

Spatial Configuration, Organisational Change and Academic Networks

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Abstract

This paper analyses the relationship between spatial configuration, organisational change and collaboration networks of academics by investigating results from an empirical case study of a single academic department at three points in time. Previous research has often excluded academia as an organisational and spatial context or has not brought the study of networks to bear.

The paper discusses in great depth and with use of simple as well as sophisticated analysis methods including Space Syntax how the organisation changed spatially and organisationally over the years, and how these changes can be reflected in structures of academic collaboration networks.

This approach allows disentangling the influences of space and organisation to a higher degree than typically possible in single case studies and therefore provides interesting insights into the multiplex ways in which organisation and space condition each other. It is concluded that both spatial and organisational influences shape the structures and evolution of academic collaboration networks and that the strength of the impact of space varies for organisational, group-related and individual behaviours. Further methodological conclusions are drawn for the future of studying complex, shifting and changing organisations.

Keywords

Intra-organisational networks; Spatial networks; Academic networks; Organisational behaviour; Interaction patterns;

Introduction

Spatial parameters, for example distances between desks of co-workers, have been shown to influence communication patterns in the workplace (Allen and Fustfeld 1975; Sailer and Penn 2009). Recently, it has been argued that spatial configuration is an important rationale for tie formation in intra-organisational networks: two actors are more likely to interact with each other when they are closely co-located and this relationship holds even when controlling for structural effects within networks (like transitivity and reciprocity) and organisational effects (perceived usefulness of alter and team affiliation) (Sailer and McCulloh 2012).

Still, it remains a major challenge to disentangle the multiple influences on intra-organisational interaction patterns. Not only do spatial parameters and organisational structures and cultures both have important roles to play, they are also closely and intricately interrelated (Sailer 2010).

Among other problems, one difficulty of research in this field is the impossibility of fully controlling variables. Therefore it has been suggested that studying the same organisation twice, once before and once after a spatial change in a so called pre- and post-occupancy setup is one of the few possible ways to establish the impact of space on behaviours more rigorously (Sailer et al. 2010). There is a problem however, in that organisations do not stay still over time. Staff change, or are promoted to new roles, while organisational units and projects evolve. This means that a single 'before-after' study must still contend with changes other than the spatial environment.

In this paper, the approach of pre and post studies to investigate organisational behaviours in relation to space is enhanced further. The paper analyses a unique data set of the same organisation (an academic institution) studied at three different points in time (November 2005, February 2008 and April 2012) after varying degrees of spatial and organisational change happened in between. In detail it analyses whether organisational cultures and academic life in the organisation remained relatively stable over time; whether interaction patterns significantly changed from one point in time to another as a result of these spatial and organisational changes; and how the networks of individual people transformed over time as a result of their personal careers and academic development, but also as people worked within different spatial settings at different points in time.

The argument proceeds in seven steps: firstly, a brief discussion of relevant literature provides a context for understanding the nature of academic institutions as distinct types of organisation. Additionally, research on academic collaboration networks, as well as the general relationship between space and organisation is reviewed. This sets the scene for the following discussion and interpretation of results. A second section introduces the case study organisation, a London-based University Department and gives an overview of the methods used in the data collection. A third section presents how the department changed over time, both in terms of organisation and space. The next three sections discuss relevant results of the study: how intra-organisational interaction networks of academics were structured through organisational and spatial influences at the level of the department as a whole, at the level of groups and roles, and finally at the level of individuals using an ego network analysis. A final section discusses the results and draws conclusions for further study.

Space and Organisation: The Case of Academic Organisations

The three different strands of relevant literature (organisational theory and culture of academic institutions, academic collaboration networks, relationship between space and organisation) are briefly sketched in the following to lay a foundation for the discussion of empirical insights into the relationship of spatial configuration, organisational change and academic networks that this paper is aiming to highlight.

Research on **organisational / management theory and organisational cultures** in particular is a thriving field of interest (Ouchi and Wilkins 1985). However, most contributions from a management background focus on corporate organisations and firms. Similarly, most scholars in higher education shun the topic of cultures in academic institutions. In effect, research on organisational cultures of academic institutions is rare, as for instance Tierney (1988) has argued.

Those scholars who have researched the organisational theory of academic institutions have highlighted the “distinctive nature of academic organisation” (Dill 1982: 319). It is argued that universities are value-rational organisations, i.e. they are driven by values of professionals and have strong belief systems rooted in various cultures such as the enterprise, the academic profession and the academic discipline (Dill 1982). Relating academic institutions to traditional organisation theory, Lane (1985) has argued that academic organisations are

characterised by a high degree of differentiation based on organic solidarities, following the argument of Burns and Stalker (1961). This means that decision-making on the level of the whole organisation is weak, therefore universities have also been called ‘organised anarchies’ (Cohen et al. 1972). Instead of a centrally organised decision-making process, every sub-unit performs with knowledge and awareness of the organisation as a whole. Lane continues taking this argument further, since not only every department can be considered a world in itself, but also “every academic is an individualistic competitor responsible only to him/herself” (Lane 1985: 245). While differentiation is at the core of academic institutions, integration, it is argued, happens through professional attitudes of academic cultures. While this caricature of individual scholarship would seem to form an important component of academic organisations, in the physical sciences and engineering where funded research predominate, larger group structures are the norm. It seems likely, therefore, that academic organisations are not characterised by single organisational structure, whether as ‘networked individuals’¹ or as hierarchically based teams, but may be formed of some kind of amalgam of different forms.

At the same time, universities are becoming more corporate and competitive in recent years (Vincent-Lancrin 2006), driven by rising student numbers (OECD 2011), international competition and global rankings (Marginson 2007) as well as an increasing influence of market elements, corporate-style leadership and management (Hatcher et al. 1999; Marginson and Considine 2000). It is still maintained that universities are “*self-reproducing, knowledge-forming organisations*” (Marginson 2007: 126), which is why they are formed of multiple and diverse sets of activities, relationships, actors and practices.

A useful argument on the distinctive nature of academia is made by Benkler (2002), when he compares the academic enterprise to open-source software development communities. He argues that neither open-source nor academic communities follow the classic model of either managerial / hierarchical organisations on the one hand or market-based organisations on the other hand. They are rather self-organised, collaborative and networked models of peer production. In these individuals are motivated by peer esteem or ‘kudos’ as much as

¹ The term ‘networked individuals’ is borrowed from Lee Rainie and Barry Wellman, *Networked: The New Social Operating System* (MIT Press, 2012).

by other forms of reward. Academics publish their insights and knowledge, and teach these in the class room, expecting citation in return.

Most studies of **academic networks** are therefore either co-authorship networks (Barabási et al. 2002; Newman 2001) or citation networks (Leydesdorff 1998) rather than intra-organisational networks of actors in an academic institution. Studies of communication and collaboration between networks of academics within a single institution are relatively rare. An exception is the networks study of a US faculty (Wineman et al. 2009), which investigated co-authorship networks of academics within the same institution and brought this together with information on spatial distances between their offices. It was found that both social (departmental affiliation) and spatial variables (distance) explained the likelihood of academics becoming co-authors. However, no other data sets of communication or collaboration patterns other than published papers were taken into account. This is a limitation, since Katz and Martin (1997) have argued that co-authorship is only a partial indicator of research collaboration. Some studies have focused on interaction and collaboration of staff in corporate offices (Oseland et al. 2011) or universities (Parkin et al. 2011), but did not involve detailed network analysis. Others included cases of academic institutions as examples of collaboration networks within offices (Sailer and Penn 2007; Sailer 2010; Sailer and McCulloh 2012), but did not elaborate on the distinct nature of academic networks as opposed to collaboration networks of colleagues working in other industries or organisations.

