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Complexity, connectivity, and management information systems: new possibilities for understanding social care?

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Abstract
Complexity research is a relatively new discipline that has developed from advances in biology, physics, computer science, and the social sciences. Organizations providing social care can be seen as complex systems, and the new perspective of complexity may give insights that will enable policy-makers and managers to make the provision of social care more effective. The paper presents data from a survey of social care that has a 'Zipf-type' distribution, characteristic of complex systems. The paper also considers the ontology of social care organizations, and the relevance of this in complexity research.

Keywords: Complexity, social care, connectivity, management information system

Introduction

There are many definitions of complex systems: Johnson (2006) notes that one source identifies 31 definitions of the term. In brief, complex systems are those with a massive number of elements that interact in a dynamic manner. Examples include business organizations, the internet, ant colonies, and the human brain. Typically, complex systems have emergent properties - for instance, the human brain produces a property of consciousness (many would argue). Consciousness is also a phenomenon that emerges from other attributes of the system (that is, in some way, that we do not fully understand, from the biochemistry of the brain).

If we consider an organization (e.g. a local authority working in partnership with other agencies), one of whose functions is to provide social care, as a complex system, it can be argued that complexity provides a new perspective to enhance our understanding of how and why the organization behaves in a certain way, and eventually may help us to manage the organization better.

Complexity may also provide a new perspective in research, since it is different from the predominantly statistical models currently used to study social care. Such models tend to use techniques based on regression (whether logistic regression, multi-level modelling, or multiple regression) for predictive and explanatory modelling of social care.

One may also consider a management information system (MIS) as an example of a complex system. Social care organizations typically collect information about their clients, the services provided, cost of services, key events that clients experience, and more, in corporate IT systems. In a sense, IT systems are a representation of 'reality'; to some extent, MISs provide the raw data analysed in research (of course they might not include information collected specifically for research projects, such as that resulting from questionnaire surveys). In addition, it can be argued, they are not intended to hold data on every variable that would be relevant in research (they hold only all the data needed for the range of corporate functions they support). Nevertheless, even with these limitations, they, too, are a kind of model of the complex system they represent.

Applications of complexity in social care

One can distinguish between what may be called qualitative and quantitative applications of complexity. In qualitative applications, concepts from complexity are introduced to give fresh insights into the phenomena in question (e.g. in social care), but data are not collected nor analysed by means of quantifiable variables (nor is a simulation usually created). This more qualitative application of complexity has been popular in strategic management and organizational change. There are many ideas from complexity that have been used in this way. For instance, the idea of 'agents' as originated in complexity research has inspired a new perspective in understanding how organizations function. The concept of agents is also associated with its meaning in computer science, where it refers to a specialised program that is self-activating, for example, on the internet those that inform website customers of new products when they are launched (see Antoniou & van Harmelen, 2004). Axelrod and Cohen (1999) discuss the idea of an agent (a person, a team, or any element in a system that is a coherent whole, interacts with other elements, and has purposeful behaviour) as a useful concept in considering organizational change. In passing, they give the example of placing children for foster care as a process involving many agents: a child, the foster carers, the professional arranging the placement, a manager who develops placement policies, the team responsible for foster care, all are agents. Interactions between these agents are part of the dynamics of the system.

In general, there is little published literature on applications of complexity in social care. An exception is Pinnock's (2004) discussion of complexity and the influence of metaphors we use in conceptualising organizations. By contrast, there are several published reports on applications in health care (e.g. Sweeney & Cassidy, 2001; Zimmerman *et al*., 2001; Plsek, 2003). A thorough critical review of complexity and strategic management can be found in Stacey (2003).

Quantitative applications are those that involve collection and analysis of data using a systematic method specifically associated with complexity research, or simulations intended to investigate theories of complexity. There does not appear to be any published research on quantitative applications of complexity in social care. On complexity in general, there is an extensive literature and accessible introductions (see Barabasi, 2002; Watts, 2003).

