.

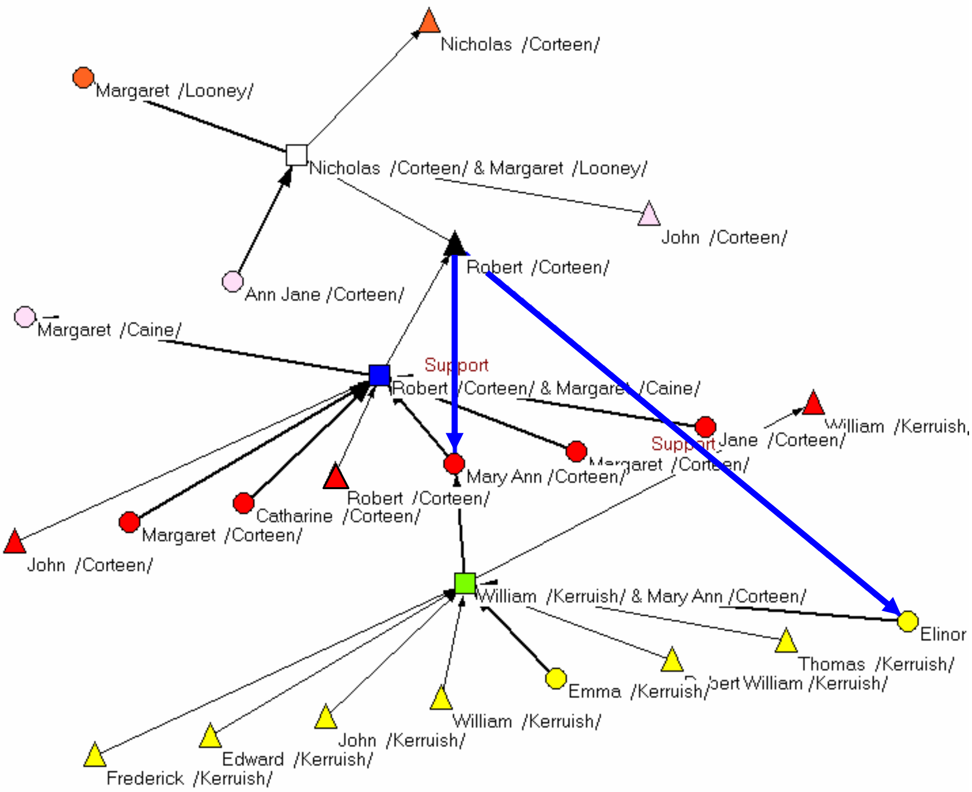


Figure 2: An ego network for Robert Corteen: Individuals, Couples (squares), kinship links (arcs up to parents), Generations (colors), and two support links (downward arcs)

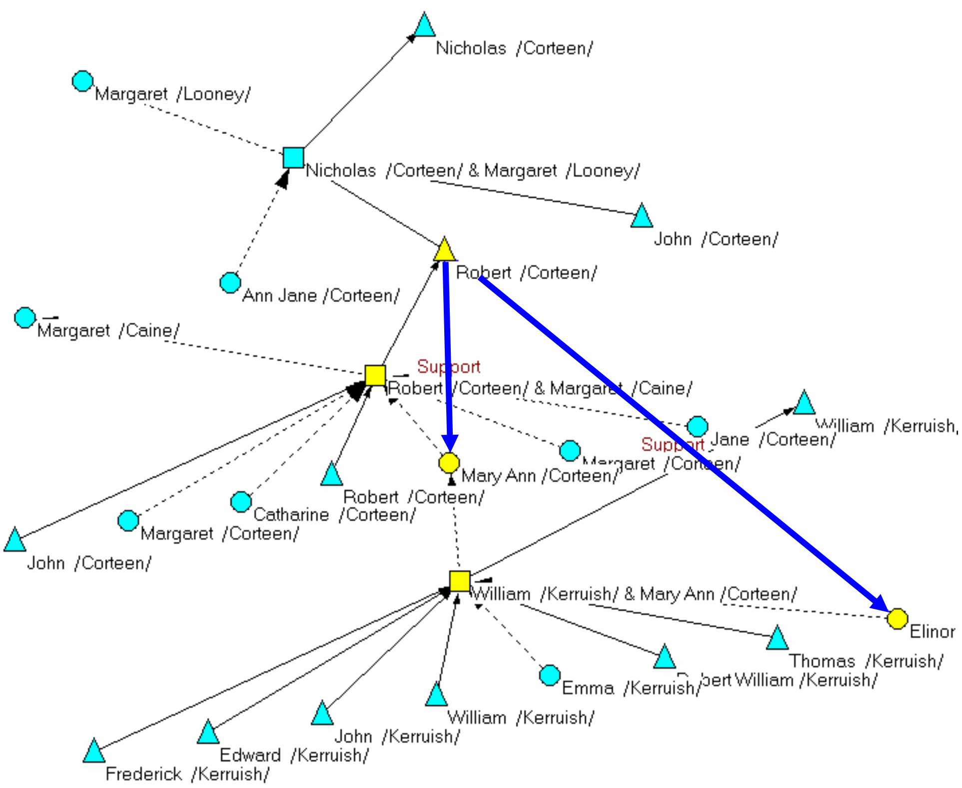


Figure 3: Robert Corteen ego network: Cohesive Subgroup Calculation (yellow nodes)

The two social support ties shown in Figure 3 are only a small fraction of the different ties in ego's network that may be identified and coded in the KASS interview, and passed along to the Pajek program for network analysis and visualization. Each different type of non-kinship tie can be given a distinct code, and Pajek can be instructed to open a project file that contains the data (either for one family, all families in a community, all families in rural areas, or as wanted for the analysis), and compute each of the sets of individuals that form bicomponents within each of the networks, taking each relation in turn. In addition, Pajek can provide summary statistics, code these sets into a binary variables, and output the calculated binary variables into SPSS for a statistical analysis of how the cohesive subgroups relate to other variables in the dataset.