Likewise, our knowledge of how **spatial configuration affects organisational behaviours** is mostly linked to the study of office workplaces and corporate organisations. What is more, this body of research is still relatively young and needs developing, or as some scholars in organisation science admit, the physical reality of organisations has been ignored for too long (Clegg and Kornberger 2006). Additionally, the evidence base on the impact of space on organisational behaviours shows highly diverse results at times (Sailer and Penn 2009) and can be considered 'scattered' (Gieryn 2002). It is established, however, that spatial configuration has a bearing on collective activities of people in the workplace, for instance the spatial configuration of the primary circulation system plays an important role in distributing movement flows in space as well as in enabling intensive interactions among co-workers. Space can also shape organisational cultures (Sailer 2010). Space works mainly in a probabilistic fashion (Hillier et al. 1987), i.e. certain behaviours (e.g. intensive interaction) are

more likely to occur under certain spatial conditions (e.g. proximity), yet the influence of space appears by no means to be deterministic. A single space may be used for quite different functions at different times, while very different spatial affordances can be appropriated for apparently similar functions. For example, an open plan environment may support awareness of the presence and availability of colleagues, encouraging interaction, or conversely fear of interrupting others may lead to a reduction in interaction. Under different circumstances the same open plan space may afford surveillance and control by managers effectively discouraging interaction. What remains unknown is the degree to which organisational behaviours in any given organisation follow these kinds of logic of space or resist and overcome spatial structures through other means of action.

To summarise, this brief literature review has highlighted that academic institutions have a distinct character as value-driven professional organisations with a high degree of differentiation and autonomy, but with groups structures and projects defining certain internal hierarchies. How academics collaborate has mostly been studied outside the context of a single institution and has rarely been related to the underlying spatial environment in which academic institutions operate. This paper aims to close this gap by looking at a data set of collaborations in an academic institution at three points in time, each following a change in spatial environment, allowing an in-depth argument to be developed about the relation between spatial configuration, organisational change and academic networks of collaboration.

Case Study and Method

The case study used in this paper is an interdisciplinary and research-intensive university department based in London / UK with around 60 members of staff. In 2005 the department occupied part of three floors of a large university building. In 2008 the department was still in the same spaces, but refurbishment had modernised seminar rooms and students areas, providing a new look and feel to public areas, moving some individuals' offices, and introducing a kitchen combined with print facilities, that also served as a staff/student common room. In 2012 the department moved into a completely different building, where people were now the sole occupants of two adjacent floors with a higher degree of staff sharing offices or sitting in open-plan space.

Methods of data gathering for all three studies included an analysis of the spatial configuration of the workplace layouts using ‘Space Syntax’ (SSX) tools and techniques (Hillier and Hanson 1984; Hillier 1996), a network questionnaire² issued to all staff inquiring into frequency of interaction³ and judgements on the ‘usefulness’ of colleagues⁴ and analysed with methods of ‘Social Network Analysis’ (SNA) (Wasserman and Faust 1994), questionnaires for staff and students asking for space usage patterns and satisfaction with the building, as well as interviews establishing working processes and organisational cultures.

Space Syntax is a theory and method for investigating the spatial configuration of a building and its relationship to the social organisation it houses⁵. It maps the way in which spatial elements (like corridors and rooms) are put together to form a spatial network. This network is then analysed quantitatively with metrics based on graph theory, which are comparable to centrality measurements of SNA, but specifically developed for spatial networks derived from geometrical representations of spatial configuration. The properties of single spatial elements (like a central corridor) can therefore be established as well as the average path length of the network (called average ‘Mean Depth’ (MD) in SSX terms).

Several methods can be used to represent space and break down the continuous flow of space into discrete spatial elements in SSX. This paper uses a method called ‘Visual Graph Analysis’ (VGA) (Turner et al. 2001) and the software Depthmap (Turner 2010; Varoudis 2012). In a VGA all areas in a building are tessellated into small squares (e.g. 0.5m x 0.5m) and an isovist is created from each of those small squares. All areas visually connected to a root square via an isovist are linked in a network. This is done for each of the squares and overlaid to create a strategic visibility map with one single component in the spatial network. Two models are used in the paper: a visibility model, which includes only solid walls and partitions of the building to represent

² Return rates for the questionnaire were 65% (2005), 73% (2008) and 64% (2012).

³ Measured on a scale from 1-5, where 1=infrequent, 2=once per month, 3=once per week, 4=2-3 times a week, 5=daily. This paper mainly uses the networks of weekly interaction including all ties with a value of 3-5 (also called freq345) and daily interaction including only ties with a value of 5 (also called freq5).

⁴ Participants were asked to rate how useful they found their colleagues for their own activities in research, teaching and support / enabling. For each category this was measured on a scale from 1-3, where 1=useful, 2=quite useful, 3=extremely useful. If all categories are summed up, the maximum usefulness score someone could achieve was 9. This paper mainly uses the network of high cumulative usefulness including all ties with a value of 6-9 (also called cumuseGT5).

⁵ Space Syntax in fact is a method that works across all scales of the built environment, i.e. it can model the configuration of single houses, large complex buildings, villages, towns, cities as well as whole urban regions. Since this paper is only interested in buildings, typical analysis methods for large scale systems (like cities) are not discussed.

visibility relationships, and an accessibility model, which includes all walls, glass partitions and all furniture to represent the potential of movement flows.

All network metrics of SNA (E-I index⁶, network densities⁷) were calculated using the software UCINET (Borgatti et al. 2002). Visualisations were made with Netdraw.

The research design was developed to tackle the multivariate nature of organisations. Since in a real world study it is impossible to control all the different variables that might affect an outcome of interest, a strict ‘hypothesis testing’ approach risks becoming reductive. Organisations are made up of multiple layers of different kinds of structure: individuals and teams, roles and statuses, reporting lines and accountability, the disposition of spaces and their actual utilisation. To complicate matters further, organisations change and evolve over time, as do the buildings they inhabit, and they do not do this in a way designed to suit the requirements of a hypothesis test. In this study a university department was surveyed in detail at three different times using a range of data and methods. Our approach follows the rationale of ‘creating phenomena’ (Hacking 1983), that then need to be explained by a theoretical proposition. This approach enables new theories to be developed in complex live environments. Necessarily at times this involves interpreting results based on anecdotal evidence, but equally it allows the organisation at hand to be considered in a holistic way, allowing the attribution of multiple interpretations to the phenomena at hand..

Organisational and Spatial Changes over Time

This section summarises the organisational and spatial changes that occurred in the university department from 2005 to 2012 in order to contextualise the following discussion on academic collaboration networks.

⁶ The E-I index measures the degree of a group’s embedding into macro-structures, e.g. group affiliation, location, etc. by comparing the numbers of ties within categories and between categories. The E-I (external - internal) index counts the number of ties of group members to outsiders, subtracts the number of ties to other group members, and divides by the total number of ties. The resulting index ranges from -1 (all ties are internal to the group) to +1 (all ties are external to the group). To ease the understanding of the meaning of those figures, the range of -1 to +1 is transformed to show percentages of internal links.

⁷ The density of a network is generally calculated as the number of actual ties in the network over the number of possible ties in the same network; it thus depicts the degree of connection and cohesion in a network and values range from 0 to 1.

Organisational changes are discussed using the following metrics: size of the department, annual turnover, numbers of new staff, numbers of leaving staff, average length of affiliation to the department, number and size of different research groups, numbers of students taught, and distribution of roles and gender.

The department shrank in size slightly from 69 to 63 and 58 staff. This was mainly due to overall growth and restructuring of the organisation, with two research groups leaving the department between 2005 and 2008 and another two between 2008 and 2012. Annual staff turnover was 14-15%, which meant that in the two and a half years between 2005 and 2008, 22 new members of staff had joined the department, whereas in the four years between 2008 and 2012, 40 new members of staff joined. A total of thirteen individual people were working for the department at all three points in time. Figure 1 gives an overview of all changes in staff numbers over the years.

