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FORUM

NETWORKS IN THE SOCIAL SCIENCES: COMPARING ACTOR-NETWORK THEORY AND SOCIAL NETWORK ANALYSIS

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ABSTRACT *While the subject of networks has been an issue in the social sciences for decades, it can still be regarded as one of the concepts significant enough to excite the imagination of both theorists and empirical researchers. Because of this interest, many different types of approaches to networks have been developed. In many cases these theoretical and analytical developments have occurred relatively independently from each other, using different vocabularies and research styles. This paper presents two prominent network approaches—namely, Actor-Network Theory (ANT) and Social Network Analysis (SNA)—in order to highlight the similarities and differences between the two. Besides providing a comparison, the paper discusses the potentially fruitful convergence of these two theories. We argue that ANT researchers could benefit from using certain SNA methods (such as visualization techniques and quantitative measures), whilst SNA researchers would benefit from developing new theoretical and empirical ideas about how to introduce non-human actors into networks that also contain humans.*

KEYWORDS: *actor-network theory, social network analysis, actor, role, connection*

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INTRODUCTION

'Network' is presently a catchy term within the social sciences. While the concept has a long history and hence cannot be regarded as something revolutionary or brand-new, it still instigates both theoretical and empirical endeavors which have resulted in different schools of network theory and analysis. However, more often than not, the different strands of these network approaches coexist in peaceful indifference, with no meaningful dialogue between them. Ironically, it may even be said that the network connections between the different schools of network theory and analysis are few and far between.

Our paper attempts to alleviate this situation. It discusses two prominent approaches to networks: Actor-Network Theory (ANT) and Social Network Analysis (SNA). These two approaches come from very different backgrounds and are very different in many respects. Because of this 'distance', they are rarely discussed together. The paper attempts to bring into one conversation these two strands of thought. In relation to this pursuit, the paper's aims are twofold. On the one hand, it is designed to provide assistance to researchers who seek to choose the appropriate approach for their research projects. On the other hand, it also offers some ideas about what the approaches could teach each other, and how they might be connected in a fruitful way.

Actor-Network Theory is firstly described based on its background, theoretical elements and the current use of ANT in research projects. Then, to facilitate comparison, Social Network Analysis is reviewed according to the same features. The article then continues by discussing the two approaches together: differences and similarities are touched upon, as well as possible areas of convergence. Some insights are offered into the cases in which these approaches can be successfully applied.

THE APPROACH OF ACTOR-NETWORK THEORY

Background

Actor-Network Theory was developed as part of a larger scientific movement called STS. This abbreviation stands for Science and Technology Studies (or alternatively, Science, Technology and Society) a research field designed to focus the lens of social scientific investigation on the production of scientific facts and technological artefacts. The genesis of this field dates back to the 1980s when two seminal pieces of work which defined the basis of the conceptual and methodological repertoires of this intellectual endeavor were published. These are the *Social Shaping of Technology* (Mackenzie et al.

1999) and *The Social Construction of Technological Systems* (Bijker et al. 1987). While there are differences between them, both attempt to highlight the importance of social forces and actors on the development of technological artefacts, systems and networks.

Under the auspices of STS a distinctive approach was developed at the Centre de Sociologie de l'Innovation (CSI) of the École Nationale Supérieure des Mines de Paris by Michel Callon (1984), Bruno Latour (1984) and John Law (1986), among others. Apart from the STS school of thought, Actor-Network Theory also heavily draws on other intellectual sources such as the semiotics of Algirdas Julien Greimas (Beetz 2015), and the philosophy of Michel Serres (Brown 2002) and Gilles Deleuze (Law 2009).

As Sismondo puts it, this particular branch of STS seeks to understand scientific and engineering work as an element of the building of larger and more resilient networks (Sismondo 2004:65). Similarly to political actors in the political game, engineers and scientists also attempt to build and maintain alliances to obtain and maintain power. Nevertheless, scientists and engineers (as well as other actors) build alliances between heterogeneous elements (Sismondo 2004). This means that both human and non-human elements can be parts of their networks and have particular 'interests', only remaining in the network if the specific conditions for their existence are ensured by the network-builders. The juggling trick, therefore, is keeping every element enrolled and 'loyal' to the goals of a network. In the following sections of this paper, the authors attempt to elaborate on these key points.

The 'style' and aims of ANT may be closely associated with those of post-structuralism (Ritzer 2008:656; Law 2009). This "family resemblance" (Wittgenstein 1953) between post-structuralism and ANT can be found in relation to several concepts, one of which is relationality. *Relationality* in its most common sense means that entities have no essence in themselves, but their properties and boundaries are formed and shaped through their relations to other elements (Ritzer 2008:656). Similarly to post-structuralism, ANT is also *anti-foundational;* that is, it attempts to avoid explaining social changes through a specific chain of causality, thereby reducing their scope to either social or material elements (Ritzer 2008:656; Law 2007).