This example is meant to show that

- Data can be exported into Pajek in one or several forms that are useful for analysis, whether pattern discovery or testing hypotheses.
- Egocentric data can be treated as networks even if the only relations are the known kin of ego, and ego's relationships with kin and/or non-kin who have other relationships with ego.
- The network analyses performed can be batched for analysis inside Pajek and the results of a batched analysis can be passed to SPSS and added to the SPSS variables. Pajek will do the formatting in SPSS, open the SPSS program to view the results, and allow the new results to be merged with already existing SPSS files. The use of appropriate identifiers for cases (e.g., individuals, families, communities, regions) can be used to check that the files are correctly merged.
- Some or all the data from the KASS interview can be saved in a single *.paj Pajek project file that allows the viewer to scroll through the individual families, view and reorganize the visual configuration of each family network, manage multiple relations, and save the output back to a second or enlarged project file.
- When desired, new variables calculated by Pajek, whether demographic or network characteristics, can be saved into the Pajek project file and exported to SPSS.

Typical demographic characteristics for an individual ego-centered family that might be calculated in batch mode (by the use of macros) within Pajek are: distribution of nuclear family sizes; the household sizes or their averages for different egos; the number of children, wives, or of an inventory of different types of kin of one or more egos; known kin indices such as the number of generations, density of ties, number of marriages per person. Many other variables, of course, may be calculated. The important features of Pajek for data analysis are these:

- For each type of analytic variable wanted, the calculation can be tested, viewed while examining the graph of raw data, and, by activating the /Menu/Record operation, the procedure can be saved for repeated use.
- Macros so constructed, after testing, can be combined in serial fashion, so that more complex analytic operations, or combinations of existing macros, can be performed in batch, saving the output in an appropriate form.

- The results of individual or batch operation can be saved.
- The user can decide which results to add to SPSS or the Pajek project file.

Among the operations that can be performed are all those listed under ¶11 above. Because Pajek is an operational language for successive or serial operations, where the output of one step in analysis being used for the next step, additional programming is not mandatory. By testing operational steps and saving operations as macros, then combining the macros when needed, Pajek produces as macros the equivalent of special programming for a given set of ethnographic and analytical projects, and these can be saved for future or repeated use.

Some sites that are useful to learn more about the use of Pajek are these:

- Sample multiple relations formats of Pajek files, and various transformations - http://mrvar.fdv.uni-lj.si/sola/info4/multinet/multinet.htm
- How to: http://vlado.fmf.uni-lj.si/pub/networks/pajek/howto.htm
- Applications - http://vlado.fmf.uni-lj.si/pub/networks/pajek/apply.htm
- Pajek / How to: Visualize genealogies http://vlado.fmf.uni-lj.si/pub/networks/pajek/howto/genea.htm
- Pajek / How to: Generate random genealogies http://vlado.fmf.uni-lj.si/pub/networks/pajek/howto/geneoRnd.htm
- Analysis of genealogies and large networks http://mrvar.fdv.uni-lj.si/sola/info4/andrej/prpart6.htm

There are numerous contributions to the study of egocentric family networks by network sociologists (e.g., Degenne 1999 and Degenne et al. 1999, 2003; Kellerhals, Widmer, Levy 2003, 2004, Levy, Widmer, and Kellerhals. 2000, Widmer, Eric. 1999, 2004, Widmer, and Weiss 1999, Widmer and La Farge 1999, 2000, Widmer, Kellerhals, and Levy 2004 forthcoming) and anthropologists (e.g., Johansen 2000) that can be emulated by these methods or more extensive data collection. One of the most useful of the methods of ego-centered family networks is that of Widmer (1999), who uses interviews from members of the same families and compares their differences in perception in terms of position within the network. His work also considers extended but reconstituted families in which step families and divorced partners bridge segments of the kin network.

In the KASS project, with 40 interviews from distinct families in each fieldsite, there may be some rural sites in which name-matching of individuals from different interviews may show connectivity across families (e.g., Brudner and White 1997). In principle, merging can be done by exporting the data from KNQ, using other software to check for melding genealogies into larger connected networks. This is a standard procedure in genealogical software. (Alternately, on future projects, the KNQ program itself might be an efficient context in which to consider name-matching such that the same nuclear families and individuals can be reliably identified across interviews.) In practice there will be some problems because of the KASS confidentiality rule that personal names are not included in the ties sent over the internet even from fieldworkers to the project HQ. However, in the case of the communities concerned, it would be worthwhile because of the analytic gains to try and overcome these problems. Merged genealogical networks can provide some additional measures of kinship cohesion and segmentations occurring in relation to both consanguineal and affinal ties, controlling for such factors as population size, migration, and dispersal workplaces. Structural cohesion and many other types of network analysis, then, can be done not only for one-family (known relative) genealogical ties plus other relationships but for larger networks where applicable.

## VIII **References**


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