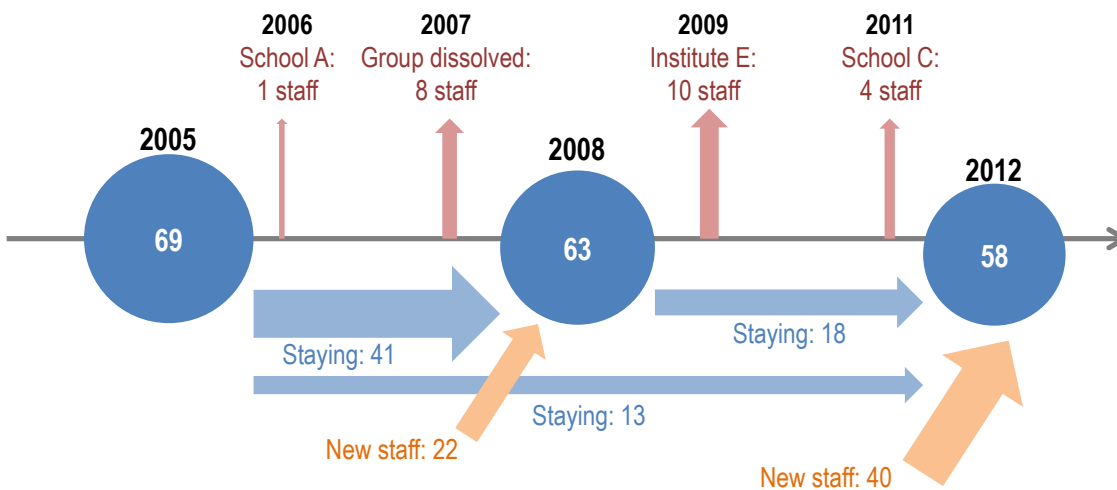


Figure 1: Development of staff numbers from 2005 to 2012

Average length of affiliation to the department varied over the years due to all the changes in restructuring the organisation. In 2005 average tenure was 6.2 years; this increased to 7.2 years in 2008 and then decreased to 5.9 years in 2012 with a high number of new recruits joining and long serving faculty moving into other parts of the faculty at the university.

Due to the restructuring of the organisation, the number of different groups in the department dropped from 7 in 2005 and 5 in 2008 to 4 in 2012⁸. Figure 2 shows the size and numbers of groups at each point in time.

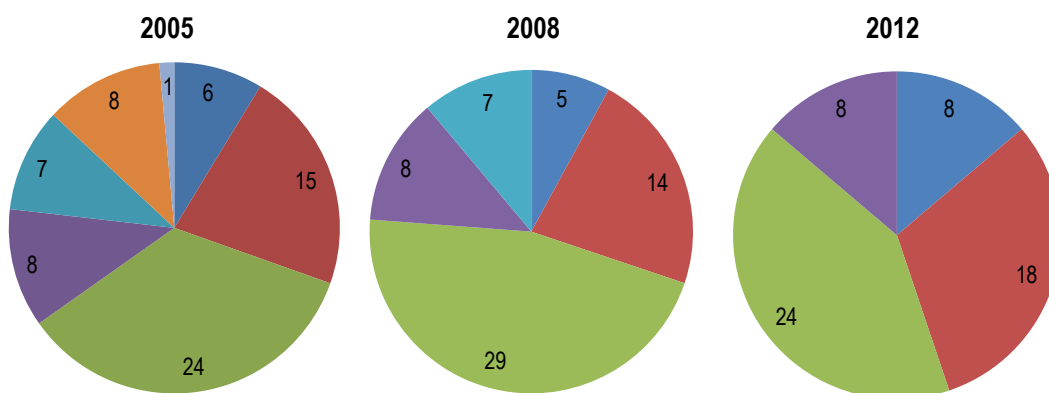


Figure 2: Group numbers and sizes in 2005, 2008 and 2012

Regarding teaching, the numbers of students remained consistent with the structure of the department. At the first point in time, in the academic year 2005/06 staff at the department taught 215 Master’s students in eleven different courses. At the time of the second study, in the academic year 2007/08 it was 226 MSc students (in eleven courses) and in the final snapshot, in the academic year 2011/12 201 students were enrolled across seven courses. The numbers of PhD students remained stable as well over the years with around 35 students enrolled each year.

The distribution of roles in the department remained relatively stable over time, as figure 3 shows. The major differences are in numbers of research assistants and research fellows, which fluctuated across the years. This is a reflection of the amount of external funding and research grants the department held at each point in time.

The gender ratio at the department became more balanced over the years. In 2005 the split was 42% females and 58% males. In 2008 the distribution was more unequal with only 33% females, but then was rebalanced to 47% females and 53% males by 2012.

⁸ This includes administrators, which are counted as their own group.

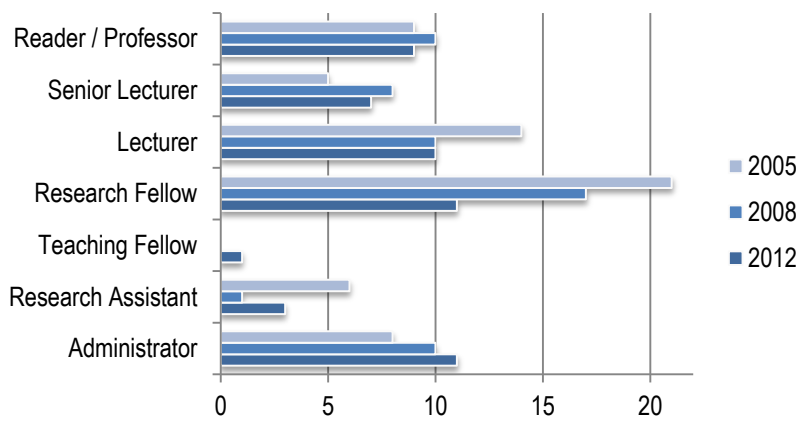


Figure 3: Overview of roles in 2005, 2008 and 2012

The **spatial changes** that the department underwent will be discussed in the following using a combination of simple metrics (total floor area, number of floors occupied, distribution of office types) and sophisticated metrics derived from a Space Syntax analysis of the floor plans (average MD of space in visibility and accessibility analysis).

In 2005 the department was distributed over three floors of an office building with the majority of staff located on the second floor and some staff occupying parts of the first and third floor with a total area of 1083sqm. One research group was located in a satellite office and a few staff did not have an office on site at all (e.g. visiting or sessional lecturers). In 2008, the overall spatial situation did not change, however, a staff common room and kitchen was introduced, several staff moved office and the space was refurbished to a new and more welcoming ‘look and feel’ as described above. In 2012 the department had moved into a completely new building across campus and now occupied two equally sized floors (ground and lower ground floor) of teaching and learning space with a total of 1146sqm.

The allocation of office types to staff (single office, double or triple cellular office, group office or open-plan office) remained comparable in 2005 and 2008 with a majority of staff (58% and 62%) accommodated in cellular space (see figure 4). The major change in 2012 was the increased share of staff accommodated in the open-plan, which rose from 9% (2005) to 31% (2012). At the same time, single offices were almost completely abolished and the share of staff in single offices dropped from 27% (2005) to 2% (2012).

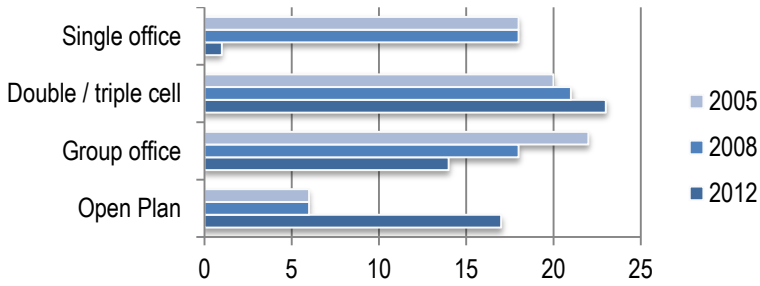


Figure 4: Distribution of staff in office types over the years

Analysing the spatial configuration of the department in 2005/2008 versus 2012 another change becomes immediately obvious: the space became shallower, i.e. average path lengths in the workplace decreased in 2012, as shown in figure 5 and table 1.



Figure 5a-c: Accessibility analysis of the department layout in 2005, 2008 and 2012; the colour scale from red to blue indicates areas of relatively low average mean depth (i.e. high closeness centrality) in warm colours (red, orange and yellow) and areas of relatively high average mean depth (i.e. low closeness centrality) in cold colours (turquoise, green and blue). The colouring is adjusted to the same levels to depict the differences between the layouts.

