BJM BRITISH JOURNAL OF MANAGEMENT
British Academy of Management

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Journal:	*British Journal of Management*
Manuscript ID:	BJM-11-184.R2
Manuscript Type:	Methodology Corner
Keywords:	social networks, network data collection, sociograms, network data display, network visualisation software, research ethics
Primary Special Interest Group (SIG):	Research Methodology
Secondary Special Interest Group (SIG):	Human Resource Management

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Abstract

Innovations in network visualisation software over the last decade or so have been important to the popularisation of social network analysis (SNA) among academics, consultants, and managers. Indeed, there is a growing literature that seeks to demonstrate how 'invisible social networks' might be revealed and leveraged for 'visible results' through management interventions. However, the seductive power of the network graphic has distracted attention away from a variety of emerging and long recognised concerns in SNA. For example, weaknesses exist in data collection techniques that often rely on nominal boundary-setting and respondent recall. Non-response can also be highly problematic. Increasingly, email data are being employed, yet this represents a poor proxy for relationships and raises issues of privacy. In displaying relational data, visualisations typically reify and ossify the network. Yet, individual perceptions of a network can vary greatly from unified visualisations, and their structure is typically fleeting. The aim of this paper is to draw together the diffuse literature concerning data input and visual output issues in SNA, in order to raise awareness among management researchers and practitioners. In doing so, the nature and impact of such weaknesses are discussed, as are ways in which these might be resolved or mitigated.

Keywords: social networks, network data collection, sociograms, network data display, network visualisation software, research ethics.

Introduction

The network literature has grown exponentially in recent years across a wide range of fields, including business and management (Borgatti and Foster 2003: 992). A key approach adopted in this literature

is that of social network analysis (SNA) (*e.g.* Ahuja and Carley 1999; Cross *et al* 2002; Canter and Graf 2006; Allen *et al* 2007; Casper 2007; Cattani and Ferriani 2008; Kijkuit and van den Ende 2010). It is argued that the emergence over the last 10-15 years of powerful and freely available network visualisation tools (*e.g.* 'Krackplot'[1], 'UCINET'[2], 'Payek'[3], 'Metasight'[4]), has encouraged the use of SNA techniques by management academics, and fuelled their popularisation among business consultants and managers.[5] Indeed, there is a growing literature that seeks to demonstrate how 'invisible social networks' might be revealed and leveraged for 'visible results' within organisations (Cross *et al* 2002; Cross and Parker 2004; Cross and Thomas 2009). Whilst it is recognised that not all network research employs visualisation tools to depict the social structure under investigation, there are nevertheless a rapidly growing number of examples that can be found within the academic literature, including the majority of the studies referenced in this paper, as well as in practitioner texts and on consultancy websites.

However, despite the growing use of SNA by business and management academics and practitioners, it is contended that too little attention in the literature has been focused on the nature of the data being collected, the manner in which it is being displayed, or the associated ethical issues in such studies. For example, it is common for SNA studies in the management field to be silent or underplay important issues relating to boundary-setting, informant response rates, and decisions concerning network visualisation (*e.g.* Stephenson and Lewin 1996; Chiffoleau 2005; Allen *et al* 2007). Ethical issues in relation to SNA research are raised rarely. The objective of this paper then is to heighten awareness of these concerns within the business and management community. Issues concerning individual techniques for processing and analysing social network data tend to be highly technical, and as such, are considered better dealt with in the specialist social network literature.[6]

In this paper we start by providing an overview of the scope of SNA usage across the field of business and management. We then turn to an evaluation of the accuracy and completeness of the data in such network studies, and highlight possible ways in which weaknesses apparent in survey methods, for

example, might be mitigated. We then consider the nature of the network visualisation itself, reflecting on the multiple ways in which a network may be viewed and depicted, and how such depictions may be interpreted. Finally, we surface the ethical and privacy issues associated with network research. These are increasingly pertinent because of the rise in use of SNA by consultants and managers in relation to decision-making within organisations (Cross *et al* 2001; Parker *et al* 2001). Indeed, Borgatti and Molina (2003: 338) rightly warn us that 'consideration of ethical issues [is] increasingly critical as organizations start basing personnel and reorganization decisions on network analyses'.

The breadth of SNA usage in business and management

Over the last couple of decades there has been a rapid growth in the use of SNA techniques to research a wide range of business and management issues and contexts. More recently, such techniques have been applied to the study of specialist academic communities within business and management itself. However, perhaps most interesting, is its diffusion into business consultancy and business practice.

Some of the earliest examples of social network analysis are associated with the classic Hawthorne Studies of the 1930s, where hand drawn 'sociograms' were produced to map interactions related to friendship, antagonisms, controversies, and the helping of colleagues (Roethlisberger and Dickson 1939: 502-507). Since then, others have mapped, for example, the informal communication networks between engineers within the R&D function of an organisation (Allen 1977: 208; Allen *et al* 2007: 186), the inter-organisational cooperation networks between scientists and innovators (Chiffoleau 2005; 1200-1202; Cantner and Graf 2006: 471; Fleming *et al* 2007: 940-941), cluster formation in biotechnology (Casper 2007: 450-452), social networks and knowledge management in supply chains (Capó-Vicedo *et al* 2011; Kim *et al* 2011), and the connections between the founders of the semiconductor sector (Castilla *et al* 2000: 228). Studies have also mapped workplace friendship

networks (Kilduff and Krackhardt 1994: 94), gender and racial diversity in workplace support and information networks (Stephenson and Krebs 1993: 70-71; Stephenson and Lewin 1996: 179-180), and friendship among the French financial elite (Kadushin 1995: 211).

