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SPATIAL LAYOUT, SOCIAL NETWORKS AND INNOVATION IN ORGANIZATIONS

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Abstract

Research on the enabling factors of innovation has focused on either the social component of organizations or on the spatial dimensions involved in the innovation process. But few have examined the aggregate consequences of the link from spatial layout to social networks to innovation.

The research explores how spatial layout and social networks promote innovation among professionals working in different research-intensive organizations. The associations between innovation within these organizations and the organization's social and spatial structure are investigated. This paper presents results for one of our partner organizations, an international automobile manufacturer.

The study applies spatial analysis to map and characterize physical space and sociometric surveys to capture contacts among employees. For the automobile manufacturer, we were able to augment these tools with location tracking methods. Our use of the UWB location system, allowed us to assess contact networks in real time.

Social networks play important roles in structuring communication, collaboration, access to knowledge, and knowledge transformation. These processes are both antecedent to and part of the innovation process. Spatial layout structures patterns of circulation, proximity, awareness of others, and encounter in an organization. These interrelationships become fundamental to the development of social networks, especially those networks critical to the innovation process. We hypothesize that network positions and office locations influence workers' ability to prospect for new ideas and mobilize the resources and attention necessary to implement those ideas, both critical ingredients to innovation.

Results demonstrate the salience of both social and spatial dimensions in the processes of innovation. Our findings indicate that relationships between salutary network positions and beneficial locales themselves derive from institutional contexts that shape the priorities, opportunities, goals and practices of discovery. Thus, we suggest that innovation is a process that occurs at the intersection of social and physical space, and moves toward a socio-spatial science of design for innovation.

Keywords: *organization theory, innovation, spatial analysis, workspace design*

Theme: *Building Morphology and Performativity*

1. Introduction

Research on the enabling factors of innovation has most often addressed either the social component of organizations or the spatial dimensions involved in the innovation process. This research bridges disparate disciplines, and their respective bodies of knowledge, to explore the social dimensions of innovation as they are embedded in a specific spatial milieu.

The research[1] focuses on three organizations: a non-profit life sciences institute dedicated to translational research on cancer, the research labs of a multinational software corporation, and the quality control group of an automobile manufacturer. The associations between innovation within these organizations and the organization's social and spatial structure are investigated. This paper presents results for one of our partner organizations, the automobile manufacturer.

A core premise of our research is that spatial layout structures patterns of circulation, proximity, awareness of others, and encounter in organizations. These interrelationships become fundamental to the development of social networks, especially those networks critical to the innovation process. It is therefore essential that we gain a fine-grained understanding of how different types of spatial layouts, such as the ones in our diverse set of organizational partners, influence the structure of formal and informal communication between organizational actors, and ultimately innovation outcomes.

Methods of space syntax are used to map and characterize physical space and sociometric surveys are administered to capture contacts among employees. For our partner organization, the automobile manufacturer, we were able to augment these tools with location tracking methods. It could be argued that sociometric surveys capture the 'perceived' social network. Social networks researchers have been very interested in assessing 'real' networks either as reliability checks on sociometric survey networks, or as stand-alone networks. Our use of the UWB location system, allowed us to assess networks in real time.

In this research, we hypothesize that network positions and office locations influence workers' ability to prospect for new ideas and mobilize the resources and attention necessary to implement those ideas, both critical ingredients to innovation. In particular, the spatial measures of proximity (*mean distance*) and movement choice (*metric choice*), and the social network measures of *betweenness* and *degree*, are examined to understand their influence on the processes of innovation.

2. Background

2.1 Social network

Most networks-based analyses of social factors related to innovation have focused on the relationship between various aspects of an actor's network position and either performance (Burt, 1987), social capital (Burt, 1987, 2000), or innovation involvement (Ibarra, 1993). Innovation has been understood as being manifest in two stages: the invention or creation stage, and the adoption or diffusion stage.

Social networks are dichotomized as sparse (brokerage) or dense (closure) depending on the density of ties between actors. Brokerage networks are commonly perceived as providing actors with advantages in the generation of good ideas (Burt, 2004a; Obstfeld, 2005) while closure networks are seen as essential to the promotion of good ideas (Obstfeld, 2005). While most

networks research has categorized brokerage and closure networks as polar opposites on a continuum, more recent research suggests that the two networks are discrete phenomena, and that both are critical for the successful generation of innovations (Burt, 2004b; Reagans and Zuckerman, 2001).