	2005	2008	2012
Accessibility: minimum MD	6.126	5.975	3.717
Accessibility: average MD	9.282	9.121	5.857
Accessibility: maximum MD	17.929	17.039	9.316
Visibility: minimum MD	4.508	4.536	3.164
Visibility: average MD	6.674	6.700	4.766
Visibility: maximum MD	12.087	13.078	6.688

Table 1: Overview of minimum, average and maximum mean depth figures for visibility and accessibility models of the spatial network of the department in 2005, 2008 and 2012

In 2005 and 2008 average mean depth of accessibility was 9.056 and 8.907, which means that on average 9 steps (comparable to walking around the corner) were needed to access every part of the building. From the most distant parts on the first floor (see the blue areas in figure 5a-b) 17-18 steps were needed on average to access all other areas in the old building. In 2012 the space was more compact and less segregated by doors; therefore average mean depth decreased to 5.857, so only about 6 steps were need to access all areas on average. In essence, overall levels of accessibility therefore almost doubled in the new building in 2012 (since depth or path length almost halved). Similarly, visibility almost doubled in 2012 as opposed to previous levels in 2005 and 2008: only 7 visual steps (comparable to looking around to corner) were needed in 2012 to see everything that is going on in the space, whereas 12-13 steps were required in 2005 and 2008.

To summarise the organisational and spatial changes the department underwent in the years from 2005 to 2012, it can be argued that the changes from 2005 to 2008 were moderate, both from the point of view of space and organisation (staff numbers, turnover, teaching courses, research groups). Changes from 2008 to 2012 were more radical with a completely new building, improved levels of accessibility and visibility, high numbers of new staff as well as a significant part of one research group in the department spun-off to create a new institute located elsewhere. What remains stable over the years are the distribution of roles (as shown) and 13 individual staff members (i.e. 22% of the department). However, even one of these staff took on a new role as faculty Dean and while still retaining membership of a research group, this individual role was transformed substantially. Everyday work activities in research and teaching, the disciplines and professional values and the cultural context of the overall institution remained similar, however it should be kept in mind for the further discussion of academic networks of collaboration in 2005, 2008 and 2012 that the organisational settings did not remain the same. Therefore comparisons need to be embedded and contextualised in the wider story of organisational and spatial developments of the department.

Collaboration Networks of Academics: The Influence of Space and Organisation

This section now looks at intra-organisational collaboration networks of academics of the studied organisation in 2005, 2008 and 2012. Networks and collaboration patterns are investigated firstly at the level of the whole

department, secondly related to groups and roles and thirdly, related to individual academics and their ego networks. Two main networks are analysed: the network of face-to-face interaction and the network of perceived cumulative usefulness of colleagues across the range of typical academic activities (research, teaching and support/enabling).

THE WHOLE – NETWORK STRUCTURES EMBEDDED IN SPACE AND ORGANISATION

The following discussion of network patterns in the whole department uses simple average values and statistics (average frequency of being seen by others, average perceived usefulness by others) as well as network metrics (E-I index, network densities).

The average frequency of face-to-face contact for the whole department increased from 2.06 (2005) to 2.66 (2008) and 2.77 (2012), as shown in table 2 below. The same effect occurred for average usefulness, which rose from 1.55 to 1.89 and 1.95. It could be maintained that space played a role in this, since average accessibility increased over the years (since mean depth decreased: 9.282 → 9.121 → 5.857). Additionally, the numbers of people sharing offices (either in double/triple cells or open-plan) increased.

It could also be argued that the rise in average contact and usefulness might have to do with size, since it is easier to interact with more people more intensively in smaller organisations. However, the size differences are not that large. Additionally, plausibility of a size effect could be challenged due to the development of network densities, since density accounts for size effects and since the density of the weekly interaction network first increased from 0.178 (2005) to 0.231 (2008), but then fell to 0.175 (2012).

	2005	2008	2012
Staff numbers	69	63	58
Av_freq	2.06	2.66	2.77
Av_use	1.55	1.89	1.95
Density freq12345 (all)	0.553	0.456	0.322
Density freq345 (weekly)	0.178	0.231	0.175
Density cumuse (all)	0.230	0.225	0.176
Density cumuseGT5 (high)	0.037	0.040	0.047

Table 2: Average figures of frequency of being seen and perceived usefulness for all staff as well as network densities of the department in 2005, 2008 and 2012

It seems that there was something else going on that may also have contributed to the steep increase in average contact and usefulness from 2005 to 2008, and again, this could be interpreted as a spatially influenced change: in 2008 a staff and student common room/kitchen/print room was introduced on the second floor, which was a meeting point for everyone in the department due to its function as a social hub (kitchen) and task-related hub (photocopier / printer). It could well be the case that this resulted in colleagues seeing each other more often in general (hence increased *av_freq*), but specifically on a weekly basis (hence increased density of *freq345*).

The importance of a common room was highlighted by staff, as this quote from an interview exemplifies:

"I don't know much about the other areas [of research] (...) Space, to be trueful has an awful lot to do with that, there is a lack of a common room, a lack of kitchen facilities, where you can just bump into people. All the cellular offices contribute to you going in, you do your bit, do it in isolation; also we are very busy." (Staff member in 2005)

In 2008, when the common room and kitchen was introduced, staff commented positively on the change it made for them:

"It is a great improvement and I have started to come down from the 3rd floor for coffee, after 15 years of splendid isolation. Thank you." (Staff member in 2008)

In 2012 both floors had its own kitchen / print room, which meant that again there was no single meeting point for everyone in the department, therefore this could be one of the reasons that the density of the weekly interaction network decreased (despite the spaces being more integrating with shorter paths overall, as argued above).

Reasons for the fact that average usefulness increased (1.55 → 1.89 → 1.95) as well as the density of the network of highly useful colleagues (0.037 → 0.040 → 0.047) can only be speculated upon. On the one hand increasing levels of visibility (i.e. decreasing mean depth: 6.674 → 6.700 → 4.766) could have provided an increased level of awareness of other colleagues and their work, however that does not explain changes from 2005 to 2008 since spatial conditions then remained comparable (apart from the newly provided common room). On the other hand managerial activities and organisational events could have had an impact on levels of usefulness of other people, since the department started organising joint events for all staff, both on a social

level (barbeques, summer parties, leaving drinks) and a professional level (termly research Pecha Kucha breakfast meetings with presentations from 3 colleagues of different research groups). This may have resulted in increased levels of perceived usefulness.

The fact that the densities of the overall networks of contact and usefulness (freq12345: 0.553 → 0.456 → 0.322 and cumuse: 0.230 → 0.225 → 0.176) continuously decreased over the years while averages of frequency of contact and usefulness increased can only be explained by a more selective interaction and collaboration behaviour, i.e. staff interacted with fewer people in total (hence lower network densities), but interacted more intensively with those contacts (hence higher averages). This might be a result of higher numbers of young and new members of staff specifically in 2012, which could mean that they were not known to other colleagues as widely (thus reducing the overall numbers of ties). Alternatively it could be a result in the reduction in numbers of separate research groups, and the increase in size of those remaining.

Looking at the structure of the academic networks of the department in 2005, 2008 and 2012 as displayed in figure 6a-c, it becomes obvious that collaborative behaviours in the department have changed from one stage to another.