There are also a growing number of fascinating SNA studies that have turned the gaze inward, onto the academic communities within business and management, such as those mapping the 'invisible college' among B2B marketing researchers (Morlacchi *et al* 2005: 14), economists concerned with technology and innovation (Verspagen and Werker 2003: 408; 2004: 1425), the information systems community (Vidgen *et al* 2007); hospitality management researchers (Hu and Racherla 2008: 306), and around specific journals, such as 'R&D Management' (McMillan 2008:74-76). Broader based studies have also sought to map the invisible college among the most prominent researchers in management and organisation studies (Acedo *et al* 2006: 976-977), and of the interconnectedness of editorial board membership across the FT 40 management and business journals (Burgess and Shaw 2010: 10-15). Hu and Racherla (2008), for example, as with a number of the above studies, employ co-authorship data from prominent journals in the field. Whilst they recognise limitations to their study, such as its inability to capture informal interactions, they suggest worryingly that the resulting network maps could 'serve as alternative metrics to evaluate (or at least imply) research impacts and contributions of individual researchers by research collaborations, which in many cases is difficult to detect by the conventional methods' (Hu and Racherla 2008: 311).

Over the last decade, SNA techniques have also been applied increasingly in consultancy work, in order to reveal informal structures and knowledge flows, and identify influential individuals, such as gatekeepers and opinion leaders. Cross *et al* (2001) argue that SNA achieves this by enabling the production of an 'X-ray' of the informal network. Parker *et al* (2001), for example, have applied such techniques within a consortium of Fortune 500 companies and government agencies, often as a precursor to identifying 'intervention opportunities'. In one case, involving a consulting practice, Parker *et al* (2001: 27) argue that 'the result of interventions was significant…the group began to sell

more…[and] a network analysis conducted nine months later revealed a well-integrated group that was leveraging and seeking its knowledge much more effectively'.

This consultancy work reflects a growing recognition within the areas of human resource management and organisational development of the potential of SNA (Stephenson and Lewin 1996; Lengwick-Hall and Lengwick-Hall 2003; Bunker *et al* 2004; Hatala 2006). Indeed, Hatala (2006: 65) argues that 'SNA can provide HRD [Human Resource Development] practitioners with valuable relational information that can assist in the assessment of performance and implementation interventions'. However, despite their extensive research and consulting work, Parker *et al* (2001: 28) recognise that 'network analysis is not a cure-all' and that 'if applied without proper forethought, the results can be inconclusive at best and damaging at worst'. This point is important to reflect upon, since as Borgatti and Molina (2003: 337-338) stress, 'The stakes are higher in the practice setting than in the academic setting, because the purpose of the network research there is explicitly to make decisions that directly or indirectly will affect the lives of employees'.

Evaluating the accuracy and completeness of SNA data inputs

The nature of network data

Social networks are comprised of three core components: actors, links, and flows. They are constructed by identifying and then connecting individual dyads. Typically, such network data are obtained through a questionnaire survey completed by the members of the network,[7] although data can also be collected through interviews, documents, observation, and from various electronic sources. A link is considered to exist where both actors in a dyad report a relationship with the other; this is termed 'reciprocal nomination' (Stork and Richards 1992). However, 'non-reciprocal

nominations' may be 'symmetrized' (Scott 1991), that is, a relationship may be considered to be present even when it is reported by only one of the two individuals in the dyad.

Since network data can not typically be collected instantaneously, and may relate to an event taking place over a period of time (*e.g.* the relationships mobilised during the development of a new product), it is subject to 'temporal grouping' (Bender-deMoll and McFarland 2006). That is, network data are aggregated from across the period of data collection, effectively conflating time and disregarding the ordering of relational events. Collecting network data from blogs, newsgroups, email, and chat rooms, is becoming more common and may serve to resolve some of these issues, although such internet sources present their own 'accuracy' and ethical issues.

It has been argued that social network studies often under-emphasize the flows through the network, whilst over-emphasizing the quantity rather than the 'quality' or 'utility' of network relationships and interactions (Conway *et al* 2001).

Problems associated with boundary-setting and choices concerning 'rules of inclusion'

Where SNA is being undertaken among an identifiable group of individuals, such as a project team or department within an organisation, then the membership is likely to be reasonably clear to the researcher. Nevertheless, it is often the boundary-spanning relationships that are of particular interest and importance to researchers and managers alike (Tushman 1977), and these linkages can be remain 'hidden' if the boundary around data collection is set too tightly to the membership of the group. However, in many cases the membership of the group of individuals under investigation is poorly-defined, such as with informal networks and communities (Ghani *et al* 1998). In such instances, the researcher may sensibly begin by approaching those known members, and proceed by identifying further members from the responses from these known members (Scott 2000: 61). In employing such

a 'snowball' sampling approach, the network researcher must at some point decide where and when to stop collecting data, otherwise they will be drawn into the 'the general ever-ramifying, ever-reticulating set of linkages that stretches within and beyond the confines of any community or organisation' (Mitchell 1969: 12). Yet, in doing so, the researcher sets a nominal boundary for the network, and effectively decides who is, and therefore who is not, part of the network (Laumann *et al* 1983).

In very large bounded groups, such as a company division of several hundred employees, the collection of network data can very quickly become unmanageable. In such instances, it is not advisable in SNA to simply select a representative sample, since this does not provide a 'useful sample of relations' (Scott 2000: 59). One strategy to cope with large networks is for the researcher to establish their own 'rules of inclusion', which may be based on characteristics such as the role, seniority, or gender, for example, of the members of the larger group. Such rules of inclusion should be clearly linked to the research questions of the project (Laumann *et al* 1983).