Connectivity

One of the most important ideas in complexity is connectivity. Complex systems typically consist of many elements with massive connections between them. One can think of complex systems as, in part, multiple interconnected networks, where a network is a set of well-defined 'things' connected via some well-defined relation. Social networks are those where the 'things' are people, and the relation is (for example) one of social affiliation (i.e. a person knows the other person to whom they are connected). There are many applications of complexity where connectivity is a central concern. One that is often discussed is the internet. The internet consists of information distributed across thousands of interconnected computers, and its physical architecture (the way computers in the network are connected) is, in part, designed to be resistant to attack and failure of individual computers or parts of the network. By contrast, social systems, and in particular business and services organizations, are in most respects far more complex than computer networks. Organizations depend on the connectivity between component elements. For instance, a partnership of organizations providing social care will probably have contracts, agreements and understandings about how they will operate. To work in this way will involve coordination of people (e.g. employees, consultants, contractors, volunteers), plans, policies, services, and information. Imagine the same organization without any connections between elements: for instance, what would happen if there were a plan, but nobody was aware of it: of course, it would have no effect. In fact, it is impossible to imagine an element of an organization that is not connected to anything else in the organization - it is a paradox, because by definition an element can only be part of an organization by virtue of its connection to some other element. Disconnections do occur, and sometimes this can cause problems, for example if two employees take some action that mutually conflicts and fail to talk to each other. In fact, organizations tend to be very resilient in many situations, in that they continue to function even with many disconnections. In other circumstances, though, disconnections can, of course, lead to catastrophic failure.

Information is of pivotal interest since large organizations generally have to manage great volumes of information in order to function effectively (indeed, failure to do so can have serious consequences in some cases). Most organizations now depend on management information systems (i.e. computer systems) for many management functions, such as finance, marketing, customer information, planning, and project management. In many cases, such IT systems will be based on relational databases that in a sense, are designed to create a model of the real world phenomena they represent. In particular, relational databases consist of tables and joins, where a table represents a type of entity, and a join represents a relation between two tables (e.g. a customer table is joined to an orders table). Information flows are very important for how organizations work together. An illustration of this principle is the high-profile case of Victoria Climbié, where several agencies (police, social services, and others) had information that indicated the serious risk she faced, but poor communication between agencies contributed to the failure to prevent her abuse and eventual murder (Laming, 2003).

Zipf distributions

There are many ways to explore how complexity applies to organizations providing social care. Let us start by exploring a 'quantitative' application. Often there are occasions in managing social care when one has to interpret a set of values: e.g. in managing a budget for foster care provision, a manager may be presented with a report showing 1,000 cases and their cost for the latest quarter. When analysing such data, it is usual to examine their distribution, which may follow one of several patterns. Each case may have a similar cost (thus producing a uniform distribution). Or the data may follow a normal distribution, (looking like a bell-shaped curve when charted), where there are a few low cost cases, a few high cost, and most fall in the middle region.

An example of data from one local authority participating in a recent England-wide survey of social care spend is illustrated in Figure 1. In this survey, all local authorities that provide social care collected detailed data on services to children and families during a one week period. Services included those for children in care (looked-after children), fostering, services associated with clients on the Child Protection Register (children at risk of serious harm), and services provided to support families experiencing problems in caring for their own children. Data were collected on the amount of time spent by practitioners (social workers and others) in direct contact with children (e.g. therapeutic work), in travelling, administrative work, meetings, on the cost of services, demographic characteristics of clients, and a variety of other variables. Figure 1 shows the distribution of spend for cases in a large Borough Council. Spend is comprised of direct spend (e.g. on residential accommodation), one-off payments (e.g. for clothing or furniture), the cost of practitioners' time, and all other costs to the organization. The distribution is highly positively skewed, that is, there are many relatively low-value cases, and a few high-cost cases. Analysis of both a different local authority and the larger national survey dataset (c. 250,000 cases), showed a similar distribution. In other words, the pattern does not seem to be a peculiarity of the authority in Figure 1 but is quite general. Thus the distribution of spend on social care is characteristic of measures associated with complex systems.