A fundamental assumption of our approach is that innovation is a process that is stimulated by new ideas (or new applications of existing ideas) but also depends upon a continuous process of communication to move an idea to implementation. We expect that these links will be manifest in the organization's social structure as we examine individual level innovation.

2.2 Spatial layout

Although we acknowledge that there are many forms of communication, this research focuses on face-to-face communication. Research suggests that there appear to be few substitutes for face-to-face interactions in knowledge intensive work. As physical distance increases, the likelihood of collaboration decreases (Olson and Olson, 2000). Olson et al. (2002) report that radical collocation doubled the productivity of software engineers by increasing the team's ability to monitor and learn from one another's work. Early studies exploring the link between space and work processes focused on the effects of linear or geometric distance on processes such as communication. Allen (1977) showed that the probability of communication between engineers dropped precipitously at the 30 meter mark. Allen's work was also seminal in suggesting that other physical aspects of the pathway between individuals, such as doorways and stairs (barriers) or turns in the corridor (topologic characteristics), extended perceived 'distance'.

The importance of proximity is not limited to one's local work group. As Allen indicates from his studies of engineers, the most powerful ideas were reported to develop not from communication within the workgroup, but through communication beyond the workgroup with others in the organization.

Innovation research has been rigorous in its treatment of the various aspects of the social dimension of innovation, but much less so the spatial dimension. The techniques for the analysis of spatial form or "space syntax analysis", developed by Bill Hillier and his colleagues at University College London (Hillier & Hanson, 1984), provided some researchers with rigorous methods of measuring both global and local spatial network characteristics and relationships between them (Peponis and Wineman, 2002). Principles of spatial organization affect the generation and distribution of movement patterns in space, space use, and the ways in which occupants encounter others in space (Penn et al., 1999).

In exploring how spatial layouts connect individuals across the organization, it becomes clear that particular layouts of offices and corridors may cluster movement locally or enhance global movement. Similarly layout patterns may concentrate movement along few pathways or distribute movement across multiple access routes. Such spatial patterns affect how individuals come into contact with others in the organization and create opportunities for the serendipitous encounters promoted by Peters and Waterman (1981). Recent studies have shown associations between spatial layout and innovation/productivity work outcomes (Peponis et al., 2007; Wineman et al., 2009).

Our efforts to explain individual level innovation in organizations thus emphasize two key points in the discovery process: the ability to access new ideas via conscious search or serendipity, *prospecting,* and the ability to enroll colleagues' support and attention in order to validate those

ideas, or *mobilizing.* In very general terms, we expect people with greater access to more varied sources of knowledge and those who are better positioned to sway others to the cause of their ideas to be more successful innovators than colleagues with limited access to diverse perspectives or lesser claims on their co-workers' attention.

3. Methodology

For our study of the automobile manufacturer, we collected survey data on social network relations, applied spatial analysis approaches to understand spatial layout characteristics, and also gathered location tracking data. The relative contributions of these measures were then examined to predict our innovation outcome measures.

3.1 Sample selection

The automobile manufacturer study group worked in collaborative teams and consulted with other units within the international organization. The group was comprised of 24 professionals occupying one floor of a multi-floor office building on a larger campus of the organization's buildings. Managers are housed in closed perimeter offices, non-managers occupy partitioned offices.

