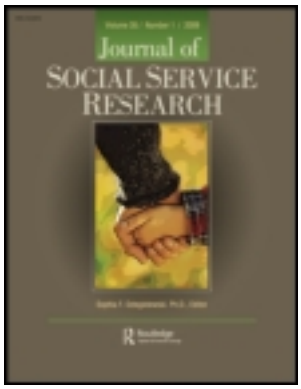

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Social Network Analysis for Analyzing Groups as Complex Systems

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ABSTRACT. The introduction and application of social network analysis, a method seen as superior to experimental or single-system research design for showing group change, examined group dynamics and change over time using a hypothetical example of an Internet group for gays and lesbians. Rather than utilizing traditional definitions of independent and dependent variables, the analysis utilized hypothetical data with nodes or individuals, ties, and the relationships they formed. The recently developed computer program NodeXL provided diagrams and statistics that demonstrated node and tie variation and individual and group development over time. Discussion demonstrated the utility of such diagrams for research and practice.

KEYWORDS. Social network analysis, LGBT support groups, complexity theory

Consider the following hypothetical example: A licensed social worker with a master's in social work had several closeted gay clients who have said they want to come out—that is, make their gay status public. However, they were concerned about the difficulties of doing so and had been seeking advice and support. To provide a safe place for discussion, the social worker created an online discussion forum. The social worker worked with other professionals such as clergy who participated in the group and invited participation of gays and lesbians who had been struggling with coming out. A secure means of entering the discussion group was created, and part of that procedure was the creation of an online identity. Upon entering the group, each person was required to create a profile. The profile asked for a user nickname (a display name), their occupation (professionals only), and whether or not they were openly gay. Closeted individuals, those who had disguised their gay status in public, were encouraged by their therapists to post their concerns and use the group to seek advice and guidance about the coming-out experience. The professionals hoped that the ensuing conversations would help the individuals come out

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in a safe environment. If they did come out, the individuals were encouraged to remain active in the group and contribute advice to others based upon their experience.

The group described here was chosen because it exemplified interplay between the individual and social conditions in several ways, and social network analysis (SNA) was developed to assist researchers in their pursuit to describe that interplay. First, members of an Internet group would have had inherent issues of safety when discussing issues with unknown members. On one hand, participation online has had the danger of long-term vulnerability to ultimate revelation of that participation. On the other hand, anonymous online participation has included concealed identity, which has offered protection, and use of the Internet to explore gay status might have been seen as a possible way to connect to people with a similar set of concerns—something that may have been impossible in a direct-contact context dominated by heterosexual people (Quinn & Reeves, 2009). Third, the concealment of gay identity versus coming out itself would have been an issue of the individual in relation to social context. Finally, the example illustrates change, both of individuals and their social context—important issues needing to be addressed.

Groups like the one described above have been viewed as a social network. A social network has been defined as an articulation of individuals' connections, usually one type of connection such as family or friendship (Watts, 2003). Social networks have been seen as dynamic and frequently changing, or dynamic systems (Israel & Wolf-Branigin, 2011) that include both local and global aspects (Arrow, McGrath, & Berdahl, 2000), or in traditional system terms, micro or mezzo aspects. Behavioral conditions, like being "out," were usually considered local or micro conditions. The consideration of the social network in social services and in social service research has united local and global conditions. To the extent that social ties have been created, altered, or broken, global change has occurred. These changes have been viewed as changes of social structure that created the small worlds and giant components that became the very basis of rapid transmission (Guimera, Uzzi, Spiro, & Nunes Amaral, 2005; Uzzi & Spiro, 2005; Watts) of things like advice. So, if a group facilitator called upon a specific member to respond to another member, they would have initiated alteration of the global structure of the group. In this article, we have proposed that the analysis of a social network can reveal the combination of local and global conditions that are important for both research and practice.

We have designated the primary purpose of this article as being the demonstration of the potential of SNA over traditional research methods, and we have argued for its inclusion, along with its theoretical bases in complex systems theory, as a research and assessment tool for use by the social services, particularly when examining group dynamics. In doing so, we have a) described the need for SNA that has begun to be addressed in the literature, b) described the general characteristics of a social network, c) provided an overview of the complex systems theory supporting SNA, d) demonstrated the basic methodological capabilities of SNA for considering the social and temporal context, particularly in a support group designed to provide advice for closeted individuals, and e) provided an example of the analysis of the influence of the social network underlying the aforementioned support group.