The distribution in Figure 1 is similar to the family of distributions known as Zipf distributions, often encountered in complex systems. A Zipf distribution is a type of frequency distribution that has a precise mathematical specification (in outline, one that follows an inverse power curve) and in essence, has a few high-value cases and many low-value cases (for details of the exact mathematical specification of such distributions see Downs & Johnson, 2006). We see such distributions in word frequency (in English there are a few words that occur very frequently, e.g. 'and', 'the', and many that are infrequent, e.g. 'disinter', 'opprobrium'). Such distributions are also seen in city populations and in the internet. As far as city population is concerned, there are a limited number of cities and towns in the world with huge populations, and thousands with relatively small populations. In regard to the internet there are a few sites, such as Google, that get a massive number of visits, while there are thousands that receive only a few. For example, Figure 2 shows the distribution of downloads from the Rhapsody music site over a one month period. A few tracks are downloaded thousands of times, while there are many that are downloaded only a few times (hence the long tail of the distribution made famous in the book of that name).

Simulation

Simulation has often been used in complexity to investigate how complex systems develop and change. In some cases, this involves applying simple rules to a computer simulation to see if this can generate complex behaviour. An example is the study of 'boids' - a computer simulation of birds. In this research (Reynolds, 2007) the rules were designed to apply to individual birds. When the rules were applied in a simulation with many individuals, the complex behaviour seen in flocks, where the birds manage to synchronise with each other, and avoid collision, was reproduced.

Simulation, in some situations, proceeds by building a detailed computer model of the system being studied. One notable example is the TRANSIMS model developed at the Los Alamos National Laboratory (see Johnson, 2006, p. 35), a simulation of the transportation network of Los Angeles. The model holds information on households, family members, trips made, the transportation network, and many other variables, derived from population census data, surveys, and other sources. TRANSIMS has been used to examine the effect of introducing changes in the network, e.g. the effect of building a new highway.

Figure 1 Zipf-type distribution of social care case spend in 2005 Children in Need Survey (English Borough Council)

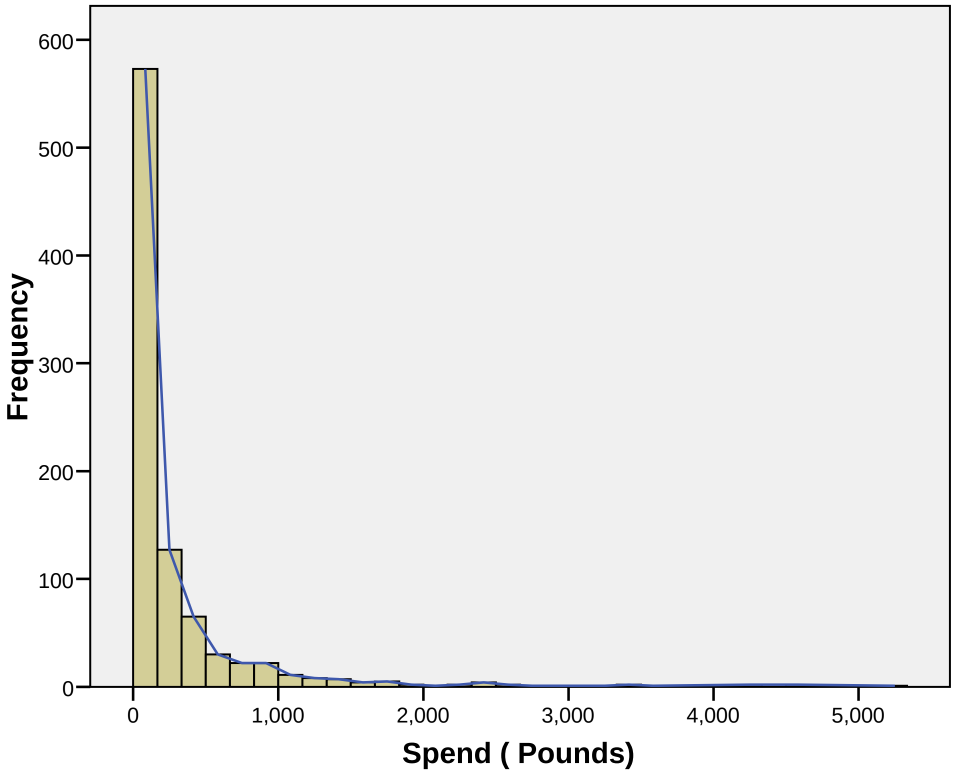


Figure 2 Rhapsody: music downloads Dec. 2005 (top 25,000 tracks)