ANT was first and foremost established in order to aid understanding of how scientific facts and technological artefacts are brought into being. It challenges deep-rooted ideas concerning the operation of science and technology. Among other things, it questions the notion that scientific facts or technological artefacts may be purely scientific and technical since the process of their creation is always messy, full of 'impure' elements and contingencies. Moreover, this approach also investigates whether these specific areas of human activity can be truly understood as distinct fields governed by their own internal logic completely free of any external forces or other constraints (Volti 2005).

Consequently, ANT's research projects attempted to show how 'messy' reality is prior to scientific facts being accepted as 'cold, hard facts,' or before a technological artefact starts working and is installed in its field of operation. Things are messy because all

kinds of different forces and effects (social, political, financial, etc.) shape and construct these entities before they reach their 'final' form. When they finally reach this point, they become part of a larger network in the manner of a 'black box'; in other words, operators or users no longer have to question how such entities work, or what they are made of. The network of different forces will only be retraced when the artefacts stop working, or in other words, when they are reluctant to cooperate with other elements of the network.

So, a computer remains a computer so long as it cooperates with the author who is writing a paper, but when the monitor goes blank, they start to wonder which element of this complex assembly went wrong. At that moment, the computer becomes a network of different bits and pieces; that is, the computer ceases to be a black-box. This example highlights how ANT attempts to understand what happens *before* 'black-boxing day'. Accordingly, it seeks to trace how society and other impure elements gradually 'disappear' from natural facts and rational and effective technological artefacts. In order to do this, ANT is utilized in the various contexts in which research and innovation 'happens'. These locations can be laboratories (Latour et al. 1979), meeting rooms (Latour 1996), during scientific fieldwork (Callon 1984) or at any site where scientific facts are 'applied' or technologies are put to work.

Over time ANT became more ambitious in its aims; seeking not only to analyze science and technology but attempting to provide a new type of understanding of society and modernity. As the now famous expression goes, "we have never been modern" (Latour 1993). This saying emphasizes how humans have never really separated material elements (nature/material elements/technology) from society, or humans (social actors) from non-humans (other actors). In line with this proposition, several supporters of ANT, but mainly Bruno Latour, have proposed a new type of social science which not only tries to understand society and people, but which is also open to the *machinations* of non-humans. ANT theorists argue that the problem with 'modern' thinking is that without nonhumans we are not able to understand how society is integrated as a whole (Latour 1992).

Elements of the theory

Defining networks in ANT

One thing which is stressed in relation to the concepts of actor and network is that they should not be understood and utilized independently (Latour 2011). Following this argument, all actors are also networks, and vice versa.

This can probably be better understood through an example of the dual nature of social phenomena. For example, think about a trader on the stock market who buys and sells, makes decisions and acts accordingly (Callon et al. 2007). The individual is an actor, but, at the same time—if one shifts the focus away from them and takes the broader perspective—they are also a network. This is because the decisions and choices they make happen through the extension of their mental capacities and include computers, technical pieces of software and algorithms. In a similar fashion, their action not only concerns the immediate environment of the trading room, but impacts a wide circle of entities around the world through their engagement with a long chain of elements containing both humans and nonhumans. This also implies that actor-networks are formed from their elements and from the relationships between these elements. Actor-networks are semiotic spaces in which the different elements that are involved are both defined and stabilized by their relationships to other entities in the web. This situation can be understood as a constantly changing web of forces which is liable to restructure itself if one of its parts changes, breaks down or becomes defective.

Using another example, the truck driver you see today is not the same truck driver who delivered goods from A to B twenty years ago. They have to use a computer in the truck, program a GPS device and keep track of inventory using an Excel sheet. Because the network of elements has changed around the driver, the very identity and the capabilities of the driver have also changed.

Defining connections

In the most general sense, a relationship in an actor-network refers to at least two entities which mutually affect (change, modify, define or stabilize) each other, either directly or through other entities. This understanding highlights that in ANT the main focus is not on which actors are directly related to each other, or how many nodes are needed to connect specific positions, but on how elements form and shape each other.

This understanding can be further elaborated by taking into account the fact that, using this approach, a relationship is often treated as an act of translation between elements or forces. Translation is a concept that was originally developed to describe how scientists and engineers move between various fields and how scientific and technological objects are transformed and modified during these shifts (Callon 1987). The concept was originally coined by Michel Serres who understood translation "as the process of making connections, of forging a passage between two domains, or simply as establishing communication"; or, as "an act of invention brought about through combination and mixing varied elements" (Brown 2002:3-6 cited in Cressman 2009:9).

Callon (1984) developed a four-stage model of translation. In the first phase, called problematization, an actor defines the nature of the problem in a specific context by

making herself indispensable (establishing herself as an obligatory point of passage [see below]) for solving it. The second phase (interessement) attempts to stabilize actors in their assigned roles and places, as defined by the actor's program. If the interessement phase is successful then the different elements are enrolled into the actor's network and various cross-connections and alliances are formed. This third phase is called enrolment, during which various strategies and tricks are utilized and multilateral negotiation takes place. Fourthly, the phase of mobilization designates all the methods through which the actor keeps the collective entities together and can represent and mobilize them without fear of betrayal or defection (Callon 1984).