THE NEED FOR SNA

A quarter century ago, McIntyre (1986), a social worker, called for the analysis of social networks. She saw networks as potential sources of information, assistance, and social support, opportunities to gain competence, and sources of influence on decisions affecting well-being—all extremely important aspects of the provision of social services. McIntyre also pointed to the underdevelopment of research methods in the area and the need for the analysis of social networks to be informed by practice. McIntyre said that direct ties, the relationships of one person to another, had been considered, but indirect ties had not. This practice was continued by Hardiman and Segal (2003) in their examination of the community membership and social networks in mental health self-help agencies.

Similarly, McIntyre said the attributes of people were considered but that the larger network was not, again exemplified by Hardiman and Segal's work. Clifton, Pilkonis, and McCarty (2007) did consider the larger network, examining centrality or the importance of a person in the network, in relation to ties while examining the social networks of individuals with borderline personality disorder, and Fuller et al. (2007), while looking at service linkage in Australian farmers' mental health, did pay some attention to the variation of ties such as reciprocity versus one-way transmission and the multiple kinds of transmission called for by McIntyre. Webb (2008) recently renewed the call for the use of SNA in both research and assessment and pointed to specific empirical methods as well as the potential for better understanding of the social environment while modeling service user participation in social care.

COMPLEXITY THEORY

We have asserted that the postulates of complexity theory guide the interpretation of the global structure of the social network in relation to the change and spread of local conditions like being "out." Applying systems theories such as complex systems theory or complexity theory has been seen as an important consideration in the social services (Hudson, 2000a). Complexity theory has provided the basis for inquiries into "how behaviors adapt to features of context, particularly the spatial properties of contexts and the relative availability of desired resources within those contexts" (Israel & Wolf-Branigin, 2011, p. 22), and it relies on general systems theory with an ecosystem approach (Wolf-Branigin, 2009). Basically, complexity theory has sought to identify patterns as they emerge from seemingly random contextual situations. Many of the social services articles related to complexity merely suggest that it may be conceptually applicable to understanding social services-related phenomena (Halmi, 2003; Hudson, 2000a, 2000b; Hudson, 2004; Warren, Franklin, & Streeter, 1998). However, a few others applied it metaphorically (Bolland & Atherton, 1999; De Jong, 1995), used it for evaluative purposes (Wolf-Branigin, Jensen, & Smith, 2008),or actually sought dynamic data patterns (Israel & Wolf-Branigin; Warren, Hawkins, & Sprott, 2003; Warren & Knox, 2000). Israel and Wolf-Branigin described agent-based modeling of complex systems, and Woehle, Jones, Barker, and Piper (2009) applied such modeling to network theory.

Change Over Time

In this article, we have asserted that the power of complexity theory in the social services lies in theory and modeling of practice-like processes. Complexity theory and modeling have been called process-driven (Cederman, 2005), but SNA was developed to reveal the structure of a network at the time data were gathered. For example, researchers could examine the closeted individual's ties to those who gave advice during a limited time. However, as Webb (2008) described, the nodes, which represent people here, and ties, which represent peoples' relationships, will come and go, their attributes will change, and the combinations of such changes will yield substantially different network diagrams at different times. In our example, the movement of the closeted individual's relationships and behavior would have been different at different times. In this case, an examination of the social network at one time might have demonstrated the closeted individual receiving advice from one network of people and ties, whereas the SNA at a later time might have revealed the same individual as a giver of advice in a different set of ties. So, SNA will have been effectively used when it reveals change over time, and this can be accomplished by undertaking SNA at multiple times.

Complex Causality

Because influences move and develop in the network, complexity theorists have asserted that causality cannot be thought of as it is in the context of the controlled experiment. Traditionally, scientists have sought the simplest answer to a causal question, assuming that it was the best answer. As the name of complexity

theory implies, it has not made that assumption. For example, traditional quantitative methods might have seen individuals as units of analysis and their attributes as variables. Some of these variables were independent, the potential causes, leading to other dependent variables, the potential effects. Traditional explanations would have reduced the number of independent and dependent variables to the smallest possible number and considered them in a fixed set of independent units of analysis. SNA and complexity theory have continued to simplify reality, and units of analysis and variables have continued as part of the analysis. However, SNA has developed the additional ability to show changing and interconnected sets of units of analysis, as well as the flow of influence on variables from one such unit of analysis (or person in the present article) to another. In addition, ties have become another kind of unit of analysis with their own attributes. Overall, SNA has been used to show the impact on the larger network as nodes and ties change. So, although basic SNA data may have resembled traditional quantitative data in part, we have asserted that the ways in which these data are recorded and how causal relationships would be analyzed by SNA should be influenced by complexity theory.