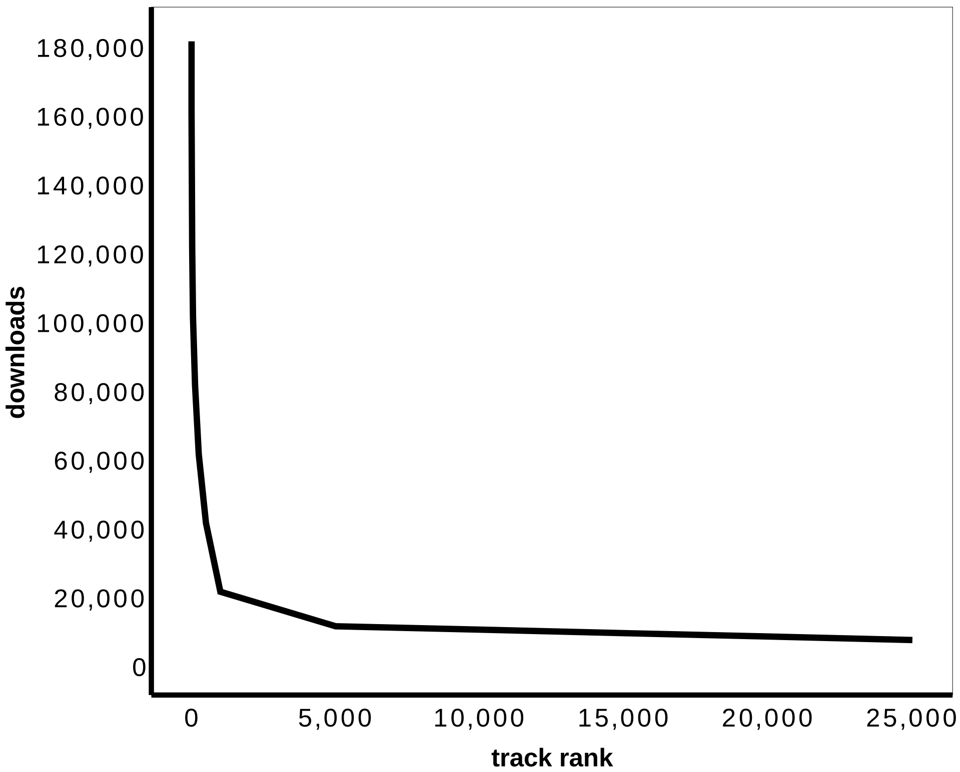


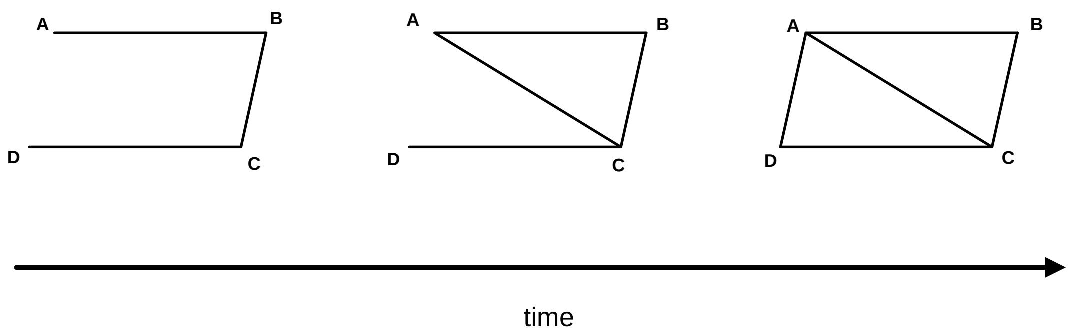
Chart adopted from "The Long Tail", Chris Anderson, 2006.