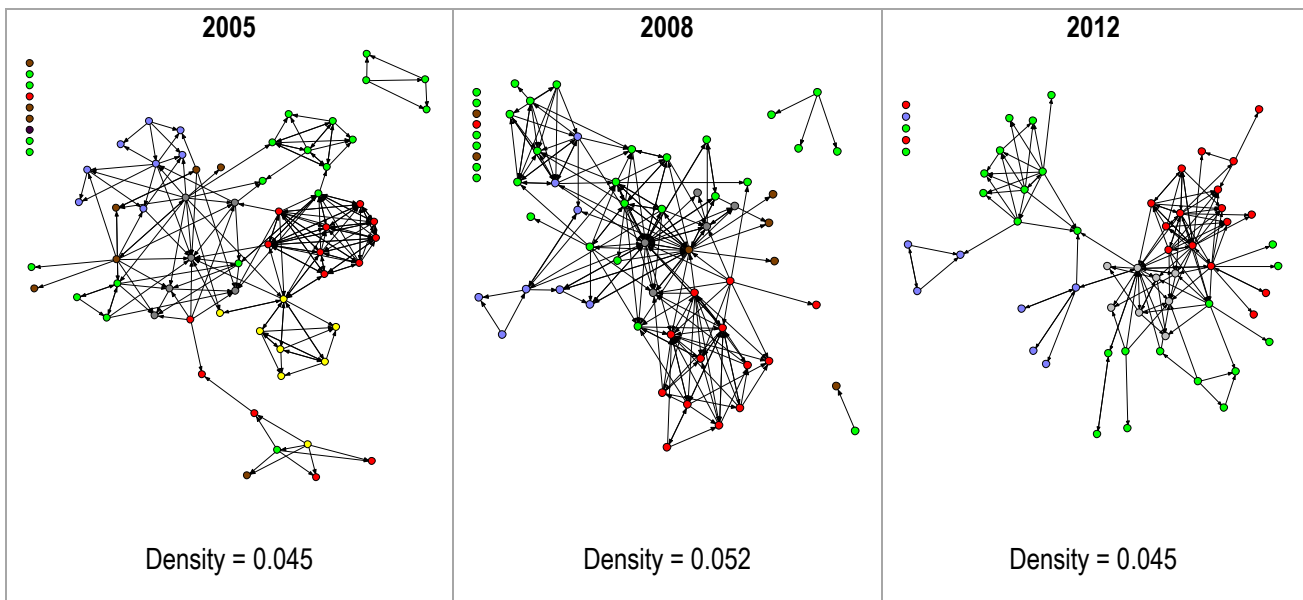


Figure 6a-c: Networks of daily face-to-face contact in the department in 2005, 2008 and 2012; nodes are coloured according to group affiliation; administrators are shown in grey.

In 2005 the network was characterised by a number of isolates, one small and one large component. Most groups were connected to each other via a few selected group members or via the administrators, who took a central role in bridging between groups. The group shown in red had a very dense, almost clique-like structure, whereas the other groups were more loosely connected. In 2008, the density of the daily face-to-face interaction network remained almost the same. The structures were very different, however: there was a handful of isolates, two small components and one large component. The differences between the groups were not so pronounced anymore and there were more ties reaching across group boundaries. Overall the network appeared quite balanced and groups were evenly connected within as well as across groups. In 2012, the network consisted of fewer isolates and only one single component. However, network cohesion became rather uneven, as the groups shown in blue and green were rather loosely structured in contrast to the group depicted in red, which was still relatively dense. Most connections between groups were brokered by the administrators.

The change from 2005 to 2008 is most likely explained by the introduction of the common room in the department, as more people across different groups began to meet each other there. This might have helped specifically those individuals on the 1st and 3rd floor (who were feeling isolated) to connect with more colleagues on a daily basis, as well as the research groups that were distributed across the floors (2005: red and green; 2008: red, green and blue). While this first change can mostly be associated with space, the change from 2008 to 2012 can be argued to have its root in both spatial and organisational changes. First of all, the departure of ten colleagues from the green group considerably weakened the group. But again, space seems to be a major driver to explain network structures, since the disjointed parts of the green group were accommodated on different floors of the new building. Additionally, the clusters within the green and red groups with relatively high cohesion had their desks in a large group office on the lower ground floor and the open-plan space on the ground floor, which allowed them easy interaction among themselves.

How space and specifically location on the same floor played a role in shaping network patterns can be more systematically evaluated by comparing ties that remain within a floor and those that reach across floors by calculating the percentage of floor internal ties via the E-I index. This is compared to the other important rationale for tie formation, i.e. group affiliation, so the percentage of group internal ties is calculated as well.

Results are shown in table 3. In essence this analysis shows the importance of group affiliation and co-location on the same floor for both weekly and daily interaction networks.

Weekly interaction mainly occurred across groups, since only 37-47% of ties were group internal. In contrast daily interaction mainly remained within the group with a proportion of 54-74%. Therefore, group affiliation determined the intensity and frequency of interaction.

	WEEKLY INTERACTION		DAILY INTERACTION	
	group internal	floor internal	group internal	floor internal
2005	42%	63%	65%	91%
2008	47%	61%	54%	86%
2012	37%	76%	74%	89%

Table 3: Overview of E-I index calculation results of weekly and daily interaction networks in 2005, 2008 and 2012 using both research group affiliation and floor of office location as category; the more prominent factor for each network is marked in bold.

The fact that group affiliation became more important for weekly interaction from 2005 to 2008 might be related to a large interdisciplinary research project that had come to an end in between the two points in time and which had involved researchers from three different groups. However, the increase is not very large. Organisational reasons might be at the heart of the decrease of group internal ties from 47% in 2008 to 37% in 2012 as well with more events taking place, thus increasing opportunities for researchers from different groups to mix. Floor internal ties in the weekly interaction network remained relatively stable from 2005 to 2008, but increased again in 2012 with a kitchen / print room provided on each of the two floors.

For the daily face-to-face interaction network, being on the same floor is a very strong determinant of who someone saw across all three points in time with percentages ranging from 86% to 91%. This remained consistently strong.

THE PARTS – GROUP AND ROLE BEHAVIOUR AS REFLECTIONS OF SPACE AND ORGANISATION

Looking at networks and behavioural patterns by research group and by role adds more depth and richness to understanding the relationship between spatial and organisational changes and academic collaboration.

Figure 7a-b shows the average frequency of contact and usefulness by role. It can be seen how the spatial and organisational changes had an impact on task- and status-driven behaviours. For example administrators were seen as increasingly useful, however in 2012 almost half of them were located on the lower ground floor, which affected their frequency of being seen face-to-face. The same is true for senior academic staff, however the reason for their decreasing levels of contact might also be caused by the deliberate absence and working from elsewhere in 2012, after they had given up the solitude of their single offices. Though the longitudinal study did not include data on such a change – and indeed absence from the office was very high in 2010 cross-sectional study - it was commented on by a member of staff in the satisfaction survey as a change from their previous workplace situation:

“Colleagues are increasingly working from home or somewhere else, thus we are losing the collaborative spirit of the environment and work is individualised and privatised.” (Member of staff in 2012)

The opposite occurred for PhD students: they were allocated a large and very central area in the new building in 2012 and thus their contact frequency and visibility to everyone else increased. The number of research assistants 2008 and 2012 was very low (n=1 and n=3)⁹, therefore the declining usefulness levels in 2008 as well as steep increases in contact frequency and usefulness in 2012 may not be representative of the role.

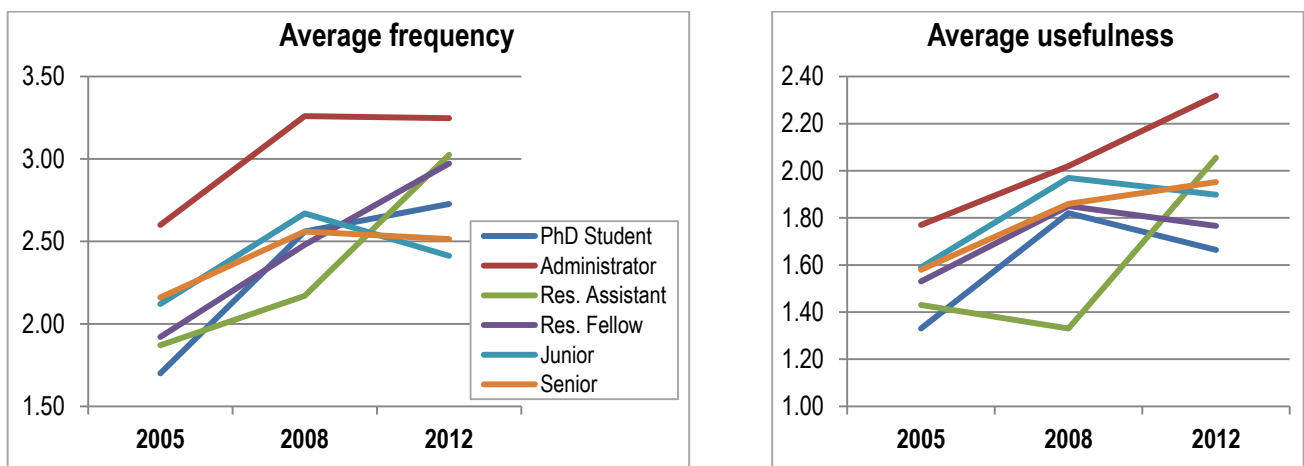


Figure 7a-b: Changes in average frequency and usefulness over the years by role; the role called ‘Junior’ combines Teaching Fellows and Lecturers, while the role called ‘Senior’ combines Senior Lecturers, Readers and Professors; data is aggregated to increase statistical validity due to higher numbers in each category;

⁹ Refer to figure 3 again for a breakdown of roles and numbers of people in each role across the three points in time.