How have causal issues been approached in complex social networks? Watts (2003) saw networks as a result of developing relationships that began with small dyads and cliques that were not connected to one another. As Barabasi (2003) described it, when a certain density of relationships is reached in a population, relationships that connected these smaller structures have caused a giant component to emerge in a rapid-phase transition. This kind of change, called the dynamics *of* the network by Watts, has been viewed as an accumulation of developing ties. In groups, changes of ties have been called global dynamics (Arrow et al., 2000). The second area of complex causality has been demonstrated by change of local variable values across a network. Watts called this process dynamics *on* the network and it often follows an S curve. In groups, local change, like coming out, might be observed first among the persons most predisposed to do so, and as more predisposed nodes were exposed, the process might have accelerated. Then, as the transmission has changed most of the nodes and they are not predisposed to further effects, a slowed process would be observed. The slow, to fast, to slow progress would have approximated the letter S; thus, it has been called an S curve. Modeling, like that of Woehle et al. (2009), has shown that dynamics on the network can cascade in a phase transition, and Fowler and Christakis (2010) provided empirical support.

Group Stages and Causality

Understanding of dynamics of and on the network has led to causal considerations incorporating nonlinearity (Israel & Wolf-Branigin, 2011) where apparent effects are not proportional to apparent causes, and in some instances surprisingly so. The irregular and multilevel nature of this change has increased the importance of observing change, or the lack thereof, over time. Traditionally, change in groups has been seen as a series of stages that Arrow et al. (2000) have reduced to three. Their first stage was group formation, which we saw as the initial establishment of ties. In our example, we presented an initial exchange of four people. Second, Arrow and her coauthors described an operation stage in which a set of ties existed. The primary activity in our example was the communication of advice and support along those ties. Finally, they saw a metamorphosis stage in which the group was transformed into something new. Arrow and her colleagues made many qualifications of this basic-stage model, but we went even further. As shown in our example, all three stages may or may not have operated at any time. That is, ties may have been created, modified, or discontinued at various times subjecting group structure to change, and the act of communication of things like advice and support altered ties so operation overlapped with formation. Moreover, because initiating or discontinuing an act of communication changed ties, the group was subject to metamorphosis at any time that changes in membership or relationships were sufficient. We maintained that if we did not observe the change of nodes and ties together, we could not understand the patterns of network change. Therefore, SNA would have to be used over time.

Change and Centrality of Nodes

We have asserted that the importance of SNA for social services research on groups lies in the ability to understand global change or local change in groups, while the importance for practice lies in the ability to intervene to bring about global and local change. Both values might have been served by SNA because it has allowed identification of the more central areas of networks where change might originate. Martins, Pereira, and Vicente's (2009) model suggested multiple nodes with high centrality. So, if a phenomenon was transmittable by the network, it would probably spread to other areas of the network from central nodes. Therefore, if the central connections of the network were located and transmittable conditions seen there were identified, that knowledge could have been used to anticipate what might have happened in other parts of the network.

Some Qualifications

SNA advocates have qualified their advice on the use of SNA. First, they have said that intervention to either promote or retard the spread of a condition would be possible (Dearing, 2009), depending on the value attached to it. As Dearing noted, all kinds of things might be subject to these kinds of spread, so much good or bad can be done through networks. In Christakis and Fowler's (2010) flu example, friends spread the flu to one another. Alternatively, encouraging friends to transmit flu prevention information by e-mail might have had the opposite result. Further, negative communication has suppressed positive outcomes for groups according to Losada and Heaphy's (2004) study. A final theoretical point regarding contextual dynamics that was ignored in our example nonetheless merits mention. The small networks diagramed here might have been considered as part of a much larger set of networks, or in context. Arrow et al. (2000) pointed to the importance of contextual dynamics for any group, and their example of an airline crew that was externally formed and whose members were required to arrive physically at the airplane and move quickly into a stable operation phase, was a group in a very different context than the group in our example. So, although we ignored context here, context is important for understanding group stability or change.

ANALYZING THE SOCIAL NETWORK

A social network in the present article was operationally defined as a set of people consisting of gay, lesbian, and professional group members interconnected by a specified set of relationships consisting of online written verbal interaction conveying advice or support. We graphed these people and relationships into network diagrams. In Figure 1, we presented a network diagram of our hypothetical group, based on nodes and ties described and defined as follows.