Simulation has also been used to model the development of Zipf distributions in city growth, simulating the development of a Zipf distribution of city size (population) as a result of the interaction between urban and rural centres (Pumain, 2004). Given that we see Zipf-type distributions in the social care domain, we might discover more about how and why they occur, by applying simulation to model their development. It may be of benefit to understand these mechanisms better. Managers and policy-makers will want to control spend in social care, and if (as the above survey suggests) a large portion of spend is determined by a few high-cost cases, then if one can understand why these cases become so costly, this may help to control spend better.

Simulation and social care

We have suggested that it may be of benefit to managers and policy-makers to understand mechanisms that underlie the development of Zipf-type distributions in social care. We also know that the study of distributions in complexity is associated with connectivity. Some aspects of connectivity in the social care domain may be associated with the development of Zipf distributions. Social networks have been researched a great deal, in particular in complexity research, and thus this appears to be one possibility worth exploring. Social networks as a field of study is concerned with relationships between people (and in other species) and how such relationships develop and change over time. Often, studies of social networks of people are concerned with friendship or other social affiliations. In the 1950s the mathematician Rapoport developed a theory of how social networks develop, and his theory has been of interest in complexity research. As Watts (2003, p. 56) describes, Rapoport suggested the following mechanism by which social networks develop. Imagine four people A, B, C, and D. (Figure 3). A is a friend of B, B a friend of C, and C a friend of D. If A forms a new friendship, is the new friend more likely to be C or D? Rapoport suggests that A is more likely to make friends with C, since C is a friend of a friend (C is a friend of B, and B is a friend of A). If D then forms a new friendship, who is most likely to be the new friend? Perhaps there is a random factor at work as well, so D may form a friendship with A. Thus the theory suggests that two mechanisms operate in the way social networks develop - one a bias to form new relationships with friends of a friend, the other a random effect. Hence Rapoport's use of the term 'random biased nets' to conceptualise the way that networks might develop.

Figure 3 Rapoport's random biased nets and the development of social networks



(adapted from Watts, D. (2003) *Six Degrees: The Science of a Connected Age,* p. 61)

As Watts (2003) explains, Rapoport's theory has proved of interest since it defines simple principles which can be built into computer models; one can then study the effect of those principles in large datasets through simulation in computer models. With the recent, huge advances in computing power, it is now possible to test a simulation, by writing a program to implement the principle or rule in question, and applying the principle to a large dataset. The idea of social networks can be expanded in the social care domain. While Rapoport's original theory concerned friendship relationships, one could extend this to a network, centred around a child (receiving social care), where the relationships include not only the child's friends, but also their family relationships, relationships with professionals (teacher, medical practitioner, etc.), and other personal relationships. The network could then be further extended to other entities. For instance, with the current interest in social exclusion, there is a focus on why children become looked after (taken into care). In the vocabulary of networks and connectivity, this question can be framed as: how is it that a connection with a new node (the event of becoming looked after) arises? In searching for an answer it would be valuable to first identify connections to intermediate nodes that typically come about before being taken into care (in other words, events that precede that situation, or relationships with other people that precede it). By analogy with Rapoport's notion of bias it may be that connections with some nodes predispose (bias) later connection to becoming looked after.

Multiple node and multiple relation types

In the previous section, it was suggested that there is a limitation with Rapoport's theory, in that a social network has only one type of node (person) and one relation (social affiliation). Indeed, most examples in the complexity literature are of this type (one node type and one relation type). In contrast, most complex systems in the social domain have many types of node and relation. As Searle (1995) observes, the ontology (in the sense of trying to identify exactly what range of things exist in social phenomena) of social reality is staggering in its complexity. To illustrate this point, Searle examines a relatively simple scenario, where an American citizen orders a beer in a bar in Paris. He outlines the ontology involved - there are many layers: the customer has an American passport and is legally entitled to be in France, the bar has to display a tariff of the price of drinks, the waiter does not own the beer he serves, the bar owner is bound by numerous rules and regulations. Consider then the ontology of organizations. They consist not only of tangible elements such as computers, buildings, products, and people, but a vast array of abstract, social, and psychological entities such as services, values, information, policies, rules, objectives, roles, legal duties, strategic plans, budgets, beliefs, feelings, knowledge, understanding, concepts, and added-value (see Table 1).