A specific example of these boundary-setting and sampling decisions can be seen in a recent investigation of the informal problem-solving network within ICI's R&D function (Allen *et al* 2007). In this study, to make data collection manageable, only senior personnel were selected, representing 152 of approximately 400 R&D staff. Furthermore, the researchers did not look at interactions across the organisational boundary, although they recognised that 'external networks and links with scientific communities are very important for research scientists' (Allen *et al* 2007: 184). As a result, the informal problem-solving network that is identified by the researchers is partial, and under-represents the complexity and diversity of the internal and external linkages. Thus, boundary-setting and sampling decisions can have a profound impact on the structure of the network that is revealed, and as a result, Fombrun (1982: 288) warns that the conclusions drawn from a network study 'must be carefully scrutinized for the possibility of alternative explanations grounded in the effects of the untapped networks'.

Problems associated with missing or inaccurate data

Having established the boundary and rules of inclusion for a network study, it is important that as close to a 'complete' data-set is obtained by the researcher. Parker *et al* (2001: 28) argue that 'while you don't have to get 100% response, we typically shoot for at least 80% response from the group we're analysing'. In contrast, others contend that 'the analysis and mapping of the structure of the network is especially sensitive to missing data' (Huisman 2009: 2), and that missing data can be 'very misleading…if the most central person is not pictured…or if the only bridge between the groups is not shown' (Borgatti and Molina 2003: 339). This latter point is emphasized graphically in Figures 1 and 2 below, which illustrate the distortion of the network structure as a result of missing data (inspired by Borgatti and Molina 2003: 340). In Figure 1, data have been collected and mapped for all actors and relationships in a network, whilst in Figure 2, depicting the same network, data are missing for two actors, *i.e.* actors '10' and '11', who hold important positions in the network. As a result of this missing data in the latter visualisation, the bridge between the two networks remains invisible to the researcher. Such bridges are considered important for promoting novelty and creating entrepreneurial opportunities (Burt 1992: 26).

[Insert Figure 1 here]

Figure 1: Arrangement 1 (data collected for all actors and relationships in the network)

[Insert Figure 2 here]

Figure 2: Arrangement 2 (same network as Figure 1, but with data missing for actors 10 and 11)

Missing and inaccurate network data can arise from a number of sources. Principal among these are the non-response of network members, questionnaire design, and informant bias (Kossinets 2006).

Missing data arising from the non-response of network members

The problems in collecting network data are often compounded by the non-response of a proportion of network members. Questions typically employed in collecting network data are 'sensitive' (Tourangeau *et al* 2000: 255), and the mapping of network data can expose the network status of individuals. This may further deter individuals from being involved in such research, especially where it is being employed to make managerial decisions (Hatala 2006). To a certain extent, non-responses can be ameliorated through a process of 'symmetrization' (Scott 1991). That is, where a network member does not respond to a survey, it might be possible to determine their connections where network members that do respond indicate links with these non-respondents. Clearly, the efficacy of such an approach diminishes as the percentage of non-response increases, although simulations indicate that reasonable results can be achieved with up to a 20% non-response rate (Huisman 2009). Even so, response rates below 100% have the potential to miss crucial network linkages.

Missing data arising from questionnaire design

Questionnaires are a common tool for collecting SNA data, and thus questionnaire design also plays its part in the 'completeness' and 'reliability' of a network data-set. SNA questionnaires typically incorporate only a very limited number of questions, since these often need to be answered in relation to a sizeable group of individuals. The questionnaire may include the full list of names of the group under investigation, against which respondents may be asked to confirm all of those individuals with which they communicate. However, this technique is not possible where the membership of the group

is not clear to the researcher. In such circumstances the questionnaire may be employed to reveal the network membership by asking the known members to indicate the names of those with which they communicate. Such an approach would then employ a snowball sampling strategy. In both instances, recall by respondents of weak connections or infrequent interactions can be an issue, and may be compounded where the group is particularly large or where the full names of contacts are not known by respondents. This is important, since whilst strong ties promote information flow, weak ties provide information novelty (Burt 1992: 26). It is also important when designing questionnaires to be wary of the terms employed. For example, many network studies ask respondents to identify their friends, yet even the term 'friends' is very ambiguous and can mean different things to different respondents (Fischer 1982).

Inaccurate data arising from informant bias

Following a number of experiments to test informant accuracy in reporting past communications, Bernard *et al* (1984: 499) concluded that 'what people say about their communications bears no useful resemblance to their behavior', since respondents recalled less than 50% of their interactions correctly. They found that respondents typically make two types of recall error – they forget some of those with whom they have interacted with and incorrectly recall interactions with others that they have not. In addition to general 'memory decay', there are a number of factors that impact the accurate recall of interactions and relationships, such as their perceived salience by the respondent, the specificity of the behaviour being investigated, and the size of the network (Bell *et al* 2007). Furthermore, and not surprisingly, respondents are much better at recalling their own relationships (*i.e.* 'direct' or 'first-order' connections), than the relationships of those to whom they are connected (*i.e.* 'indirect' or 'second-order' connections).

Such research would seem to undermine dramatically the utility of 'recalled' network data. However, subsequent research by Freeman *et al* (1987: 321-322) found that informants typically drew from 'somewhere between experience and recall' in their responses. That is, 'what is recalled...is what is typical – whether it happened or not'. Interestingly, as a result, this research reveals that individuals are, in fact, very good at recalling enduring patterns of relations with others, although this will lead to an under-reporting of weak-ties. The accuracy of network data may also be distorted by 'self-presentation' (Goffman 1973). That is, respondents perhaps wanting to be viewed as more connected or interactive than they actually are. Research concerning the self-presentation of individuals on social networking sites, for example, has found that users often presented 'hoped-for possible selves' online that differed from their 'real selves' offline (Zhao *et al* 2008).