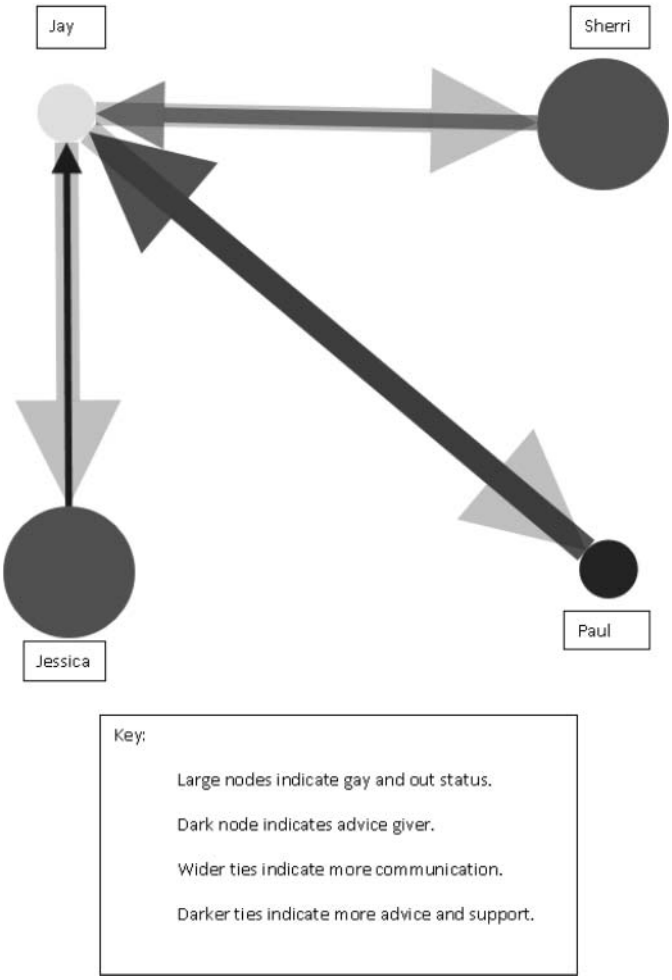
Nodes

In this article, each node in a network was designated as a person. The attributes of these nodes or people were designated as their psychological or behavioral characteristics. For example, we assumed a person has a store of information, accumulated from their experiences such as an attitude about coming out. In the figures in this article, nodes are represented by circles. Larger nodes represented people who were out, and darker shades of nodes represented the status of the person as a giver of advice and support.

Ties

The nodes or people in the diagrams were connected by ties that represented relationships. These ties also had attributes. In our example, the ties represented communication of information like advice. Ties then were the basic units of social structure with attributes like strength or direction. In our figures, the ties were represented by arrows. Arrows called in-degrees pointed to the node or person who received the communication, whereas those arrows called out-degrees pointed out from a giver of communication. The width of the arrow's shaft indicated greater amounts of communication, while darker shades indicated greater amounts of advice or support. We assumed that the cumulative pattern of all of the ties at a given time represented the global

FIGURE 1. Diagram of Hypothetical Initial Interaction Exemplified in Text



social structure of the network at that moment in time.

Limitation of Traditional Methods

We have claimed that SNA reveals how the support group in our example aided in the struggle to come out. Traditional quantitative research methods would have stripped the investigation of the ties between individuals and how those ties resulted in resolution of the struggle. For example, controlled experiments would have randomized participants' assignment to groups and probably would have been limited to two observations over time—pretest and posttest observations. Closeted individuals might have been randomly assigned to a support group or a control group (no support) to see if their comfort about coming out changed from the start of the group to the end of the group. In the experiment, the focus would have been on determining the probability that the group caused a change in attitudes, not on the extent and influence of the interaction within the group. A similar dilemma would have been present in single-subject design, a quantitative design found to be useful in the social services when studying individual people. Although a single-system design would have used multiple successive observations and therefore dealt with time better than experimental design, it would have made little or no attempt to deal with global conditions.

SNA Methods

Data collected for SNA would have demonstrated connections between individuals and change of individuals. In our example, the connection was the communication between individuals. By inquiring about the connection and diagramming the network, a depiction of social context might be achieved. Both nodes and ties, as well as nodes' effect on one another via ties, might have varied over time, so the out status of a group member might have been influenced by the group members with whom that member has had contact. The ties could also have been given attributes. In our example, ties were weighted according to the amount of communication shared between the two individuals. Between any two individuals, the ties might have varied from nonexistent, to going from one ego to alter, that alter to that ego, or both, and these directional indications might have become tie attributes. Thus, examination of the social network not only included assigning attributes to the individuals or nodes in the form of predispositions, but extended the analysis to include variation in the ties. So, ties and their attributes have been added to traditional analysis of people and their attributes. Finally, the total network can be viewed using SNA. So, individuals, specific social relationships, and the resulting cumulative network have become apparent through SNA.