'Information' as an entity has a unique place in the ontology: it is itself a kind of ontology, since it represents many of the other elements in the system and the relationships between them. Information is evident in many guises - in organizational charts, in the conversations employees have about their work, in reports and far more. But information in the form of a MIS has a special role, since an MIS is intended to be a model (an ontology?) of many aspects of the organization and many things external to it.

If there are many elements in the ontology and they are all connected, then there are multiple relationships between them. For instance, all clients are connected to one or more services (e.g. a child receiving social care may be in care (looked-after) and also on the Child Protection Register); clients are connected to practitioners; clients are connected to their data in information systems, and so on. These relationships constitute the connectivity in the system.

Table 1 Entities of an organizational ontology

ENTITIES
Budgets
Objectives
Plans
Knowledge
Skills
Conversations
Office locations (sites)
Procurement
Expense claims
Legal duties
Objectives
Reports
Feelings
Beliefs
Values (to guide action)
Added-value (produced by services provided)
Performance indicators
Employee professional qualifications
Employee educational qualifications
Schedules
Projects
Programmes of work
Contracts
Negotiations
Marketing campaigns
Subcontractors
Employees
Desks
Chairs
Computer hardware
Computer software
Information
Databases
Clients
Services
Complaints
Teams
Stakeholders
Partner organizations
Meetings
Conferences
Policies

Datasets for testing the idea of random biased nets and complexity in social care

We have proposed that it may be of benefit to apply the idea of random biased nets to the social care domain, and also that there are many kinds of entity in the organizational structures that provide social care. It has also been argued that the connectivities between entities are an essential aspect of organizational structures. To examine whether these ideas can be usefully applied in social care research, one will need suitable data to test.

There is data available that could be analysed and that would save having to undertake an extensive data collection exercise. For instance, data collected via the SSDA903[1] statutory return in England provides a large dataset. It consists of a broad range of information about looked-after children, including demographic details, episodes of care, reason for becoming looked after, educational attainment, adoption procedures, whether in education, employment, or training, type of accommodation (e.g. fostering, residential homes, secure units), etc. This data has been collected for 150 local authorities for 3 years (on full data) and for further years for a 33% sample. Furthermore, the data is thought to be of good quality since, when uploaded to the central government website, it is subject to automated validation and correction. Thus, it seems that a suitable dataset available for testing this theory is, in principle, available.

Conclusions

In this paper, I have tried to outline complexity research and why it is relevant to organizations with responsibility for social care. An example - applying a technique of quantitative analysis from complexity to social care data was described and the results suggest that Zipf distributions associated with complex systems also occur in the social care domain. One may conclude from this that it is worthwhile to explore further the mechanisms that cause these distributions.

Complexity research makes us think about the ontology of organizations - in other words, what things organizations consist of, and what structures connect the component parts. Organizations are composed of a surprising diversity of things – tangible, abstract, social, and psychological. This is true to an even greater extent for organizations that work together in partnerships. Appreciation of the complex relationships between elements in the system is an example of a 'qualitative' insight that complexity gives us.

Exploring complexity in social care may be beneficial not only in research, but also in the day-to-day management of social care organizations. Corporate IT systems used to manage our social care services and policies are a kind of model of reality. If such systems are designed to more accurately reflect the complexity of services and clients, we may be able to manage these services more effectively. Complexity is in its infancy, but many people predict that, in the future, tools developed in complexity will become commonplace - as routine as spreadsheets and word processor documents are today.

Note: This paper is adapted from part of a presentation to the SSRG Annual Conference *Joining up locally: Partnerships for better practice* held at Stamford Hall, University of Leicester, 16-18 April 2007. An earlier version of the discussion of Zipf distributions and social care survey data can be found in Downs & Johnson (2006); see also Pinnock (2004). The SSRG Workshop was a joint presentation by Mike Pinnock and Clive Downs.

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Endnote

[1] the SSDA903 statutory return is the main annual collection of data on looked-after children used to provide official statistics for England. Results are published annually, for instance in *Children Looked After in England (including Adoption and Care Leavers (2005-2006,)* downloaded June 5 2007 from: http://www.everychildmatters.gov.uk/socialcare/lookedafterchildren/research/.

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