Non-humans in networks

In order to challenge the 'default' outlook of social scientists who focus mainly on social actors and relations, ANT theorists opt for a position of radical symmetry, arguing that nonhumans can also have agency, and thus can also be actors. However, agency may take on different meanings in relation to non-humans, as Sayes shows in a brilliant paper (Sayes 2014).

Firstly, this means that humans are not the only ones who shape their world; material elements can also have a (sometimes unexpected and unintended) effect and influence on other elements in a network, including humans. This also means that elements in certain positions in a network can change from human to non-human, or vice versa. The most famous example of this relates to an example of how to make motorists drive more slowly (past an elementary school, for example). A hypothetical city council might decide to put up a speed limit sign, build a speed bump, install an automatic camera to photograph speeding drivers or order a policeman to stand at a specific spot (Latour 1992). The potential 'translation' between humans and non-human actors will change and redefine the specific relationships in this situation. This redefinition process, in turn, affects the identity and particular function of the given element (speed bump, sign, police officer, etc.) in particular, and the actor-network in general.

Secondly, the principle of radical symmetry also underlines that the actor is never alone while acting. Action in this sense is always interaction (Sayes 2014) since the actor must mobilize other elements of her network in order to have an effect on its environment.

Thirdly, non-humans can contribute to the ordering of the social sphere, rendering durability to social norms, values and decrees through various times and spaces, and extending the power of those who create, maintain and operate networks. Social order(s) are thus constructed from various, heterogeneous elements.

Key actors, roles and structural characteristics of networks

ANT identifies the key roles that are played in the network. Among others, the most important of these are obligatory points of passage, immutable mobiles and boundary objects. *Obligatory points of passage* (henceforth: OPP) can be defined as critical network channels or funnels through which actors (mainly the primary actor or the network builder) become indispensable for the operation of the network. For an innovation project, for example, project-leaders must arrange all entities, resources and forces so as to converge them in a given direction. By creating a strong OPP they not only ensure that all flows (information, materials, interests, etc.) must pass through their domain, but they can act upon the entities in the network in order to translate and align them towards the goals of the project.

As for *immutable mobiles*, Bruno Latour developed this term in order to describe those objects which are transportable while essentially remaining the same (they preserve their inherent characteristics). Immutable mobiles are important for maintaining and stabilizing actor-networks since they are capable of circulating in the network space without losing their meaning (or shape) in the process (Latour 1987). The most obvious example of such an object is a printing press, which allows ideas printed on paper to be disseminated across space and time without being distorted.

The third key role in actor-networks is played by *boundary objects*. "Boundary objects are objects which are both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They are weakly structured in common use, and become strongly structured in individual-site use. They may be abstract or concrete. They have different meanings in different social worlds but their structure is common enough to more than one world to make them recognizable means of translation. The creation and management of boundary objects is key in developing and maintaining coherence across intersecting social worlds" (Star et al. 1989:393). One opportune example of this for social science scholars concerns data, especially the utilization of data in a mixed-methods research project (Creswell 2009). The very same data can be processed, analyzed and interpreted differently by qualitative and quantitative researchers.

It is worth mentioning that in ANT there is no clear structure as far as networks are concerned, since their inner organization is in constant flux. Actor-networks can always redefine themselves if new entities connect to them.

The topography of a network is not a formal (and visual) representation of a network but an analysis of how translations, mobilization, the circulation of entities (both human and nonhuman) and orderings (i.e. the extension and stabilization of power relations in new spaces) occur.

How ANT is used today

It is interesting to see how ANT is utilized today in research and knowledge production. Latour (2005:80-82) mentions four key areas where ANT is particularly useful. These areas relate to those occasions when the web of forces, which is normally embedded in an actor-network and is thus hidden from view, can be revealed and analyzed. In the first area (the field of innovation), how particular entities and forces are enrolled, pampered or forced together to serve a common goal can be traced (Miettinen 1999; Avgerou et al. 2004; Mol et al. 1996; Mesman 2008). These activities can be followed, for example, on a shop floor where processes involving conflicts, complex negotiations and arbitrary decisions take place. After the processes come to an end (that is, when the innovations start to become operational), this work becomes invisible and the product is black-boxed (Latour 2005:80). The second area – user-unfriendly situations – is ideal for research because it relates to when products lose their taken-for-granted nature when they are used by individuals who lack the knowledge for this (Gherardi et al. 2000; Akrich 1992; Fenwick et al. 2010). The third field of research in ANT is connected with accidents, breakdowns and strikes. When these events occur, all of the relationships that were during an operation resurface and become discernible for study (Law et al. 2009; Kaghan et al. 2001; Alcadipani 2010). Finally, the fourth area of study, argues Latour, relates to historical accounts of technologies and technological systems (Latour 2005; Farias et al. 2012; Latour 1993; Latour 1996).