Investigating average contact frequencies and usefulness by research group again shows overall trends and deviating patterns, as seen in figure 8a-b. Administrators (marked in grey) were clearly seen most often and found most useful in all three studies.

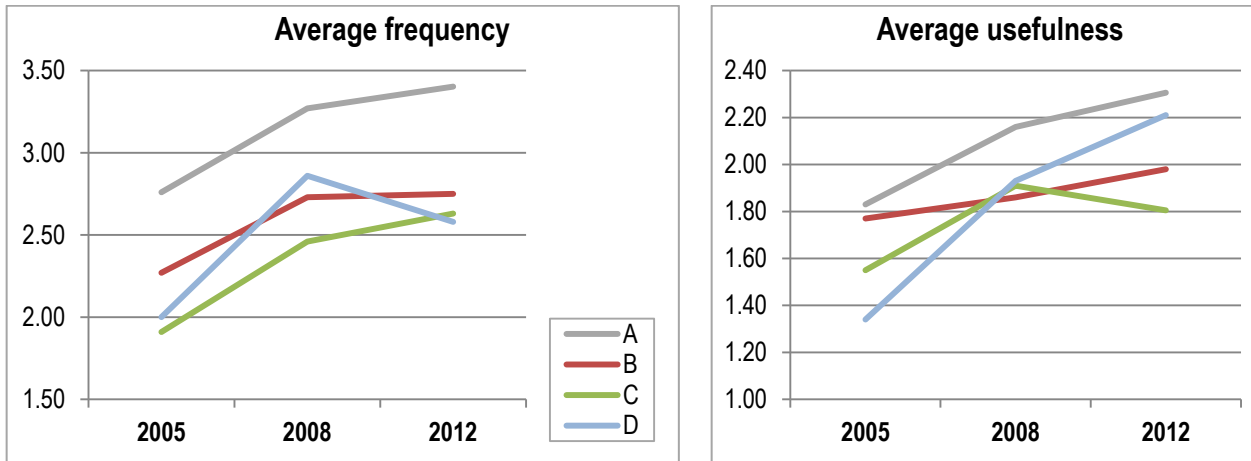


Figure 8a-b: Changes in average frequency and usefulness over the years by research group (A, B, C, D); group A is the administrators of the department;

What is interesting is the frequency of contact for group D in 2012, which decreased against the trend of all other groups. Group D is the only group accommodated completely on the lower ground floor of the new building, which cut them off significantly from others based on the ground floor. However, this did not affect their value to everyone else, since members of group D were still found highly useful, as figure 8b highlights. Regarding usefulness, group C behaved against the trend and showed lower values of average usefulness than everyone else. This might be rooted in the weakening of the group with some of their closest colleagues leaving for another organisational unit at the university.

This story of group C (shown in green colour in the network diagrams) presents itself very powerfully in the group internal network visualisations of high usefulness (figure 9d-f).

In 2005, the group had a relatively dense core cluster (consisting of professors, senior lecturers, lecturer and key research fellows) surrounded mostly by researchers at the periphery. In 2008 the group became more inclusive and dense involving most individuals in more intensive collaborations. This is in stark contrast to the structure of the group in 2012, which changed to more isolates and a core structure of collaborative ties in dyads or triplets. It seems that academics in the group were only collaborating intensively with very few

colleagues in the department and it can be speculated that ties of high usefulness were now directed at researchers outside of the department.

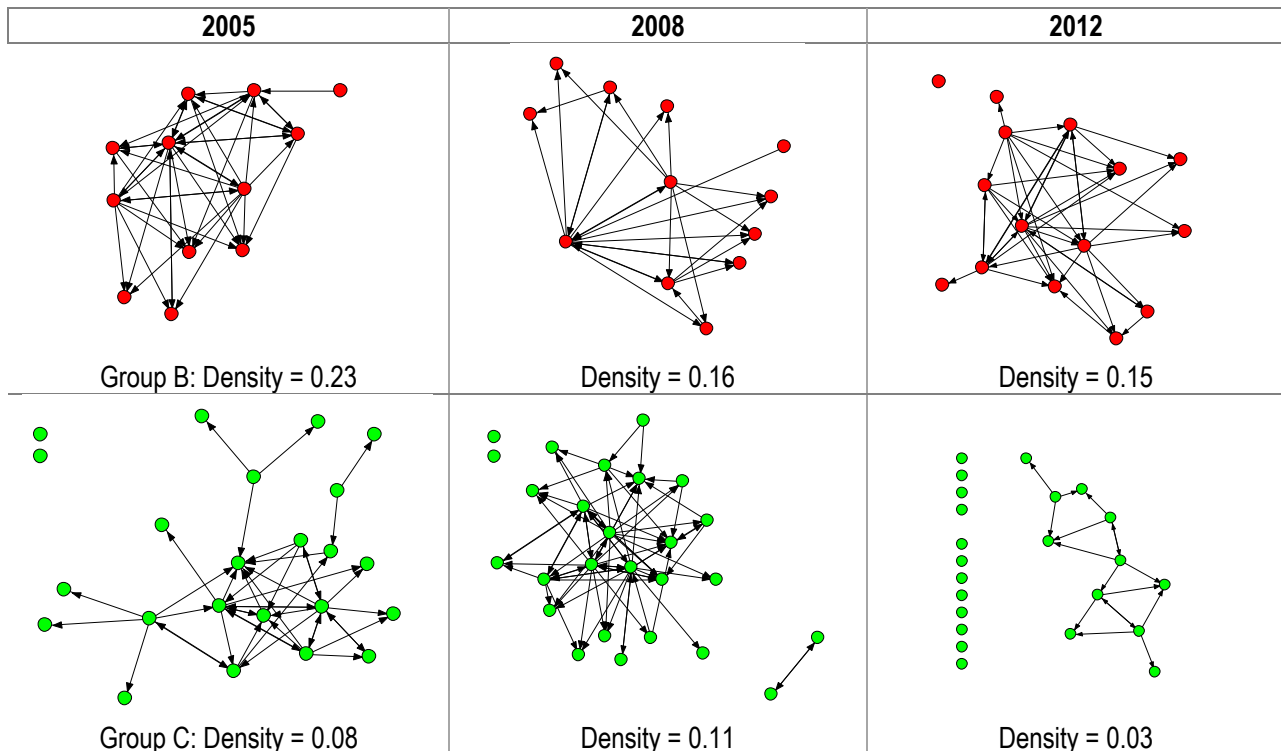


Figure 9a-f: Internal networks of high usefulness (cumuseGT5) of research groups B and C including density figures; PhD students were excluded from the analysis;

In contrast, the usefulness networks of group B (shown in red in figure 9a-c) changed as well from 2005 to 2008 and 2012, yet not in such a dramatic fashion, which makes it reasonable to associate the changes in group C to the organisational restructuring of the department, which most affected them, but not the other groups.

The story of group B shows transformations of an organisational as well as spatial nature. Firstly, it reflects research projects: a large project that kept the group busy in 2005 had ended, which meant the clique-like mutual usefulness patterns in 2005 dissolved to a degree and became more star-shaped and hierarchical in 2008. In 2012 two externally funded research projects made the group connected in a more equal fashion again. The shift from 2008 to 2012 was supported by spatial changes, since the group moved from a situation in 2008 with six staff open-plan, two in a double office and five in single offices to almost everyone open-plan including two professors and a reader (eleven academics in total) and only two staff in a double cellular space

(due to their role as course directors). This allowed the group to interact with ease and build stronger bonds between everyone without the need to rely on management or leadership.

THE INDIVIDUALS – EGO NETWORKS AND CAREER DEVELOPMENT IN THE CONTEXT OF SPATIAL AND ORGANISATIONAL CHANGES

Last but not least, an analysis of ego networks of six selected individuals¹⁰ will be discussed, who have been part of the organisation across all three time periods. Their career development is discussed together with the structure and size of their ego-network and their spatial location in the workplace. Figure 10a-f shows the ego networks of high usefulness of the six academics (named A-F) at each of the three points in time; table 4 brings information on their spatial location and network metrics together.