Recently, Smith et al. (2009) developed an accessible add-on template for Microsoft Excel, called NodeXL. As indicated, Smith and his colleagues sought to develop "a tool that avoids the use of a programming language for the simplest forms of data manipulation and visualization, to open network analysis to a wider population of users" (p. 2). Webb (2008) described data analysis using previously developed programs. Although Webb found these programs to be elementary, Smith et al. argued that they require higher technical skills and interfaces between statistical programs that are not required by NodeXL. Furthermore, as Webb noted, older SNA programs often required data matrices, a complex format not found in most social services research methods texts or understood by social service practitioners. The shortcomings of earlier computer programs might have explained why SNA has been rare in social service research and certainly made it inaccessible as an assessment technique in practice. For anyone who has become familiar with Excel, however, NodeXL can be quickly learned. Network data can be entered by simply listing the interacting dyads in Excel columns. In our case, an interacting dyad was simply the names of the two people communicating. Multiple listings of dyads can be automatically collapsed and weighted. So, if two people interact three times, that tie can automatically be given a weight of three, or attributes of the dyadic tie can be calculated and entered manually. A spreadsheet displaying an unduplicated list of nodes, or names in our example, can be made available at the click of a mouse, and several statistics can be calculated for nodes or the total network. For example, betweenness centrality, a measure of the extent to which a given person is on a path between other people in the network, can be calculated for nodes. Smith et al. also developed visualization capability in NodeXL, and through the click of the mouse, this program can depict networks with varying node and tie characteristics and can use differing algorithms to arrange nodes. In addition, nodes in the network diagram can be dragged and dropped with the mouse for optimum visual clarity. Also, the diagram image can be moved to the clipboard for insertion into other documents.

In short, NodeXL has made network analysis accessible. A network diagram can be drawn directly, can be manipulated manually, and can be converted to text formats for publication or presentation. Smith et al. (2009) have met their goal and developed "an extendible network analysis tool kit that encourages interactive overview, discovery and exploration through 'direct' data manipulation, graphing and visualization" (p. 2).

A HYPOTHETICAL EXAMPLE OF SOCIAL NETWORK ANALYSIS

Consider the following exchange in our hypothetical Internet support group for closeted individuals.

> ***Jay (male, 36, closeted):*** *Hi. My social worker has asked me to introduce myself*

to the group. Well, hi. I am 36 years old. I am not married and have always gone out with women. However, I recently had a few sexual encounters with guys and I find myself no longer attracted to females. My best friend is coming to stay with me, and when he's in town, he likes to bar hop and pick up women. So, any suggestions on how to come out to my friend?

Paul (male, 49, social worker, straight): *Hi, Jay. Nice to hear from you. Welcome to the group. A couple of questions: a) How long have you known this friend? b) Have you shared personal intimate details? c) What do you anticipate the response will be?*

Sherri (female, 22, open): *Hi, Jay. I am open about being gay. I told my best friend that I was a lesbian before I told anyone else. She hugged me and told me that she loved me no matter what. She also told me she had suspicions. I have done lots of reading on other discussion boards, and I notice that most people's friends had some idea that their friends were gay.*

Jay (male, 36, closeted): *Thanks to both of you for your words. To answer Paul, we have been friends since childhood, and he was there during my mom's death. So I have been in situations where I have shared intimate details with him. I am nervous that he will shun me because he often makes comments about how 'so-and-so' looks so gay.*

Sherri (female, 22, open): *I hope he doesn't shun you. Good luck.*

Paul (male, 49, social worker, straight): *Hi, Jay. Thanks for answering my questions. It has been my experience that long friendships seem resilient to change. However, not all individuals do well talking openly about being gay or lesbian. Do you have a sense of what you want to say to your friend? Maybe one thing I can do (or the discussion group can do) is help you role-play what you want to say to your friend.*

Jessica (female, 63, open): *Hi, Jay. Welcome to the group. Hope your talk goes well.*

Jay (male, 36, closeted): *Here goes—Paul, I have something that I need to tell you. I'm gay. I have been attracted to men for about 2 years now. Don't worry, I'm not attracted to you. What do you think?*

Paul (male, 49, social worker, straight): *Looks good, Jay. One suggestion, though. I would not reassure your friend that you are not attracted to him. My concern is that would distract him from supporting you and would immediately redirect him to think of your relationship with him, rather than focusing his energies on listening to you.*

Jay (male, 36, closeted): *Well, I told my friend. Sherri, you were right; he suspected that I might be gay. When I told him, he stood up, gave me a hug, and reassured me that our relationship will be OK. Thanks, everyone.*

To make a network diagram, data regarding the nodes and ties must first be coded. The coding for the above dialogue is provided in Table 1.