It is worth mentioning that among the recent developments in ANT we may find instances of when researchers have built and utilized large databases (Cambroosio et al. 2014) and, in relation to these, quite interesting experiments have been carried out concerning how to visualize connections between heterogeneous entities in a networked space (Mützel 2009). These endeavors include investigations of cases when co-authorship and thematic connections were used to create a heterogeneous network of social and semantic ties (Bourret et al. 2006).

THE APPROACH OF SOCIAL NETWORK ANALYSIS

Background

SNA is a paradigm that became rooted early on in the social sciences (e.g. Comte, Durkheim, Marx, Simmel, Morgan) yet the theoretical and methodological development of the paradigm started only towards the end of the 1920s.

Before WWII, the anthropological and sociometric approach was developed. Radcliffe-Brown's (1940) structural-functional theory emphasized that society is a system of social relations, and the author urged British anthropologists to systematically study networks. Following Radcliffe-Brown's call, Gluckman also stressed the importance of collecting data about interactions, and through seminars brought together Barnes, Bott and Mitchell, today recognized as the pioneers of systematic personal network analysis and data collection.

Scott recognizes the existence of two major SNA communities prior to the 1960s; one is the Manchester school of anthropologists, consisting of Barnes, Bott and Mitchell, while the second is centered on sociologist Harrison White, and Harvard University (Scott 2000).

Barnes studied the personal ties that link elements together in the formal structure of a village. This author was also the first to use the concept of a (social) network (Barnes 1954). Bott's kinship investigation recognized the variability in connectedness, differentiating between 'close-knit' and 'loose knit' networks (Bott 1957). Mitchell identified the structural, categorical and personal order of social relationships that serve to interpret behavior and differentiated between total networks and personal or ego-centered networks (Mitchell 1969). Research conducted by Moreno and Jennings (who were later joined by Lazarsfeld) among prisoners, and later among students (Moreno 1953; 1934), are among the most well-known sociometric studies and are considered to be another pillar of SNA. White played a major role by training scholars (Granovetter, Bonacich, Breiger, Wellman, etc.), also known as the Harvard structuralists, who later became the leaders of the field and established the SNA paradigm.

SNA, by adopting elements from several social theories and impacting many others, cuts through traditional social theory boundaries. It is more flexible than other social paradigms—such as functionalism, conflict theory or symbolic interaction theory. Empirical SNA research does not imply the use of theoretically strict institutional, class or group boundaries. Additionally, SNA's relationship with the major theories and research that have focused on network positions can be compared to conflict theory, while its relational approach comes closer to symbolic interaction theory (Tardos 1995). Positivist tendencies can be observed within SNA with regard to its combination of rational choice theory and deductive hypothesis testing (Marin and Wellman 2011) that seek to predict future interactions (Kadushin 2012).

Freeman recognizes four defining features of the SNA paradigm, such as the shift from the use of analytical to relational data (from attributes to relations as the central items of investigation) which is collected in a systematic manner, its reliance on graph theories, and a preference for analysis with computational tools and visually displayed graphical images (Freeman 2004). Kadushin adds a fifth feature: the study of flows in a network (Kadushin 2005).

The social network paradigm seeks to analyze social relations and interactions within an observed community, thereby providing the most basic definition of SNA as the

investigation of ties and tie patterns between actors and the exchange of resources and funds (Wasserman and Faust 1994). Since the work of Harary et al. (1965) and Freeman (1979) the further development of the paradigm has been strongly characterized by reliance on graph theories. Today, SNA studies nodes/actors and the ties/interactions/relationships connected to them using graph theory. Until the 1990s—when the development of SNA started to be based on a more natural scientific approach—the paradigm was mainly developed in the field of sociology. While the application of mathematics ensured the success of SNA, it also allowed it to develop into a predominantly quantitative approach (Heath et al. 2009).

According to Borgatti, the argument that SNA is more of a descriptive tool than a theoretical paradigm may have been true of some early research, but is definitely not true of much of the recent work (Borgatti et al. 2014).

In the development of SNA several network-theorizing trends have had significant influence, such as social capital theories (Coleman 1990; Granovetter 1973; Putnam 2000; Lin 2001), structural hole theory (Burt 1995), and small world theory (Milgram 1967; Watts and Strogatz 1998).

Generally, SNA may be considered part of a wider positivist paradigm with its expectations of measurable topics, generalizable results and an objective view of ties and network positions. While there are times when SNA does not assume that the measured variables are independent, it generally seeks to identify the relationships between actors in the same network (Scott 2000).

Elements of the theory

Defining networks

The most important characteristic of network theory is that, in order to explain social phenomena, it asks that we turn our attention to relational data and the relationships among the interdependent subjects in society, inferring a shift away from monadic variables (attributes of actors) towards dyadic variables (attributes of pairs of actors, attributes of relations among actors) among the total set of actors. Relying on graph theory, a network can be construed as a graph formed by a set of actors/vertices (social actors or objects) and the set of relations which connect them, although a network also contains more information than can be depicted by a graph such as the nature of vertices and/or the relations on the graph.