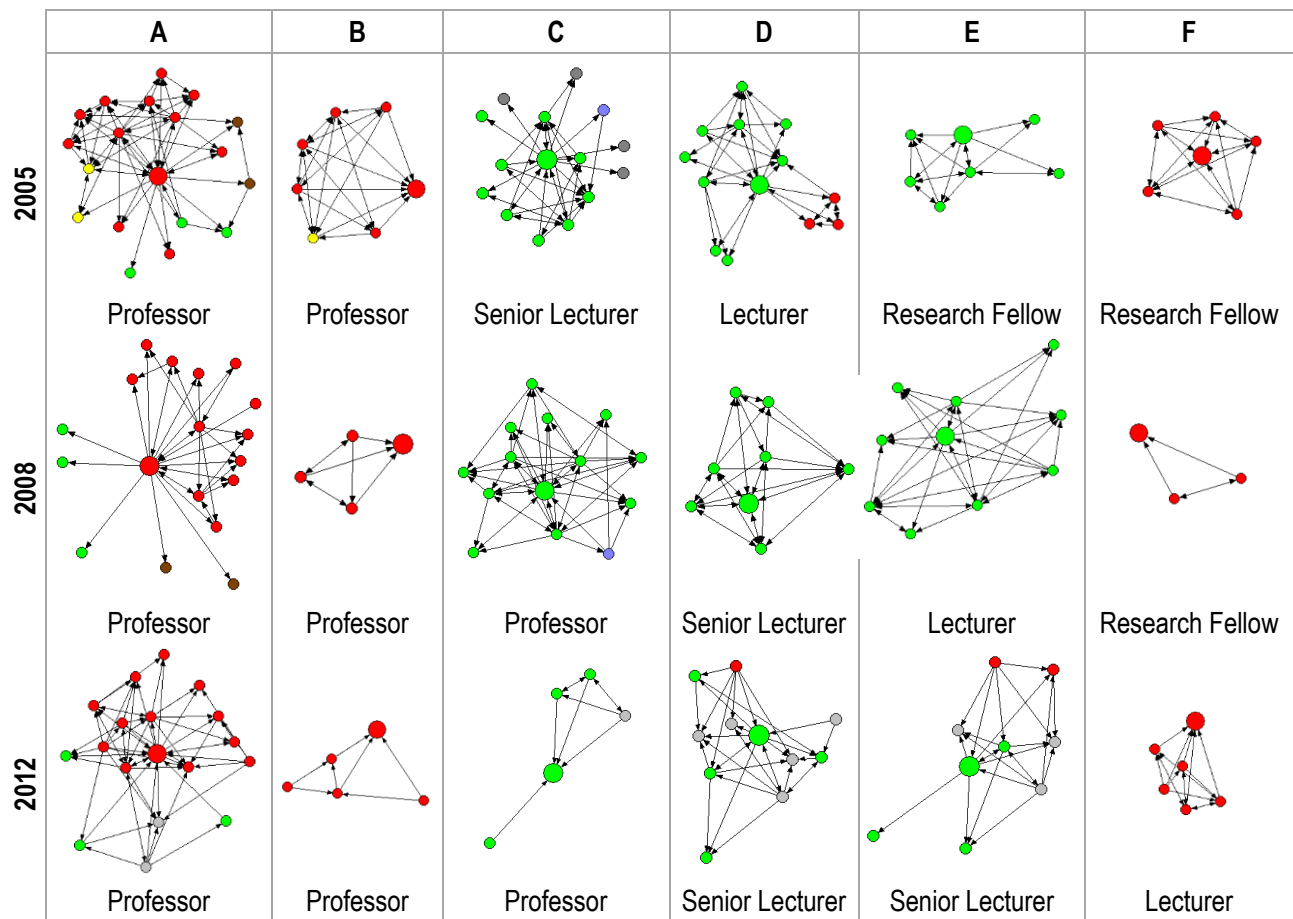


Figure 10a-f: Evolution of ego-networks of six selected individual academics of the department over the years; the network shown is the high usefulness network (cumuseGT5); ego is displayed larger; colours depict research groups (red: group B, green: group C, grey: administrators).

¹⁰ A total of thirteen academics were part of the organisation across all three points of time. Of these, nine gave consent to have their ego networks studied. Three were omitted from the analysis due to very small and unchanging ego-networks.

The first obvious thing to note is how different and individual those networks look, even for people holding the same position. The professorial networks especially are remarkably different in structure, size, diversity and reach. It seems that the networks not only tell a story about the department or the role, i.e. what it means professionally to be a lecturer or researcher or professor (more on this later), but also about the identity, character and habits of the individual people behind those networks. This diversity is possible because of the nature of academic organisations as ‘organised anarchies’, where every person can choose to perform their tasks in their own style.

		A	B	C	D	E	F
2005	Role	Professor	Professor	Senior Lecturer	Lecturer	Research Fellow	Research Fellow
	Office Type	Single Cellular	Single Cellular	Double Cellular	Single Cellular	Group Office	Open plan
	Accessibility [MD] ¹¹	11.091	10.121	7.398	10.414	15.914	11.101
	Ego Size	18	6	14	12	6	5
	nEgoBetweenness ¹²	30.7	0.0	27.8	47.0	6.7	0.0
	Homophily ¹³	61%	83%	64%	75%	100%	100%
2008	Role	Professor	Professor	Professor	Senior Lecturer	Lecturer	Research Fellow
	Office Type	Single Cellular	Single Cellular	Single Cellular	Single Cellular	Double Cellular	Open plan
	Accessibility [MD] ¹⁴	10.493	10.427	7.278	9.839	7.229	10.828
	Ego Size	17	3	16	7	9	2
	nEgoBetweenness	29.8	0.0	24.7	17.9	4.1	0.0
	Homophily	71%	100%	75%	100%	100%	100%
2012	Role	Professor	Professor	Professor	Senior Lecturer	Senior Lecturer	Lecturer
	Office Type	Single (off site)	Open plan	Double Cellular	Double Cellular	Double Cellular	Open plan
	Accessibility [MD] ¹⁵	---	6.658	5.191	5.191	5.981	5.709
	Ego Size	17	4	4	10	8	5
	nEgoBetweenness	30.4	0.0	0.0	15.6	7.1	0.0
	Homophily	71%	100%	75%	40%	38%	100%

Table 4: Spatial information and metrics as well as network metrics of the ego networks of six selected academics over the years;

Person A for instance is a ‘networker’ by nature with a consistently large size of ego network (17 to 18 alters), whereas person B is rather the ‘distinguished eminence’, who is consulted by other academics and collaborates intensively (with 3-6 alters), but not as extensively and widely as does person A. Personal stories are clearly

¹¹ Average MD in 2005 was 9.282

¹² Normalised ego betweenness is a measure of the sum of ego’s proportion of times ego lies on the shortest path between each pair of alters, normalised by the size of the ego network.

¹³ Homophily is the percentage of homophily in the ego network, i.e. the number of ties between ego and an alter in the same group divided by ego’s total number of ties.

¹⁴ Average MD in 2008 was 9.121

¹⁵ Average MD in 2012 was 5.857

reflected in the ego networks, for instance person F had won a first major grant in 2011 and therefore collaborated very closely with the immediate research team during the 2012 study. Person D's career started in the department with an interdisciplinary research project involving academics from the red group, which meant links to this group were maintained.

Secondly, it can be noticed how the structure and size of the networks vary depending on the role of people. The more senior people tend to have larger and more heterophilic networks. They also tend to be more central in their own ego networks, i.e. they connect the researchers around them; for instance person A and to some degree also person C have high levels of betweenness.

The fact that networks vary according to seniority is closely related to the fact that most ego networks seem to evolve over time. As academics advance in their career, ego networks grow: for instance the network of person E grew from 6 to 9 to 8. Ego networks also diversify with career advancement, for instance network homophily decreased for person D from 75% in 2005 to 40% in 2012, or for person E from 100% to 38%. This shows how academics established themselves with their own agendas, research topics, reputation and networks. This may also show how academics take on different and multiple roles in the organisation as they gain seniority. The head of a research group that became Dean (person A) is a case in point, serving to change relationships to both the immediate research group (the individual is no longer physically present in the groups space) and to the wider organisation where much of their time is spent in managing external relationships across the Faculty. Similar effects can be seen at lecturer/senior lecturer level where individual's ego networks with administrative staff develop in response to formal administrative roles as departmental tutors (person D and E).