Participants in the exchange were listed in the first two columns. The communication exchanged between Jay and Sherri demonstrated many of the coding considerations for data entry in NodeXL. Those who were out had their name bolded in the table and their node bolded in the diagrams, as was the case for Sherri. Jay and Sherri have communicated in both directions, and a separate tie entry was made for each direction of information flow. We assumed that if the social worker Paul had coded the information for mapping the network, he would have had to make some judgments about the content. Further, the coding would have to be in a readable format for NodeXL, which would make nodes or

TABLE 1. Data on Out Status of Persons and Rankings of Communication

Pairs of People in Interaction		Communication Amount (Width)	Proportion of Advice and Support (Opacity)
Jay	Paul	5	1
Paul	Jay	4	3
Jay	**Sherri**	3	1
Sherri	Jay	2	2
Jay	**Jessica**	3	1
Jessica	Jay	1	4

Note. Out Status Bolded.

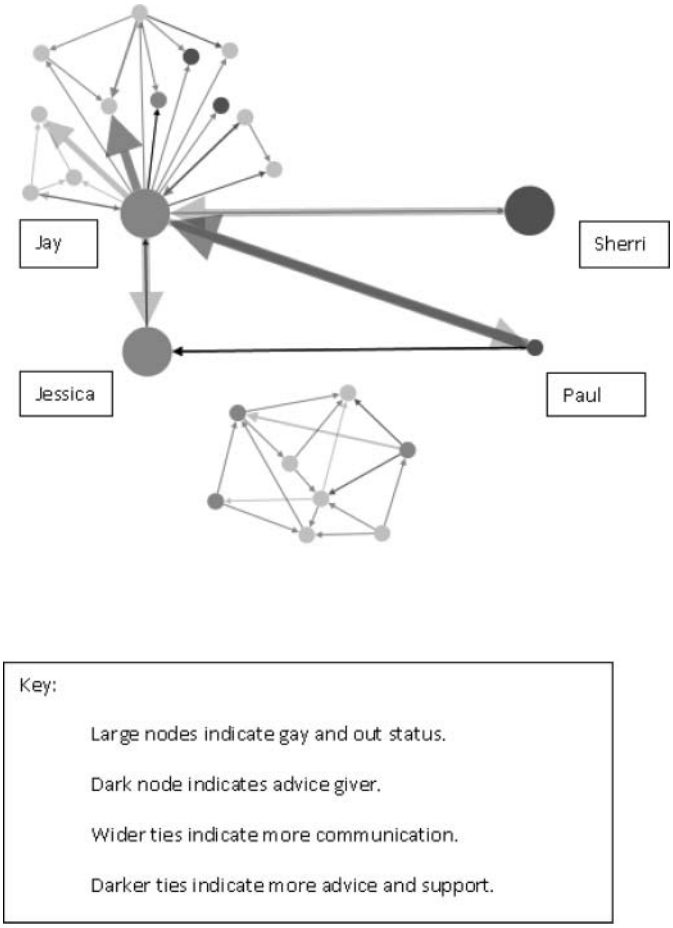
ties of size 0 invisible, so all coded values would have to be greater than 0. We suggested a ranking system that ranked relative amounts of communication and advice and support. We assumed that Jay's general introduction was addressed to Sherri as well as the other respondents. Jay told us his age, his recent acceptance of his sexuality, and his problem of coming out to his friend, and he provided an eventual report back to Sherri. Sherri told us she is out, that she first came out to her best friend, that her friend had suspected she was gay, and her friend accepted her. Note that Jay's communication to Sherri is of substantially greater length than Sherri's communication to Jay. Thus, Jay's communication was given a rank of 3, while Sherri's was ranked 2, in an assumed larger range of ranks in the whole coding system. Coding the content required some judgment, because at first glance, both seemed to be introducing themselves. Jay's introduction had the purpose of providing information to others while asking for help and then reporting the result, but Sherri's communication included implied advice and support, namely: 1) I have done this, you can too; 2) your friend may already have an idea you are gay; and 3) your friend may accept this, but it is possible he will not. So, we ranked Jay's statement as the smallest possible, or 1, for advice and support, but ranked Sherri's statement as 2 because it implied advice and support beyond the information given. We have kept this relatively simple to provide a readable example here, and actual applications of NodeXL could use a variety of coding schemes.

The data from Table 1 were also used to configure Figure 1.