Alternative data collection methods and alternative data sources

Although network studies are often associated with the collection of data via questionnaires, a variety of methods and data sources may be employed to reveal network data. These include, for example, interviews (*e.g.* Freeman *et al* 1989; Cross *et al* 2001), observation (*e.g.* Freeman *et al* 1989; Conti and Doreian 2010), biographies (Crossley 2008), personal letters (Edwards and Crossley 2009), co-citation data from journal articles (*e.g.* Acedo *et al* 2006; Hu and Racherla 2008), and social networking sites, such as *Facebook* (*e.g.* Lewis *et al* 2008). Each approach has its inherent strengths and weaknesses. Lewis *et al* (2008: 341), for example, highlight the ease with which network data can be obtained from *Facebook*, whilst also recognising that respondents 'differ tremendously in the extent to which they "act out their social lives" on Facebook'.

There is evidence that network researchers are increasingly employing multiple methods in order to yield complementary data (*e.g.* Human and Provan 1997; Crossley 2008; Edwards and Crossley 2009; Park and Kluver 2009; Conti and Doreian 2010). In this regard, quantitative approaches may be

viewed as being relatively effective at revealing the structure of networks, whilst the in-depth data available through qualitative approaches may be seen as more effective in providing insight into the process, content, and context of relationships and interactions. In some cases mixed methods have been employed explicitly to triangulate the data. Lievrouw *et al* (1987), for example, in their study of the intellectual connections between biomedical scientists, employed both co-citation data and interviews. Nevertheless, in recent years, there has been an increasing recognition that qualitative methods have been under-utilised, and that there is a need for the adoption of mixed methods in network research to broaden and deepen our understanding (Hoang and Antoncic 2003; Coviello 2005; Jack 2010). In particular, Coviello (2005) argues that mixed methods have a useful role to play in collecting data on network dynamics.

Network visualisation and early visualisation techniques

Academic studies have employed network visualisation techniques for over seventy five years to reveal the social structure in a huge variety of interesting contexts, from mapping the social structure among cohorts of school pupils (Moreno 1934: 154-161), the interlocking directorates between organisations (Levine 1972: 15), and the spread of AIDS through social contacts (Klovdahl 1985: 1204), to revealing terrorist networks (Krebs 2002: 46, 50), informal connections in Formula 1 (Henry and Pinch 2000: 200), and the social network of the UK 'punk' movement (Crossley 2008: 101).

Moreno (1934) is generally credited with the first attempts to visualise social networks. His 'sociograms' were hand-drawn depictions. So too were the network visualisations of others in the subsequent decades (*e.g.* Roethlisberger and Dickson 1939: 502-507; Levine 1972). Yet, despite the power of the graphic for displaying relational data, network visualisations remained relatively rare until recently. Klovdahl (1986: 313) attributes this under-utilisation to 'the time and tedium involved in producing hand-drawn diagrams' and 'the impossibility of manipulating these once they are drawn'.

During this period, a 'data matrix' was widely employed to record and display network data (Scott 2000: 40). Table 1 represents the network in Figure 3 as a data matrix, where a '1' indicates that a link exists between two actors, and a '0' indicates that no link exists. Interpreting such matrices remains a skill associated with experienced network researchers. Given these alternatives for displaying network data, it is easy to see why the emergence of network visualisation software has been such an important innovation in the popularisation of SNA, particularly among consultants and practitioners.

[Insert Table 1 here]

Table 1: An example of a 'data matrix' – this employs the same network data as Figure 3

One of the key features of network visualisation software is the ease with which it allows the researcher to manipulate the graphic, such as in the re-positioning or removal of actors. Many SNA software packages allow for the automated presentation of network data using what is termed 'multi-dimensional scaling' (MDS). Scott (2000: 149) notes that at its simplest, MDS is a technique for converting network metrics, such as 'centrality' and 'path distance', into physical distance on the screen or page. This can be a powerful way for revealing clusters, for example. However, as the value of network metrics change, so to do the physical positions of individual actors on the screen or page, which can be confusing when attempting to compare a network at different points in time.

Network visualisations are currently employed in a number of different ways. As an output from a network study, they can provide a powerful medium for displaying and revealing the key features of the network under investigation, such as 'clusters', 'structural holes', and 'bridges'. These in turn, can inform consultants and practitioners of potential interventions to alter the morphology of the network toward particular goals, such as improving communication and knowledge flow between distinct organisational groups. Network maps are sometimes used during the data collection process itself, for example, as a way of interacting with respondents to confirm the 'completeness' of a network created

from an earlier data collection phase. They can also be employed to co-create the network in 'real-time'; a process sometimes referred to as 'participatory mapping' (Lubbers *et al* 2010), and they have been employed to help guide the researcher toward fruitful areas of focus during subsequent data collection phases (Biddex and Park 2008; Park and Kluver 2009). Network visualisations also have a role to play in aiding the process of theory building, since through the manipulation of a depiction new insights can emerge (Klovdahl 1981, 1986; Conway and Steward 1998; Moody *et al* 2005).

'The map is not the territory': the multiple visual representations of a network structure

The role of the researcher in designing the network depiction

It is clear from a review of a broad array of network depictions in the literature, such as those indicated earlier, that there is considerable variety in the network data that are displayed, and the way that these data are represented. This is perhaps not surprising, given that it would appear that many network visualisations are arrived at through trial-and-error (Bertin 1983: 271; Freeman 2000), without recourse to 'a set of recognised conventions' (Conway and Steward 1998; Bender-deMoll and McFarland 2006). Indeed, there is no 'one right way' to depict a network (Scott 2000: 65; McGrath and Blythe 2004).

There are two prominent approaches to the production of network graphics. The first might be labelled a 'graphical excellence' approach, as typified by the work of Tufte (1983, 1990) and Bertin (1983). From this orientation, 'excellence in...graphics consists of complex ideas communicated with clarity, precision, and efficiency' (Tufte 1983: 13). This is achieved through the considered use of what Bertin (1983: 71) has termed the 'visual' or 'retinal' variables, such as size, colour, and shape, in depicting the individual actors, links, and flows. The second may be termed a 'visual argument' approach (Simon 1969: 5). From such a standpoint, Levine (1972: 13) argues that 'the value (or deceptiveness) of a [graphical] representation lies in what it suggests...its ability to stimulate thought'. Whilst these two approaches are

potentially complementary, for Tufte (1983: 51) 'graphical excellence' requires the researcher to 'tell the truth about the data' via the visual display; clearly this is at odds with a perspective that seeks to emphasize a particular version of the 'truth'.