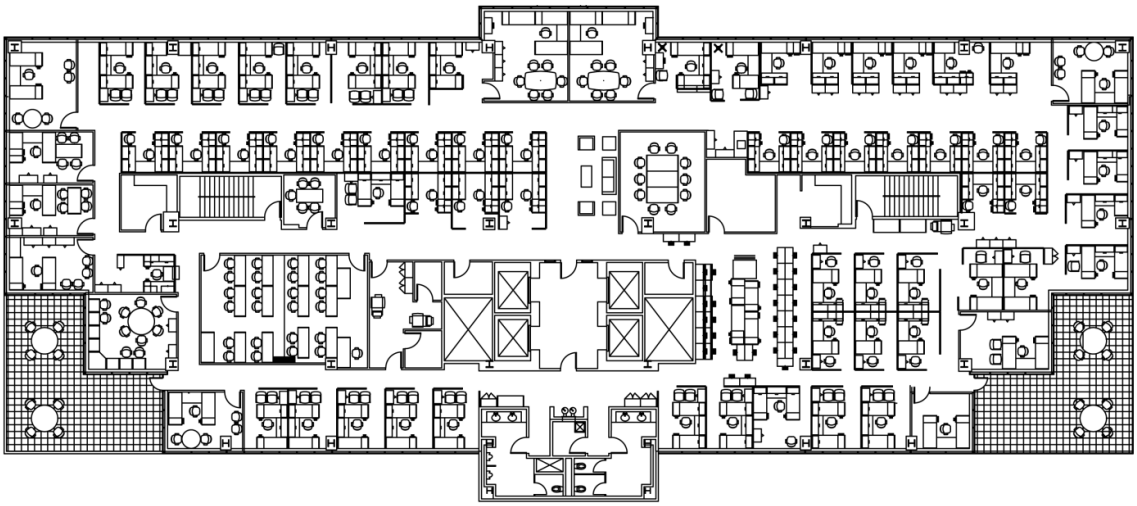

Figure 1: Typical floor plan. Plan has been modified to protect partner organization anonymity.

3.2 Measures of innovation

Our approach to the development of innovation measures has been predicated on the premise that, rather than attempt to identify a measure or set of measures for all organizations, it would be more prudent to find innovation outcomes that are most pertinent to each organization. Using data from manager interviews, we have identified target innovation measures as follows.

Innovation for the automobile manufacturer focused on team projects. One distinguishing feature about this organization is that it is exceedingly difficult if not impossible to parse out a given individual's contribution to the organization's project(s), given that work and innovation are heavily structure around work groups or teams. Therefore, there were no ready-made innovation outcome measures that allowed us to assess individual innovativeness.

For the automobile manufacturing company (AM), organizational administrators provided us with a list of recent/ongoing innovative projects. Since we had a much smaller data set and many individuals participated in only one project, our innovation measure was a binary variable that represented participation or no participation in these creative projects.

3.3 Social network survey

All professional personnel in our study group were asked to complete a sociometric survey. This survey collected data on the nature of the relations between the professional colleagues in the group (unit) in our study. Network models reflect responses to the question: About how often do you have discussions with this person in order to get your work done?

The social network variables used in this study are *degree* (number of communication links) and *betweenness* (how often you are likely on the shortest path between others in the network). *Closeness* (social distance from others) was highly correlated with the other two variables, so we removed this variable from our analysis.

3.4 Spatial layout characteristics

The spatial variables used in this study to characterize spatial layout are *mean distance* (a measure of the mean metric distance between an individual's workstation and all other professional employees' workstations within the study unit) and *metric choice*. The variable *metric choice* represents the extent to which an individual's workstation is on or near spaces that are on the shortest path (based on metric distance) when moving from all professionals' workstations (within the study unit) to all others.