Some have used an understanding of relations to investigate more substantive questions (Burt 1995; Wellman 1979; Granovetter 1973; etc.), whilst others have followed a more formalistic approach by mainly focusing on the mathematical form of networks (Watts 1999; Barabási-Albert 1999; Buchanan 2002; etc.). With the emergence of disciplines such as network science, social computing has facilitated collaboration between the natural sciences (physics, mathematics, biology, etc.) and social science.

Defining connections

Ties themselves can be as diverse as it is possible to imagine as they embrace every aspect of social relations including kinships, friendships, co-workers, co-authors, the transmission of disease, trade flows, flows of information, the diffusion of innovations, material support, military support, institutional affiliations, political affiliation, etc. Among the same set of actors many networks can be mapped, each with different structures, roles and positions. Each kind of tie can form a separate network, and multiple networks may be analyzed and compared for the same group of actors. In the social sciences, dyadic ties can be classified into the following four categories: 1) similarities based on location, membership or attribute; 2) social relations based on kinship, other role, affective or cognitive; 3) interactions; and, 4) flows (Borgatti et al. 2009).

Key actors and roles

In SNA several indicators and measurements have been developed and are frequently used for the definition and identification of the key actors and/or roles that are fulfilled within a network. Among the most important ones are centrality, brokerage, and prestige.

Centrality can occur in three ways: through the existence of many ties (degree), through the short distance from one actor to another (closeness), or by an actor being a component of many paths between other actors (betweenness) (Freeman 1979). Betweenness centrality at a local level suggests that actors can take advantage of structural holes; that is, the absence of a tie between two neighbors (Burt 1995). Prestige and ranking indicators rely on the hypothesis that not all ties are symmetrical, and that social inequalities are reflected by these asymmetries. Identification and ranking within a network may be undertaken on the basis of popularity—among other methods—depending on the number of incoming ties, proximity prestige, clusters and triads. The identification of leadership, brokership, embeddeddness, influence (Katz 1957), and homophily (McPherson et al. 2001) is central to SNA.

When analyzing a social network, structural characteristics such as network size, density (the ratio of existing ties to all possible ties) closeness (the distance between any

two actors in the network) and clustering (the existence of dense regions in the network) as well as the number and character of subgroups (cliques, clans, etc.) can be investigated (Wasserman and Faust 1994).

Non-humans in networks

"A social network is a set of socially relevant nodes connected by one or more relations" (Marin and Wellman 2011). At the center of scientific research are not actors, but the relations which connect them. Any kind of units can be considered network actors, but in SNA these units are predominantly either individuals, or (more or less formal) groups of individuals such as institutions or organizations. In some cases, 2-mode networks are used in analysis: 2-mode networks connect different kinds of actors such as individuals to localities in a network (of commuting habits/tourism, etc.), and, usually, individuals to organizations and localities, etc.

While in the great majority of research SNA is undertaken to examine relationships and interactions among humans, the method is also sometimes used to investigate non-human actors. The SNA of institutions concerns the connections between organizations (Ebers 1997; Uzzi 1997), although these connections are often maintained by human actors.

Citation networks are another field of investigation for SNA, which claims that that "networks can also be made up of objects that have no obvious action identity as actors in the sense of individual, groups, organizations, or nations" (Felrigoj et al. 2011:435). While publications are typically considered non-human actors in SNA, they are closely related to human activities as both citation and co-authorship ties are initiated and executed by humans. A third area of application of SNA for non-human actors is the field of animal behavior (Brent and Ramos-Fernandez 2011; Maryanski 1987; Watts and Strogats 1998; Faust and Skvoretz 2002).

Network analytical approaches have also been applied to examine culture, whereby concepts, categories and narrative clauses were treated as nodes (Carley 1997; Martin 2000). Here, human and non-human elements were treated as separate networks. Moreover, White's (1992) relational sociology approach also utilizes human and non-human elements. Since the 1970s White has been concerned about the theoretical understanding of types of ties, and in his book, *Identity and Control,* he presents a narrative foundation for social structures. Networks themselves are created by narratives, built up by discourses, stories, and meanings: "a tie becomes constituted by story, which defines a social time by its narrative of ties" (White 1992:67) while individuals are involved in fluid interactions and the constant (re)interpretation of these interactions.

How SNA is used today

Understanding that social networks are not static and that a cross-sectional analysis may provide only a limited explanation is a scientific discovery of recent years, and the shift in interest towards a more dynamic analysis of social networks has become increasingly accentuated. The spread of health information, diseases, help, and support can be efficiently observed and mapped through the use of personal networks, and investigating the network aspects of diffusion continues to be an outstanding area of application of SNA (Valente 1995). Exponential Random Graph Models (ERGM) explain networks according to observed tie-based structures, also called network configurations (Lusher et al. 2012). Stochastic actor-based models that rely on longitudinal observations investigate the co-evolution of networks and behavior, along with attitudes and performance (Snijders et al. 2010). Another current research topic is how the social network of the elderly correlate with social isolation, loneliness, access to health services, and mental and physical health (Kobayashi and Smith 2011). Longitudinal studies of personal network dynamics lead back to the so-called East York studies conducted in the 1980s which focused on how communication and distance influence the changes that occur in personal networks (Mok and Wellman 2007).