There is often a trade-off between 'seeing the overall forest – the clusters of overall groups and their relative social proximity or ordering in relation to each other – and seeing the finer detail of the trees – identifying key players and roles within these groups' (McGrath *et al* 2003: 46). Through the graphic, the researcher may seek to highlight particular features of the network, such as clusters of actors, bridges between clusters, or the diversity and size of the overall network (Conway and Steward 1998; McGrath and Blythe 2004; Bender-deMoll and McFarland 2006). However, different spatial arrangements of the same network might either highlight or obscure such network features. This point is emphasized in Figures 3 and 4 below (inspired by McGrath *et al* 1997: 226).

[Insert Figure 3 here]

Figure 3: Arrangement 1 (arranged to emphasize clusters and bridge)

[Insert Figure 4 here]

Figure 4: Arrangement 2 (circle arrangement)

Consideration must also be given to the selection of the characteristics of the actors, links, and flows, to be displayed. A network map is able to incorporate a variety of quantitative and qualitative information. However, the choice of visual variable to be employed in the display of such different types of data is crucial (Bertin 1983: 71). Typically, 'size' is most effectively mobilised for the 'quantitative' features of actors and links, such as years of experience or the strength of a relationship.

In contrast, 'colour' and 'shape' are best suited to displaying 'qualitative' features, such as an actor's gender or functional location, and the type of 'flow' through a link (*e.g.* knowledge, friendship, power).

The viewer's interpretation of a network depiction

There are a number of dangers in the choices made by researchers to encode certain features of the actors, links or flows, or in the manipulation of the network graphic in order to present a specific 'visual argument'. First, there is the possibility, whether intentional or accidental, that the viewer might be misled about certain characteristics of the network (Bender-deMoll and McFarland 2006). Second, relatively little is known about how viewers interpret or decode the network visualisations they are presented with (McGrath *et al* 2003; McGrath and Blythe 2004; Bender-deMoll and McFarland 2006). In part, this is because viewers 'bring a rich vocabulary of graphical idioms and conventions to the table when they interpret the visualization' (McGrath and Blythe 2004: 1).

From researcher generated aggregated network maps to individualised 'cognitive maps'

It is the norm for network analysts to aggregate the network data of individual respondents to create a single network map. Yet there has long been evidence to indicate that individuals within a network may have very different 'cognitive maps' or 'cognitive structures' of the very same network (Krackhardt 1987, 1990). That is, 'to some extent, social structure is in the eye of the beholder' (Kilduff and Krackhardt 1994: 87). Colville and Pye (2010: 378) contend that 'this poses problems of aggregation…as you raise the level of the analysis from the individual to the collective in search of network insight'. Interestingly, a recent study by Kilduff *et al* (2008) revealed that individuals perceive more clustering than is present in the 'actual' network, and attributed more popularity and brokerage to individuals they perceived as popular. As a result, Kilduff *et al* (2008: 25) argue that:

> 'Perceiving the organization as a small world may reassure the individual concerning the approachability of even distant people…On the other hand, a tendency to misperceive clustering…together with a tendency to attribute more importance to perceivedly popular people, may lead active networkers to be overly confident in picking key people in the network with whom to form attachments. Managers, for example, might assume that they are keeping in touch with all the important clusters, when, in fact, the clustering and connectivity they perceive are more figments of their imagination than accurate features of the social network'.

That individuals perceive such different network structures, may be seen as a process of 'sense-making' by individuals within an organisation when they are faced with complex and dynamic webs of relationships (Weick 1995: 38-39; Colville and Pye 2010; Purchase *et al* 2010; Ramos and Ford, 2011). Thus, we might expect the cognitive map of an individual to shape their behaviour within a network, rather than an aggregated version of this network map as represented by the researcher.

Emerging approaches to depicting networks – moving from 'snap-shots' to 'movies'

Social networks are typically dynamic structures. However, attempts to 'capture' and 'make visible' networks have often led to the mapping of a single 'snap-shot in time' of the network structure. In doing so, there is a danger that the network visualisation presents an ossified version of the network. This is likely to reinforce the prevailing attention on 'static structures' rather than 'the dynamic processes that *transform* those matrices of transactions in some fashion' (Emirbayer 1997: 305). Attempts to address this concern have lead to a growing interest in longitudinal research in the study of social networks. Interesting examples include that of social network formation and inter-firm mobility

within the San Diego biotechnology cluster (Casper 2007), field evolution in the Life Sciences (Powell *et al* 2005), and changes in managerial sense-making (Öberg *et al* 2007).

In longitudinal research, data are typically collected at intervals and displayed as a series of snap-shots (*e.g.* Degenne and Lebeaux 2005; Powell *et al* 2005; Casper 2007). Yet for Moody *et al* (2005: 1207), such depictions 'do a poor job of representing *change* in networks', since whilst on the one hand, longitudinal data might capture the enduring patterns within a network, on the other, the fluctuations in relationships and interactions between the sampling periods are lost. Furthermore, each snap-shot suffers from the 'temporal grouping' noted earlier. Increasing the frequency of these discrete waves of data collection and the resulting number of snap-spots can help mitigate these concerns, although this is likely to have a major impact on the effort required to collect the requisite data. Nevertheless, Bender-deMoll and McFarland (2006: 4) argue that whilst we can 'talk usefully about network change [in such research]…it is difficult to argue that "dynamics" and "evolution" have been recorded'.