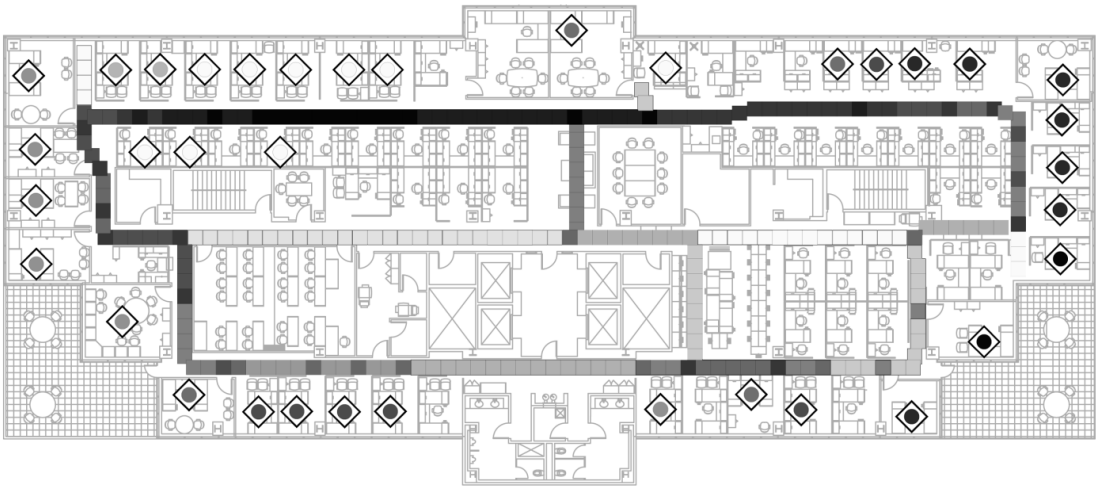

Figure 2: Spatial structure of floorplan. Dots denote the locations of employees. Diamonds denote the locations of respondents. Darker shades of dots indicate higher *mean distance*. Darker shades of corridor segment rectangles denote higher *metric choice*.

3.5 Location tracking

As mentioned above, we were able to collect movement tracking data at AM. Movement tracking entailed the use of a non-intrusive ultra-wideband (UWB) location system to track participants (on a volunteer basis) at the research project site. Tracking enabled us to accurately map patterns of spatial use and real-time social interactions.

UWB technology has accuracy advantages over rival systems when it comes to indoor tracking. The accuracy advantage is not insignificant as it allowed us to track people to within 12-24" locational accuracy. The system allowed us to tag and categorize certain kinds of events, such as the 'interaction' event described below and have them stored in a separate database for our analysis. For example, we specified that each time certain tags (representing different actors) were within a certain distance of each other for a minimum period of time or longer, that this be tagged as an interaction event. Further, we could then categorize these events by the type of space where the interaction took place e.g. hallways and other circulation spaces, coffee/break rooms, workspaces, etc.

Each participant in the study wore a tag with a unique identifier during working hours for the study period. Tracking was conducted at AM over a nine week period September-November, 2009.

Social networks were then constructed based on our real-time communication data. On average a pair of respondents had 13 conversations during the nine week tracking period. This suggests a similar pattern to the sociometric responses of 'several times a week or more'. However, it is acknowledged that these two definitions may be capturing different numbers/kinds of interactions. Results for AM will be presented for data from both the sociometric survey and location tracking.

4. Findings

An initial analysis was conducted to examine correlations between the social network constructed from sociometric data and that constructed from our location tracking data. The reported strength of a tie (sociometric survey) was strongly correlated with interaction frequency (location tracking) between dyadic contacts (r^2 = 0.455, $p<0.001$ n=435). However, the sociometric network diverged in its ability to capture the centrality of respondents as compared to the data derived through location tracking (Degree: β=-0.000, p=0.998, Closeness: β=0.222, p=0.239, Betweenness: β=-0.169, p=0.373, Eigenvector Centrality: β=0.174, p=0.357). The sociometric model built on the basis of location tracking provided stronger results than the model constructed from survey data. Therefore, for this analysis we will be summarizing results from the location tracking model (although results for both models are presented in Table 1).

Logistic regression was applied to examine the contributions of social network power (*betweenness)* and prominence (*degree)*, and relative spatial location, as measured by the variables *mean distance* and *metric choice*, to our outcome variable, innovation. Initially models included managers and non-manager professionals.

For this and other sites, variables became significant when managers were excluded from subsequent analysis. Managers are likely to have job-associated functions that bring them into contact with others across the organization, and are therefore less reliant on the effects of spatial layout. In addition to looking at only one job type, non-manager professionals, the control variable *distance to coffee bar* (CafeDist) was also included in our analysis.

Findings suggest individual contributions of spatial measures and social network measures to innovation outcomes (see Table 1).