Knox argues that quantitative SNA methods may be overlooking some "real life" network elements (Knox et al. 2006). Recently, some authors have argued for the use of qualitative elements in SNA. By combining qualitative elements, researchers can explore more complex topics and phenomena and are able to gain deeper understanding of the complexity of social relations and their dynamics (Edwards 2010; Carpentier and Ducharme 2005; Curran et al. 1993; Robson 1993). Relational sociology (White 2008) uses a qualitative approach to collect data – even if formal quantitative analysis is also done later on. This type of relational sociology is different from mainstream SNA in many respects, as it "pushes sociological theory beyond rational choice, structuralist, mechanistic and variable-based sociologies towards a more dynamic and contextual model by considering how meaning arises in a relational context and, dually, how relations create meaning." (Mützel 2009:874). The approach is built "on empirically observable uncertainties and contingencies in action encountered in everyday life" (Mützel 2009:875). Relational sociology looks at the "inseparable intermingling of network relations and discursive processes" (Mützel 2009:875). Breiger (1974) also adapted the Simmelian concept of "duality", making an important contribution to SNA and relational sociology and the way we understand individuals and groups today, thereby anticipating 2-Mode (multi-mode) network analysis. This cultural turn "offers new potential to re-engage different traditions of network thinking" (Knox et al. 2006) by including the narrative of the network in the analysis. As Edwards (2010) argues, this interpretation corresponds to a mixed methods approach.

THE TWO APPROACHES

In this paper so far we have described two very different 'traditions' that both use the concept of 'networks'. When comparing ANT and SNA, it should be taken into account that these two approaches are not homogenous in themselves—although the predominant strand of SNA can be determined more easily than is the case with ANT—and nor are they equally well known among social scientists. ANT involves a "diffuse, diverse and contested set of framings and practices" (Fenwick and Edwards 2010:ix), and can be thought of as "a virtual 'cloud', continually moving, shifting and stretching, dissolving in any attempt to grasp it firmly" (Fenwick and Edwards 2010:ix). SNA also contains different strands, although these can be more easily grouped into distinct types, and much of SNA research is dominated by the quantitative, structural, hypothesis-testing type of research.

Differences and similarities

Despite the diffuse nature of ANT, some general statements regarding the differences between ANT and SNA can be made that are true of the majority of research in these two fields:

– The approaches come from different philosophical backgrounds and take different epistemological and ontological perspectives. Accordingly, they utilize different styles of research and core concepts and apply a different way of presenting research results.
– While one method in many respects seeks to construe complexity, the other often seeks to simplify by testing hypotheses.
– Whereas ANT attempts to map the connections between heterogeneous entities without attempting to quantify the strength of connections or build a model which can be applied in various contexts, some of the SNA research is conducted with the specific goal of formulating and testing causal hypotheses.
– They have developed in different fields of social sciences.
– ANT and SNA literature does not speak to the same scientific audience; moreover, scientific communication between the different communities is sparse – each community having its own distinct set of conferences and journals.
– The two approaches have different views about what a network is: many social scientists would probably not consider to be networks those that ANT understands by the term. In ANT, a network is a special kind of metaphor. Formalized presentations are typically not used by the approach. Meanwhile, SNA has generated a well-developed methodology for actor selection and tie definition and uses several kinds of software to analyze and formalize visualizations of a network.

– Additionally, there is different understanding of what relationships are. SNA uses a more concrete definition and system of categorizing relationships/ties, whilst within ANT the term relationship is more loosely used to mean that at least two entities mutually affect each other – or the focus is on the process of translation.
– The two traditions have different views about agency, and non-human entities are treated differently. Whilst some proponents of ANT argue for radical symmetry in terms of the treatment of human and non-human actors, SNA predominantly focuses on humans and interpersonal networks. Studies that use SNA for non-human actors analyze networks that are nonetheless closely related to groups of people or to human activities. SNA is also used for obtaining a better understanding of animal behavior, but in this case all the actors in the network are animals.
– With SNA, non-human actors (such as objects) are neglected and their importance from a sociological perspective is often not perceived. In contrast, within ANT non-human and non-animal objects – buildings, ships, technologies, etc.—are routinely components of the networks under scrutiny.
– Within ANT different kinds of entities (human and non-human) are routinely located within the same network. In contrast, most SNA focuses on homogenous entities, although in some cases 2-mode networks are employed—however, this is not the most dominant form of use.
– Whilst within SNA there is a concrete limit to an actor's relationships, within ANT the boundaries of networks constantly shift.
– The approaches employ different ways of generating nodes for their networks: ANT utilizes an open, qualitative follow-the-actor approach, whilst within social network analysis subjects are often selected according to network definitions or by sampling methods, and relationships are most commonly identified through use of a questionnaire.
– As SNA is predominantly quantitative and ANT predominantly qualitative in nature, this also results in the investigation of different areas of interest.
– Whilst SNA has been routinely employed to analyze a wide range of topics, ANT was originally popularized in connection with science and technology.