For researchers to effectively capture the dynamics of a network, they will need to 'tease apart' the relationship between the micro-level interactions and the overall network. Ideally, this would be done by capturing changes or activity as it occurs, to collect a continuous 'stream' of data. These data could then be displayed not as a series of discrete network pictures, but as an animated 'network movie', with gradual changes in individual actors, links, and flows, that seamlessly and gradually reshape the network map (Moody *et al* 2005; Bender-deMoll and McFarland 2006). New sources of data, particularly those associated with online interactions, and innovations in data collection tools, are presenting new opportunities to achieve this challenge (Ackland 2009; Szell and Thurner 2010). However, others have argued that a more processual orientation to network studies is required (Purchase *et al* 2010).

Issues of Privacy and Ethics

Despite the personal nature of much of the data collected and presented in the typical network study, surprisingly little attention has been directed towards addressing the associated issues of privacy and research ethics. Indeed, Breiger (2005: 89-90) pulls no punches in contending that the social network field has 'a greater ability to arrive at incisive analyses than to comprehend the conditions for responsible uses of such analyses'. This is clearly problematic, since as Borgatti and Molina (2003: 337) argue 'In addition to all the usual ethical problems that can arise with any kind of inquiry, network analyses, by their very nature, introduce special ethical problems that should be recognized'. For example, in order to construct a network, the researcher must be able to identify the respondent and the individuals to which the respondents say they are linked. Thus, although anonymity may be provided at the data presentation stage (*i.e.* within the network graphic), it is not possible during the data collection stage. Furthermore, network visualisations are 'low-level displays that represent the raw data' rather than 'highly digested outputs of analysis' (Borgatti and Molina 2003: 341), and thus, where they are employed, it is often possible for knowledgeable individuals to identify others within the network even where they have been anonymised.

It is common for network studies to ask personal questions, such as 'Who are you friends with at work?' or 'Who do you socialise with outside of work?'. However, despite the use of consent forms, most respondents in network studies will not have been involved in such research before, and are unlikely to be aware of how they might feel if they are identified through such questions as being 'marginal' or 'unliked' in their group. Furthermore, where the research forms part of a consultancy project, rather than a piece of academic work, respondents may also be unaware of the possible consequences that might result from subsequent management interventions intended to address features revealed by the network study. As Borgatti and Molina (2003: 344) state, 'If subordinates do not understand that their answers on the survey could determine their fate, this could be seen as deceptive and constitute an unethical use of network analysis'.

Interestingly, consent can also be a major problem in SNA with regard to non-participants. Since respondents in SNA research reveal details about their relationships and exchanges with others, the non-participation of an individual in a study does not rule out that data may be collected about them or that they may be included in subsequent analyses or network depictions. There is also increasing use by academics, consultants, and managers, of electronic sources of 'social' data from social networking sites, chat rooms, blogs, and email logs, for example. The privacy and consent issues relating to such data sources have received insufficient serious attention. Hoser and Nitschke (2010) contend that it is not enough to assume the free use of social data simply because it resides in the public domain, arguing for the establishment of a code of behaviour that embraces the notion of 'perceived privacy' (Eyenbach and Till 2001); thus data posted on a social networking site or newsgroup should only be used 'in the context and by the audience he or she intended it for'.

Implications for network researchers and practitioners

For Borgatti and Molina (2003: 337), 'the concept of network has become *the* metaphor for understanding organizations', both among academics and management consultants. It is within this context that we have sought to provide a critique of the robustness of an increasingly popular approach for revealing and mapping social network structure. This critique is not intended to dismiss the potential of SNA for theory-building or management practice, but rather to surface issues that require consideration, and where possible, resolution or mitigation.

Implications for network researchers and further research

We have argued that the seductive nature of network visualisations has distracted attention away from a number of emerging and long standing issues in SNA. We contend that network researchers need to reflect more on the choices made concerning boundary-setting and data collection techniques, as well as on the potential impact of missing or inaccurate data. After all, as Rogers (1987: 17) has noted 'without good data, network analysis is worthless'. Indeed, there is a pressing need for further research to improve our understanding of the 'patterns and consequences' of missing network data, since as Kossinets (2006: 248) argues 'Although missing data is abundant in empirical [network] studies, little research has been conducted on the possible effects of missing links or nodes on the measurable properties of networks'.

McGrath *et al* (2003: 46) also raise concerns about our understanding of the way in which such network visualisations are interpreted by users, arguing 'To be sure, we can make more programs that seem to us as researchers/programmers to make 'better' pictures; but we are relatively ignorant of how general human perception interacts with these fancy new features…'. Thus, further research is required in relation to understanding how various users of network maps interpret the visualisations with which they are presented.

It was noted earlier, that network studies typically under-emphasize the flows through a network, and over-emphasize the quantity rather than the 'quality' or 'utility' of network relationships and interactions (Conway *et al* 2001). Such a pattern is likely to be reinforced by the use of network surveys or data-mining of social media logs. It is thus recommended that researchers adopt a mixed method approach, incorporating both quantitative and qualitative data collection methods.

Implications for consultants and business practitioners

Network researchers typically construct a single map. Yet as we have indicated, research has highlighted that individual perceptions (*i.e.* 'cognitive maps') of a social network can vary greatly from such unified visualisations. This conflation can have far-reaching impacts on the organisation, since as Kilduff *et al* (2008: 25-26) contend, such 'schema use by individuals in their perceptions of social worlds may affect individuals and larger entities…[thus] there may be unanticipated consequences not just for the individuals concerned, but also for the collectivity to which they belong'. Consideration might be given to analysing both the 'cognitive maps' of individual network members as well as the 'aggregated' network maps produced by network analysts. Social networks are also dynamic in nature; their structure is often fleeting and transitory. Thus, in attempting to make 'invisible' social structures 'visible', network visualisations typically focus attention on the network 'as was' (*i.e.* when the data were collected), rather than 'as is'. Practitioners must be aware of the implications of the time-lag between data collection and managerial intervention.