Again, we represented the exchange between Sherri and Jay. Arrows pointed from the person addressing to the person being addressed, so an exchange had arrows in both directions, true for all exchanges in Figure 1. The darker the shade of the arrow, the greater the proportion of advice and support, so the dark shaft pointing to Jay indicated more advice and support. Data on the communication were also represented in the nodes: When a node was a receiver of advice and support, the node was given a darker shade of gray, exemplified by Jay compared with Paul. Then, the lines were ranked in terms of the amount of communication, which provided the width for the ties as seen in Figure 1; wider lines meant more communication. The amount of communication and the amount of advice and support varied, so two overlapping arrows were developed in each case. This was most evident in the exchange between Jay and Jessica. Clearly, Jay communicated substantial amounts of information and questions to discussants including Jessica, who responded with a smaller amount of support. Thus a light (non-advice/support) but broad (large amount) arrow described the flow of communication to Jessica, who responded with a small amount (narrow) of support (dark). Finally, some judgment was used in data coding for direction of the arrow. For example, when a person posted a question, it was not always addressed to a particular member. So, it was assumed to be addressed to the person who responded.

More developed networks were diagrammed in Figures 2 and 3. Those networks built on the initial exchange in Figure 1, still visible and labeled with names in Figures 2 and 3. The pattern of Figure 1 was arbitrarily maintained

FIGURE 2. Hypothetical Developing Interaction Network Around Initial Interaction



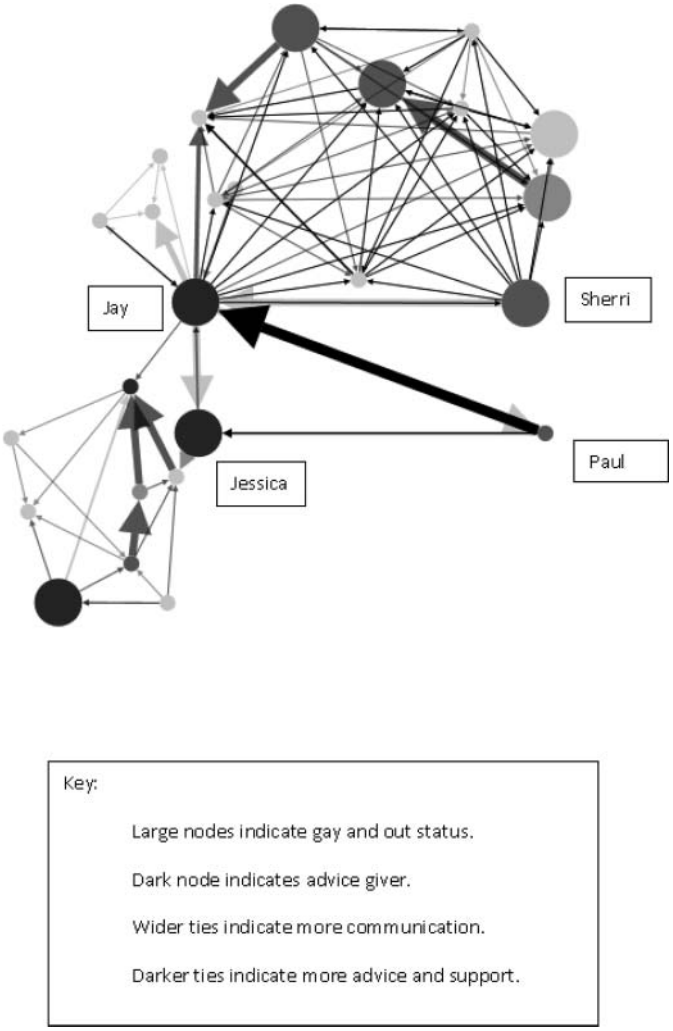
in our example to clearly visualize network development.

In Figure 2, we diagrammed Jay as a large node, or out, and showed him as communicating with many additional participants. Indeed, Jay had become an important figure in the expansion of the network of communication. In addition, a new interacting group had emerged separate from the initial group. This might be a group that had come to the site with recommendations from a professional other than Paul. None of the participants in either group were out, and the group in the lower part of Figure 2 was cliquish, meaning that members tended to interact with all other members. The amount of interaction was small in both groups in Figure 2, indicated by the narrow lines, and the light shade of many lines and nodes indicated that the amount of advice and support was limited.

Figure 3 showed continued development of the interaction. In Figure 3, Jay and Jessica reached out to the previously isolated clique in the lower part of the diagram. There were three subgroups evident in Figure 3: a large clique of mostly out participants at the top of the diagram, a small clique of closeted participants to Jay's left, and another clique below Jay. All three gay participants from Figure 1 were now key connectors of the three cliques in Figure 3, while the social worker Paul had become somewhat isolated.