It is worth noting how important organisational changes are reflected in the ego networks. The departure of important colleagues and collaborators to join the newly founded institute E at the university clearly left its mark in the networks of all three individuals of the associated group (person C, D and E), although it had the most severe impact on person C, whose network within the department shrank dramatically¹⁶.

¹⁶ It should be noted, however, that the social network survey did not extend to include members of the new institute, and had it done so we would expect person C's network to have remained more extensive or quite possibly to have expanded.

Finally it can be observed that space did not play a major role for the structure of ego-networks. Neither office type nor location (as measured by accessibility) seems to display any single pattern. It might be more appropriate to suggest that spaces are appropriated for different kinds of function and are used in multiple ways.

Conclusions

This paper has tried to shed light on how patterns of collaboration and interaction in academic institutions can be explained through spatial or organisational influences. Since space and organisation are deeply intertwined, it is inherently difficult to disentangle which behaviours stem from which influence, especially when only single cases are investigated. If different cases are compared, again it is almost impossible to draw conclusions on the impact of space or organisation, because both factors vary across the cases, leading to the assumption that the space-organisation relationship is often unique (Sailer 2010). One contribution of this paper is that it studies the same organisation repeatedly after spatial changes have occurred in order to minimise intervening variables. This specifically allows the study of the impact of varying configurations and affordances of space on collaborative behaviours in comparable organisational settings. Another contribution of the study is to use a deep understanding of a specific organisation as means to develop richer interpretations.

To summarise the results of this paper, both spatial and organisational influences appear to have shaped the structures and evolution of academic collaboration networks in the department – at the level of the whole network and the level of groups, as well as at the level of individuals.

Certain phenomena could clearly be associated with space, for instance the fact that co-location on the same floor reflected intensive tie formation, whether as a result of the colocation of pre-existing groups, or the result of ties emerging. Being split across floors formed a major barrier to interactions in academic environments, since the vast majority of intensive interactions remained within the same floor. For all weekly and daily networks, co-location on the same floor was an even stronger driver for tie formation than group affiliation. Clearly the spatial configuration of the new building in 2012 with higher overall levels of visibility and accessibility as well as the allocation of space to people (split between lower ground and ground floor, more shared offices and open-plan workplaces) played a major role in shifting behavioural patterns and network structures as well.

On the other hand it became obvious that organisational changes, for instance the restructuring of the department was responsible for changing network structures, specifically for group C, which lost some of its closest collaborators to a newly founded institute.

Still in a lot of cases it is hard to draw clear conclusions on the distinct roles of space and organisation. For instance, the increasing number of social and professional events as an organisational impact, or the arrangement of kitchen/print rooms as a spatial driver were considered reflections of changes in network cohesion and average frequencies of contact and usefulness, however, it could not be fully established what caused what in detail.

Clearly, one might consider that this points to a limitation of the paper: the case study may have not been ideally suited to draw conclusions on the distinct roles of space and organisation in shaping academic collaborative networks within an organisation because the organisation changed too much in between the three points in time, so that in effect both variables, space and organisation changed, making it difficult to come to conclusive results. However, it is our contention that change is the norm for organisations in general, and so our expectation of a study methodology should be to explain multivariate and multi-layered complex structures when almost all factors change and evolve over time, quite possibly each affecting the other in this process. A model for the mutual impact of individual agency, network agency and network structures based on Archer's morphogenetic approach (Archer 1995) was developed elsewhere (Sailer and Penn 2010), yet it could be argued that this applies to the relation between organisational change, spatial change and collaboration networks, too, where one condition shapes the future development of another one with various feedback and feed-forward loops. For instance, the decision to introduce a common room in 2008 is a spatial change influenced by the previous lack of collaboration. More intensive collaboration may then lead to an understanding and valuing of research exchanges and thus to future spatial, organisational and behavioural changes or actions, for instance increasing numbers of events like the Research Pecha Kucha in the department. It is therefore an important conclusion that in organisational studies all variables are endogenous and entailed in complex ways.

Three more main contributions of this paper can be highlighted: firstly, the evolution of academic networks over time was contextualised by the discussion of spatial and organisational changes. Secondly, using quantitative as well as qualitative methods has added rigour as well as richness and depth to the discussion. Looking at collaboration patterns of academics by means of networks has provided a fruitful perspective to studying organisational change. In the networks, a variety of stories were reflected: stories of organisational restructuring; of spatial separation; of the advantages and disadvantages of certain spatial locations; of personal development and growth. Thus, Social Network Analysis in addition to Space Syntax methodologies has enabled a critical understanding of an organisation. In particular, for an academic organisation, the 'usefulness' network represents an aspect of the social structure that is critical to individual motivation, since Benkler proposes that the main motivations are autonomy and peer esteem. In addition, as Penn and Sailer have found previously (Sailer and Penn 2007), 'usefulness' and frequency of being seen are related (if you are never seen you are unlikely to be found useful); therefore this provides a direct relationship to an effect of space. The cellular or open plan nature of space, the division by floors and the generalised accessibility provided by the circulation structure, could all be seen to vary from time point to time point in the study.

Thirdly, by studying networks of academics systematically at the level of the whole organisation, the group, and the individual, this paper has enabled a reinforced understanding of the nature of space. However, it has also helped to develop a picture of the nature of the academic organisation. Much consideration of organisational structure in the literature has taken its lead from normative theories of 'how a well-ordered organisation should look'. Against this background, academic organisations may appear to be dysfunctional, lacking in top down strategic direction or corporate objectives, and with an apparent schism between managers and academics. It is unsurprising that they appear anarchic. Here we have suggested that by looking at the multiplex system at individual, group and whole department level, academic organisations may instead be seen as well-ordered examples of dynamic and emergent organisation. In these the structure provided by the spatial environment provides an important form of stability.

Space clearly shapes behaviours of an organisation as a whole – for instance in managing proximity and distance between people. Buildings are mechanisms for bringing people together or keeping them apart (Hillier

and Hanson 1984). Those with their work areas on the same floor naturally end up interacting more intensively, even across the boundaries of research groups. Spaces that bring people together, for instance the common room introduced in 2008, significantly transformed network patterns of the department and increased network cohesion. Likewise, the increase in spatial accessibility and visibility in 2012 raised average levels of contact and usefulness. Or put the other way, spatial conditions that pull people apart, for instance providing a kitchen/print room on each floor of the department in 2012, may have had an adverse effect on network cohesion. On a group level, the role of space was highlighted, for instance in showing how being placed on the lower ground floor decreased the visibility of group D and therefore their average contact intensities; likewise, the integrated location of PhD students increased their contact frequencies. On the level of individual people and the structures of their ego networks, however, no clear impact of space could be identified. This underlines the importance of investigating collective behavioural patterns, as proposed by Hillier: *“The relation between space and social existence does not lie at the level of the individual space, or individual activity. It lies in the relations between configurations of people and configurations of space.”* (Hillier 1996: 31)

To conclude, spatial configuration is an important driver of academic networks of collaboration, while at the same time organisational structures and activities shape networked behaviours. Comparing how networks in one organisation evolved at three different points in time and systematically discussing the resulting changes has allowed some new insights into the difficulties of disentangling the space-organisation relationship. There is still much to be understood.

Therefore, suggestions for future research in this emerging and fascinating new field of spatial and social network analysis include further studies investigating the interplay between space and organisation in real life and complex situations by studying the same organisation at multiple points in time across different types of organisations and sectors. Results from this study of an academic institution with regards to the relationship between organisational change, spatial change and collaboration networks could well be transferable to other types of knowledge-intensive organisations.

It also seems fruitful to study not only how academics collaborate within their departments, but in addition, how networks reach out to other actors within the institution and beyond, so combining the traditional study of intra-organisational networks with the many types of academic network analysis that are done in separation, for instance co-authorship analysis, citation analysis or social media network analysis. To include the other ways in which academics collaborate, for instance in the peer production of knowledge as argued by Benkler and embed this in a study of spatial configurations across different spatialities, physical as well as virtual space, could add interesting insights.

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