Indeed, it is perhaps harder to find similarities with the two approaches than differences – especially if we compare ANT with the dominant (quantitative) SNA approach. Still, some similarities between ANT and the majority of SNA approaches may be discerned:

– Both use the concepts of networks and actors and both also examine the relationships between actors and emphasize the importance of relationships.
– In both approaches networks can have non-human elements (but about their different use, see above).
– Both differentiate different kinds of actors, some of which are more central than others.

– Although ANT was originally used in connection with science-related research, its scope has widened, so nowadays some topics of investigation overlap with those of SNA – for example, co-authorship and economic markets.

When a researcher is thinking about applying a network-oriented approach, one option is to make a choice between the two approaches and apply just one. Another option is to choose not just one, but to think about how the methods converge. We discuss these two options in the following section of this paper.

Choosing between ANT and SNA

There are several factors that are worth considering when deciding between ANT and SNA. In decision-making you can, for example, take into account which scientific community you aspire to belong to, and which philosophical background and scientific style you prefer. A look at the abstracts of the major conferences and journals of the Science and Technology Studies field in which ANT scholars publish (such as the EASST conferences, or the Social Studies of Science journal) and the major conferences and journals of the SNA tradition (such as Sunbelt and the European Sunbelt, and the journals Social Networks, and Connections) can quickly give you a feel for the divergent nature of the two scientific communities, the different philosophical underpinnings and research styles involved.

Another issue to consider is the topic under examination and how the strengths of the approaches may be best utilized. For example, and as discussed earlier, one of the strengths of ANT is that it is a useful analytical tool for studying the construction of networks. Applying the terminology of the different stages of translation (problematization, interessement, enrolment, mobilization) can be illuminating in the study of the process of network creation. As also mentioned previously, ANT can be especially useful in the study of innovations, user-unfriendly situations, accidents and/or breakdowns and historical accounts: in these cases the relevance of non-human elements can be made more easily visible. Moreover, a preexisting body of research has already applied ANT in these fields so one may find guiding examples when designing a project.

Network size may be an issue to consider as well. When dealing with very large networks with many elements, one strength of SNA is that it can summarize major aspects of the networks using quantitative processes.

SNA has proved its efficiency in several fields of research and in scientific disciplines. Whether concerning the evolution of certain relationships (positive or negative) over time, or the way a network is shaped by the different attributes of the actors, SNA with its developed methodology has been successfully employed. Diffusion studies (the spread of

innovation, information, disease, etc.) and the way that social networks influence quality of life, and understanding the opportunities that may be obtained by fulfilling central roles and positions within a network are only some of the major areas of interest of SNA.

Hypothesis testing using both visually and statistically powerful tools is another asset of SNA that could lead one to opt for this approach. A visually meaningful/interesting network can be successfully implemented into mixed-methods research by using it as a tool for guiding narrative interviews.

Potential convergence

We have argued that it may be fruitful to promote some convergence between SNA and ANT. However, many issues have not been resolved so far in respect of how this can be done. It is important that the different philosophical underpinnings are explicitly reflected upon in the solutions that are offered, and how convergence influences theoretical thought in the two areas is considered (for example, how theories in SNA could be modified if non-human elements were also taken into account as nodes within a heterogeneous network).

We cannot emphasize enough that much of the work of ANT and SNA speaks to different research communities which use different research styles and adhere to different ontologies and epistemologies. Accordingly, the audience is also an important factor to consider when thinking about how it might be possible to use ideas from both traditions: who would be a willing recipient of such a mixture of ideas? The authors are of the view that this problem might be more easily solved if either approach was infused with a small contribution from the other so that variations are created that lean either towards the ANT or SNA approach, rather than attempting to fully blend the two approaches. The differences in the philosophical underpinnings of the two strands of thought also support the view that caution should be applied when attempting to merge the two traditions and stress the need to reinterpret these concepts in the process of fitting them to the main area of research interest.

The fact that there are different versions and interpretations of SNA and ANT should also be taken into account. In their mainstream formulations, the points of intersection might be hard to discern, but both within ANT and SNA some new trends have appeared which bring the perspectives closer to each other. Although proponents of ANT were originally wary of SNA tools and visualizations, there have been recent cases of ANT researchers using formal visualizations to analyze large networks. Areas which both ANT researchers (using more formalized visualization techniques) and SNA researchers investigate include co-authorship networks and economic market topics (Mützel 2009). Relational sociology has appeared as a topic of interest within SNA, which similarly to

ANT places the emphasis on processes, not structure, understands networks as culturally constituted processes, emphasizes that "we live in a world of contingencies", and has employed both human and non-human elements in networks, as well as applied qualitative data collection methods (Mützel 2009: 875).