Jay's role changed considerably, both by coming out and by becoming central to the group. Jay had established relationships to the clique in the

FIGURE 3. Hypothetical Developed Interaction Network With Initial Interaction



upper part of the network and reached out to the remainder of the network. He had evolved from a receiver to a giver of advice and support, resulting in local change. His activity resulted in global change as well. Because many of the paths from one extreme of the group to another passed through Jay, he had high betweenness centrality. His centrality would have been a key to holding the cliques together and thus facilitated communication across the group. Indeed, Jay's and Jessica's changed roles showed how a small amount of activity led to a large change in the group structure. As individuals, both would probably have seen their connections to the group in the lower part of Figure 2 as a small effort. However, by connecting the two parts, the overall network size increased dramatically. So, the large global change was precipitated by relatively small local efforts by Jay and Jessica, a nonlinear phase change. If Jay was to drop out and new ties were not established, the group network would be split again. Jay's position demonstrated the potentially rapid nonlinear change suggested by complexity theory and showed how local change is connected to global change.

DISCUSSION

The local and global development depicted in the movement from Figure 1 to Figure 3 suggests

that SNA interpreted according to complexity theory is important for both research and practice. At the local level, we can map the changes that individuals make in psychological dispositions and behavior, such as showing a member of our group as being out by diagramming that individual as becoming a larger node. However, SNA incorporates such local or individual change with social or global change. For example, we indicated Jay's role changed considerably, both by coming out and by becoming central to the group. SNA incorporates the aspects of role that relate to individual behavior as well as to relationships with others. When a group member adopts a new role that is perceived as a positive change by the individual and other group members, it also serves as a model and a potential source of advice and support for group members. When interaction with that newly changed person is initiated, the group changes. SNA reveals both kinds of change, a valuable contribution to the analysis of groups. In practice, the observation of the local and global changes is appropriate for assessment in groups, because the practitioner should be interested in both. In research, multiple observations of local and global changes in various kinds of groups might lead to better conceptualization of the ways in which the two kinds of change work together.

Examination of the complete network diagram reveals yet more global change. For instance, if we examine the total network pattern as it changes over time, some individuals will be much more central than others. Statistics for measuring centrality include the betweenness measure we mentioned earlier. People with relatively high betweenness might be more influential than others because their influence can easily flow out several degrees to most members of the network. Further, a group member can develop centrality by reaching out to other group members, and though the initial effort may be small, the global result may be large. Jay's and Jessica's changing roles show how a small amount of activity can lead to a large change in the group structure. If one member connects to members in another previously unconnected part of the network, the size of the overall connected component increases dramatically. So, the large global change may be precipitated by relatively small local efforts, a nonlinear phase change. Moreover, SNA can point to the people who are holding the group together: Jay as the lone node between two parts of the network, for example. Change in the network structure is global change, but rapid local changes might also result from changes in the network. In our example, the rate of coming out might be accelerated by the availability of connections to people who were out previously. Rapid nonlinear change, whether local or global, suggests the importance of complexity theory. Using SNA over time would make such changes clear.

Local and global changes in groups are relevant for both practice and research. With regard to practice, a group worker like Paul would be interested in how he or she is situated in the network. SNA allows ongoing assessment of that place. Conversely, the development of the group should eventually begin to supplant the place of the group worker, so the practitioner needs to monitor the group development as well. For research, group stages reviewed above—formation or the initial establishment of ties, operation as the ties exist, or the metamorphosis stage in which the group is transformed into something new—might be approximated by network diagrams for assessment and may reveal how group stages overlap for advancing research. Although our hypothetical diagrams accumulated over time, NodeXL also allows filtering by time, so that the emergent forms could be automatically filtered to observe sudden changes to notably different stages. Further, an assessment use for SNA might include potential harm that might lie outside the group in the larger context. This article has not emphasized context—that is, group members' ties that extend outside the depicted networks. Contextual dynamics of such ties have been addressed conceptually by Arrow et al. (2000) and have been exemplified by the communication reported by Jay regarding coming out to his friend in our example. Jay was concerned about the effect of coming out on his friendship, but dangers in the context might extend further even to physical violence. Our discussion has been limited to the group participants, but the issues of contextual dynamics cannot be ignored in either research or practice. So, we would suggest, even urge, future

attention to contextual ties in both research and practice.

Finally noteworthy is the fact that network diagrams can be combined with traditional research methods to reveal network forces. Because the network diagram can clearly locate the surrounding nodes or people, data for analyzing such impacts can be reliably accumulated directly from those people. Those data, converted to traditional variables for persons as units of analysis, could then be used in such traditional methods as regression. For example, the proportion of persons connected to a given person who is closeted could become an attribute predicting the coming out of the given person. Across all people in a network, each closeted person might have such attributes which that then be analyzed to predict coming out at a later time.

In brief, SNA is seen as a valuable tool for research and practice in the human services. We have presented a group example to show how it might be utilized and how research or practice might be informed by its use. Finally, understanding the complexities of human interactions within social services will be best improved with SNA if the social networks are interpreted in the context of complexity theory.

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