Practitioners must also recognise that as more network audits are undertaken within their organisation, it is likely that employees might start to refuse to cooperate, or to complete surveys 'strategically', leading to 'a kind of dialectical arms race' where researchers utilise increasingly sophisticated and passive methods of data collection and employees respond in kind via collusion and manipulation of the data (Borgatti and Molina 2003: 345). Openness with employees in relation to the collection and use of network data within organisations might help to prevent this cycle occurring.

Despite the range of ethical concerns outlined above, Borgatti and Molina (2003: 342) argue that what ultimately matters is 'who sees the data and what the data will be used for'. Thus, where the data remain anonymised and do not result in potential consequences for respondents, the ethical 'exposure' may be seen to be greatly reduced. However, these conditions are unlikely to be met where the purpose of the study is to identify appropriate managerial interventions to improve organisational or individual 'performance'. It is also worth researchers seriously considering whether personal

questions associated with friendship, both within the work and non-work environments, are appropriate questions to ask when the study has been commissioned by managers of an organisation.

Interestingly, for Kadushin (2005: 151, 139) the question of 'who benefits' is crucial, arguing that 'academic researchers always benefit, organizations, society and science may benefit, but individual respondents rarely do'. The implication of this position is that as network researchers we must become much more sensitized to the range of potential repercussions for respondents. In addressing this issue, some have focused on providing a number of concrete suggestions for the further development of research guidelines and processes (Borgatti and Molina 2005; Klovdahl 2005). However, Goolsby (2005) is bolder, contending that there is a need for developing 'an ethical imagination' to tackle these prevailing concerns.

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Endnotes

[1] KrackPlot http://www.andrew.cmu.edu/user/krack/krackplot.shtml - well-established SNA software.

[2] UCINET http://www.analytictech.com/ucinet/ - well-established SNA software.

[3] Pajek http://pajek.imfm.si/doku.php - specialised software for dealing with large networks.

[4] Metasight http://www.morphix.com/Pages/MetaSight/MetaSight.html - uses email data as input.

[5] See Freeman (2000) for an overview of the history and diversity of social network visualisation tools, and see wikipedia.org/wiki/Social_network_analysis_software [accessed on 22/11/11] for a good overview of a large range of software applications for the visualisation of social network data, and links to websites for individual applications.

[6] Such as Social Networks, Sociometry, Connections, the Journal of Social Structure, and the Journal of Quantitative Anthropology.

[7] For a sample of social network questionnaires see the webpage for Prof. Krackhardt of the Heinz School of Public Policy and Management, Carnegie Mellon University (www.andrew.cmu.edu/user/krack/questionnaires.shtml)

	Helen	Frances	John	Alan	Peter	Mike	Jane	Will	Mark	Abby	Steve
Helen	0	1	1	1	0	0	0	0	0	0	0
Frances	1	0	1	1	0	0	0	0	0	0	0
John	1	1	0	1	1	1	0	0	0	0	0
Alan	1	1	1	0	1	1	0	0	1	0	0
Peter	0	0	1	1	0	1	0	0	0	0	0
Mike	0	0	1	1	1	0	0	0	0	0	0
Jane	0	0	0	0	0	0	0	1	1	1	1
Will	0	0	0	0	0	0	1	0	1	1	1
Mark	0	0	0	1	0	0	1	1	0	0	1
Abby	0	0	0	0	0	0	1	1	0	0	0
Steve	0	0	0	0	0	0	1	1	1	0	0

Table 1: An example of a 'data matrix' – this employs the same network data as Figure 1

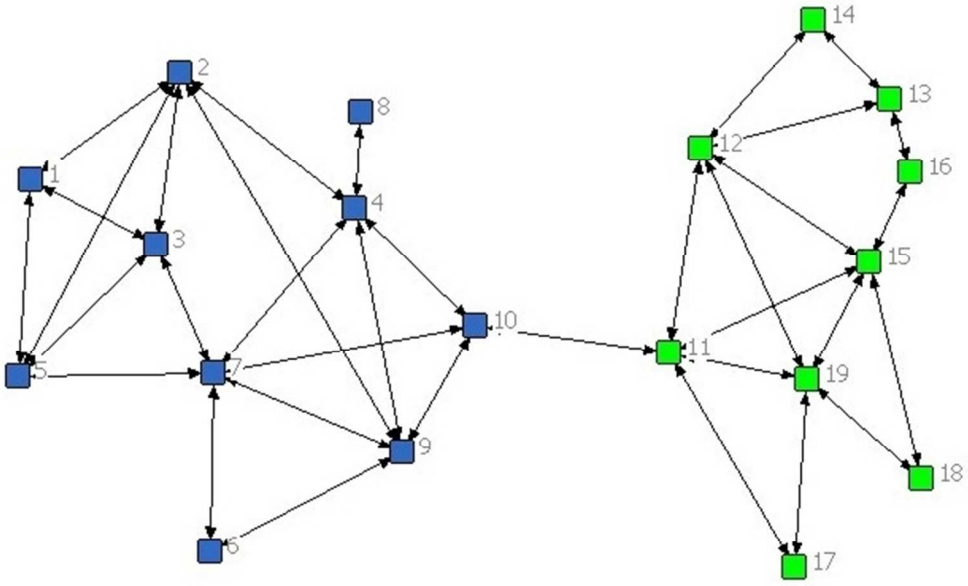

Figure 1: Arrangement 1 (data collected for all actors and relationships in the network)
166x111mm (96 x 96 DPI)