Some studies seek to reinterpret these analytical techniques more in terms of methodology than theory (Sayes 2014; Salancik 1995). Sayes (2014:9) regards ANT as a "methodological sensibility" which "introduces uncertainty concerning the nature of agency and the possible extent to which nonhumans might be actors." In his interpretation of ANT he emphasizes that while ANT attributes agency to non-humans as well, this does not mean that the agency of non-humans is of the same type as that of humans. According to this author, ANT should not be interpreted as arguing for the non-existence of a distinction between humans and nonhumans, but that these distinctions should not be "foreclosed…prior to analysis" (Sayes 2014:10). Sayes acknowledges that ANT literature lends itself to other types of interpretations as well, but argues that understanding the statements made by proponents of ANT as theoretical is not compatible with the "position's methodological comportment" (Sayes 2014:10). Salancik (1995) also states that SNA is 'atheoretical'. When SNA and ANT are understood in a more open way as a form of methodology/methodological sensibility, their convergence can be more easily imagined.

One example of this kind of convergence is found in work by Wickramasinghe and Bali (2009), who put forward arguments for the usefulness of applying a "S'ANT" approach: a hybrid approach combining both methods. The authors regard these two methods as analytical tools, and in their interpretation argue that even though ANT has theory incorporated in its name, it is actually more of a framework than theory. Using the S'ANT approach, actors are defined using an ANT perspective as "someone or something that can make its present individually felt and can make a difference to the situation under investigation" (Wickramasinghe and Bali 2009:53). It is emphasized that both human and non-human entities can become actors in a network (for example, in the worldwide healthcare network that Wickramasinghe and Bali analyze, medical practitioners, medical equipment, technology, patients, organizations, and administrative computer systems can be elements of the network). The authors apply the follow-the-actor approach of ANT. Then interviews are made with the actors who have been identified to better understand the nature of their relationships, including how they negotiate and form networks. Interviewing the non-human elements, according to the researchers, involves finding "someone (or something) to speak on their behalf. For an item of medical technology this might be its designer or user, or it might just be the instruction manual" (Wickramasinghe and Bali 2009:53). The idea of negotiations taking place between human and non-human elements also draws on ideas present in ANT. As Wickramasinghe and Bali (2009:53-54) write: "Human actors, such as medical practitioners, can 'negotiate' with non-human actors such as X-Ray or dialysis machines by seeing what these machines can do for them,

how easy they are to use, what they cost to use, and how flexible they are in performing the tasks required. If negotiations are successfully completed then an association between the medical practitioner and the machine is created and the machine is used to advantage – the network has become durable. If the negotiations are unsuccessful then the machine is either not used at all, or not used to full advantage".

After constructing a network of healthcare operations based on these considerations and methods, the idea is then to map the flow of knowledge using SNA tools. By doing this, findings based on the construction of the network and the negotiations which were involved lean heavily on ANT concepts, and results that deal with the flow of knowledge in the network would come closer to those expected from SNA-style research. By taking this approach, Wickramasinghe and Bali (2009) do not take into account several of the dilemmas mentioned earlier, including the historically different philosophical underpinnings of the two approaches (they do not discuss the philosophical basis of their work explicitly). Still, they provide a starting point for thinking about the potential convergence between ANT and SNA.

CONCLUSIONS

The aim of this paper was to describe two traditions that deal with networks which are usually not discussed together and bring them into one conversation. The authors' goal was also to suggest grounds for choosing between the two approaches—if one must commit to using only one of them, and also to suggest ways in which the two positions can productively be connected, thereby creating new and innovative findings. We feel that both SNA and ANT scholars could benefit from looking at some of the advances that have been taking place in the respective fields, and experiment with making connections. However, combinations should be constructed with care, taking into account the divergent philosophical backgrounds, research communities, and scientific styles. The combined approach could build on the relative strengths of the two methods. The S'ANT approach that was presented in the paper is a good start in the development of such combinations. There are still unresolved issues, such as which research paradigm the end result will fit into. Philosophical underpinnings have to be explicitly stated, and whether these positions are being treated as methodologies without any philosophical baggage should be clarified.

The aim behind this paper was not to offer a final methodological solution—this is nearly impossible at this early stage of potential collaboration—, but to describe the basic ideas about ANT and SNA that may encourage the relevant scholars from these fields to engage in conversation about a combined approach. If this paper has succeeded in highlighting the opportunity of bringing about a new understanding of different network

processes and/or characteristics to SNA by encouraging the introduction of non-human actors into networks that also contain humans, or managed to raise the interest of ANT scholars in using some of the tools employed in SNA (such as formal visualizations or quantitative measures), we consider it successful. Making these types of connections would help bridge two areas of social sciences that, while both working with social networks, are doing so in a very independent way.

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