Table 1: Logit regression analysis

	AM	**AM**
D.V.	Innovation Involvement	Innovation Involvement
Regression Model	Logit	Logit
Observations	23	23
Data Collection	Location Tracking	Sociometric Survey
Independent Var.	**B (p-value)**	**B (p-value)**
MetChoice	8.192 (0.018)*	2.944 (0.194)
MeanDist	10.721 (0.019)*	5.205 (0.083)+
Deg	-2.716 (0.065)+	1.322 (0.153)
Bet	5.540 (0.075)+	0.962 (0.661)
Controls	**CafeDist** -5.634 (0.038)*	**CafeDist** -3.620 (0.057)+

Notes: +p<0.1;*p<.05; **p<0.01; ***p<0.001

Spatial variables *metric choice* and *mean distance* were found to consistently contribute significant elements to the model for innovation. For AM whose production depends on innovative projects, individuals who have easy access to spaces that are likely to attract and channel movement (spaces that individuals from various locations in the building choose to move through or 'high *metric choice* spaces') have a higher likelihood of innovation (MetChoice: B=8.192, p=.018). Spatially, high movement spaces create opportunities for serendipitous encounters that support the activity of *prospecting* for new ideas.

The second spatial layout variable we explored was *mean distance* from an individual to all other professionals in the study unit. For AM, where the study unit was located on one floor of a multi-floor building, a person whose office location was more distant to all others (low access) would be more likely to be a participant in innovative projects (MeanDist: B=10.721, p=.019). It is suggested that in organizations, where being adjacent to high movement corridors is potentially valuable to innovation, the opposite is true for mean distance to others.

Results for the association between the social measures (*degree* and *betweenness*) and innovation were also significant. For the automobile manufacturer (AM), a higher number of conversation partners (degree) was associated with lower innovation (Deg: B=-2.716, p=.065). This relationship seems to follow a similar pattern to the spatial variable mean distance (as discussed above). For AM, high betweenness was associated with higher innovation (Bet: B=-5.540, p=.075).

Results suggest that for the spatial measures, organizations appear to depend upon either *metric choice* or *mean distance* to bring professionals into contact with others. For AM, innovation is higher for professionals whose offices locations are close to high use spaces with lower access to others.

5. Conclusions

First and foremost we have found that spatial variables matter to innovation. The spatial variable *metric choice* is a significant and positive influence on innovation for AM. The second spatial variable *mean distance* was also found to be a significant contributing factor for innovation. For AM, greater distance to others (low access) supported innovation.

In interpreting our results it is informative to refer to the recent work of Obstfeld (2005) who suggests that while much of the social network literature focuses on strategic network positions that allow an individual to prospect for new ideas (sparse networks and structural holes), these network locations are less supportive of activities such as the mobilization of resources that are necessary to bring an idea to fruition. Obstfeld's research indicates that enhancing connections between individuals (higher density networks) enables the assembly of resources associated with innovation.

We propose that, through exposure to moving others, locations with high *metric choice* may provide the opportunities for serendipitous encounters among individuals who may come from disparate parts of an organization (prospect for new ideas); whereas low *mean distance* to others may provide the enhanced connections necessary to mobilize the resources and attention to move innovative ideas forward. These dual functions of spatial network relations can suggest insights into the interpretation of our research results.

AM is an organization focused on innovative *project* outcomes. These projects bring diverse professionals together to create new processes and products. Individuals are more successful if they are spatially situated to maximize opportunities to prospect for new ideas. Workspaces should be designed such that circulation and social spaces concentrate activity and enhance the likelihood that professionals from across the organization will encounter one another (high *metric choice*). We see a similar effect in the social network. More productive social locations are those on the shortest links between all other professionals (high *betweenness*).

Professionals benefit from spatial locations that are more separated from others (high *mean distance*). This may also be a function of the size of this work unit and their location on one floor of a single building. Professionals are likely to know everyone and therefore be less dependent on spatial support for promotion of innovative ideas. Similarly for the social network, individuals with fewer social ties (low *degree*) have higher innovation. Socially for AM, it is less important how many people you know, but how you are situated to access new ideas.

To summarize, results demonstrate the salience of both social and spatial dimensions in the processes of innovation. Thus, we suggest that innovation is a process that occurs at the intersection of social and physical space, and moves toward a socio-spatial science of design for innovation.

As foundational work, the limitations to this research are many. Future studies will benefit from larger sample sizes and exploring organizational contexts and innovative outcomes in more controlled settings. It would also be useful to extend the contact networks to reflect other modes of communication, such as email. Results from the further development of this work will provide guidance for institutions in creating environments and organizational contexts that enhance the processes of discovery.

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