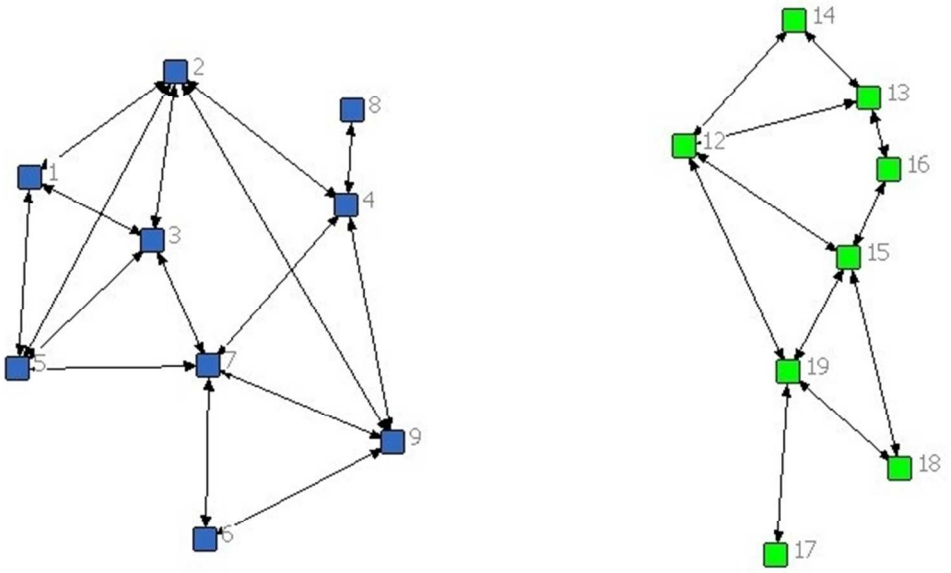

Figure 2: Arrangement 2 (same network as Figure 1, but with data missing for actors 10 and 11)
170x109mm (96 x 96 DPI)

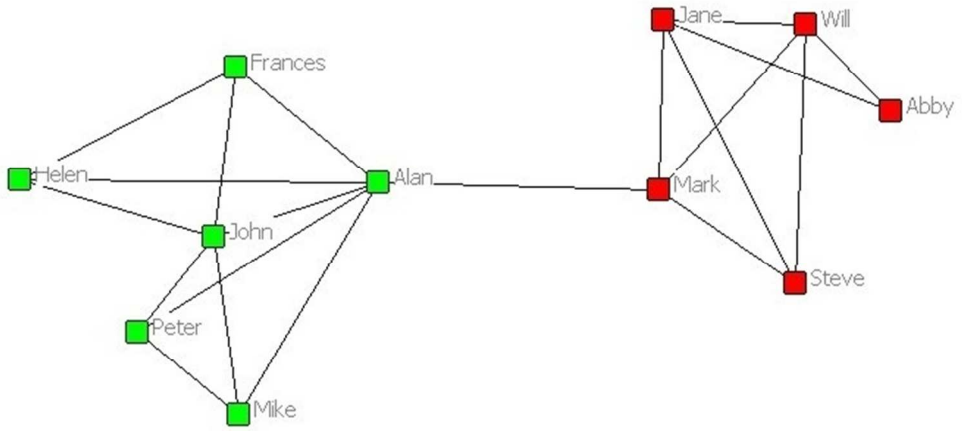

Figure 3: Arrangement 1 (arranged to emphasize clusters and bridge)
180x85mm (96 x 96 DPI)

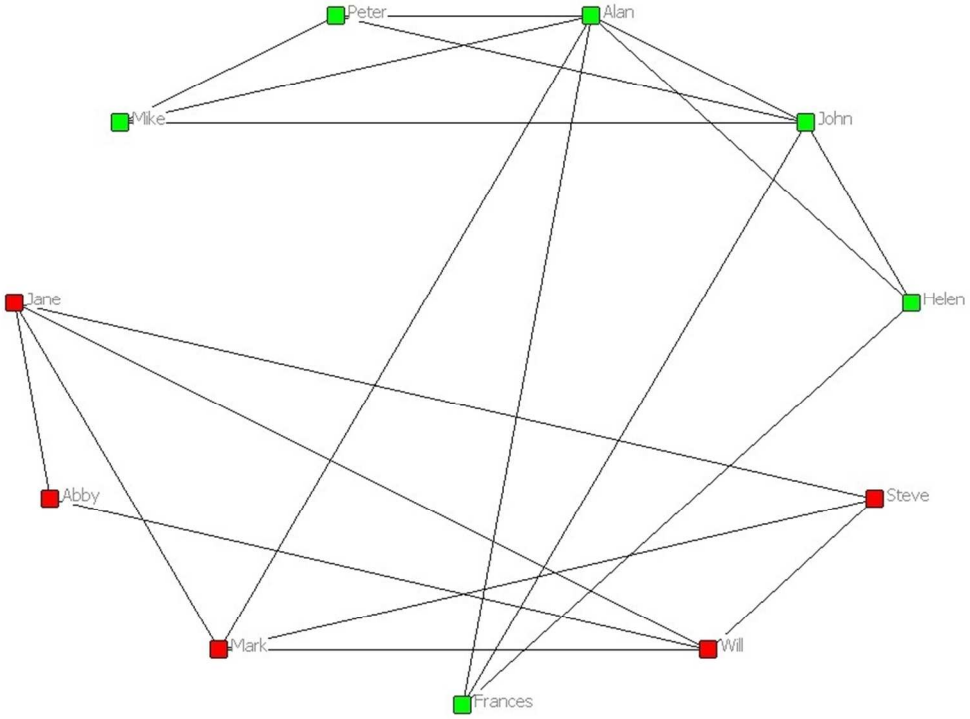

Figure 4: Arrangement 2 (circle arrangement)
230x171mm (96 x 96 DPI)