Face-to-Face Interaction in Office Setting:
What You Know About It May Not Be Always True!

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Abstract

Whereas much recent office design seeks to increase communication away from the private workspace, little is known about how the global structure of an office affects the location and amount of interaction. This study used syntax theories and methods to understand the effects of spatial layout on movement and co-presence (i.e., visibility of people), and on face-to-face interaction. The study results showed that people preferred to interact more in individual workspaces than in semi-public and public territories of any office setting. The results also showed that co-presence was important for face-to-face interactions, and that more co-presence instigated more interactions. Surprisingly, movement did not consistently predict face-to-face interaction. This study suggests that while rigorous definitions of spatial layout can predict movement and interaction, these relationships are tempered by organizational programs.

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Introduction

In this paper, we explore the role of spatial characteristics of offices in predicting the location and amount of social interaction.

A great deal has changed over the past few decades as work organizations attempt to become more customer-responsive, efficient and agile. Many office organizations are breaking themselves up into smaller, more mobile, less hierarchical units that are more autonomous in their decision-making (e.g., ASID, 2001; Becker & Sims, 2000; Becker & Steele, 1995; Brill et al., 2001; Duffy & Hannay, 1992; Duffy et al., 1993; Duffy & Powell, 1997; Duffy, 1998; Wineman, 1986). To accelerate decision-making, more work is now done simultaneously, rather than waiting for a sequential flow of decisions. More work is seen as "knowledge work," and the asset value of employees as "intellectual capital" is more commonly recognized, putting greater emphasis on comfort and retention. Team contributions are more noticed and rewarded. Organizations are continually seeking improvements through innovations, and a much wider range of workers are made responsible for innovating.

These changes mean that the patterns of communication that serve the organization have become less predictable. On one hand, the relatively limited and hierarchical ways of communicating about work tasks that had characterized many organizations in the past have evolved into communication patterns where workers need to talk to a variety of people in different functional roles. At the same time, informal communication is increasingly recognized as a way to create and reinforce organizational culture (Allen, 1977; Becker & Sims, 2001; Cross & Borgatti, 2002; Sundstrom & Altman, 1989; Wineman & Serrato, 1998). Rather than being a distraction, informal communication is seen as a way to build commitment, spread ideas about how "we do things around here" and as a way to share knowledge and skills that go beyond the written requirements for doing a job.

In this context, space is recognized as an organizational resource because of the ways it may affect informal interaction. Many work organizations have made significant investments in space in an attempt to reinforce these more complex patterns of communication. In particular, many offices have capitalized on unplanned social interaction, where people chat when they encounter each other in the hallways or common space. For example,

the classic Salk Institute or the Steelcase R&D building provide amenities such as whiteboards and seating near where people encounter each other in hallways; innovative offices such as the US General Services Administration's "Office of the Future" in Auburn, Washington provide lounge-like commons areas for group work, with comfortable seating and access to coffee[1] .

However, spatial investment in these offices is made not only to reinforce the already existing patterns of informal interaction but also to generate and sustain new patterns of interaction. For example, smaller individual workspaces are used to push interactions out of these spaces into public or semi-public territories. In addition, the layouts of these offices are made highly interconnected, with increased visibility, openness and accessibility in an attempt to boost chance-encounters, hopefully leading to more interactions. To accommodate these serendipitous and planned interactions, the office organizations enhance public or semi-public territories with attractive lounge-like spaces. The intention is that these layouts will help foster new patterns of interaction and communication, leading to such organizational outcomes as more even spread of information, improved coordination, group formation, improved organizational agility, etc. A set of such office examples can be found in a recent publication of the Office of the Governmentwide Policy and the General Services Administration (OGP, 2002).

The principal aspects of these spatial interventions can be described in the workplace interaction model illustrated in Figure 1. We describe the model in more detail in the next section, then discuss an empirical study of four office settings in the following sections.

The workplace interaction model

The workplace interaction model links changes in spatial layout to behavioral change and organizational change. We focus on the principal spatial and behavioral variables that are addressed in new generation innovative offices. Among the spatial variables, we include *visual fields*, *relational pattern of space*, *sightlines*, and *size*, *type* and *scale* of spaces. These are variables linked directly to visibility, accessibility, and openness of a spatial setting. On the other hand, among behaviors, we include *movement* (defined as the number of people moving along a path), *co-presence* (defined as the number of people visible from a path), and *interaction* (defined as the number the

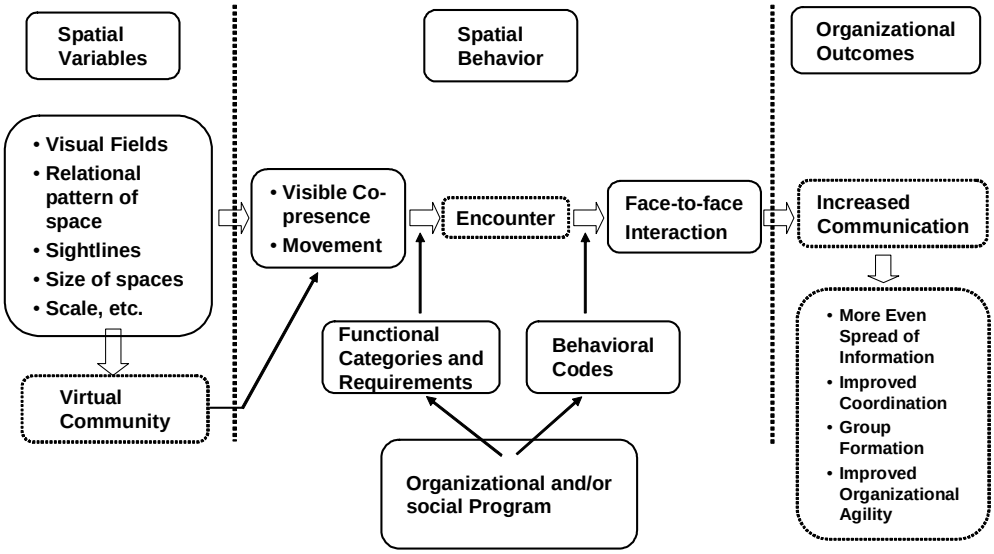


Figure 1: A hypothetical model relating space, behavior, and organizational outcomes

number of people engaged in any reciprocal exchanges involving two or more people along a path and in the spaces along it) in the working model. We view *encounter* as different from both co-presence and face-to-face interaction. By encounter we mean that people are together in the same place and time, at a distance close enough to support face-to-face interaction. Hence, encounter is a subset of co-presence. (Co-presence also includes moving and stationary people who are visible but too far to interact with.)

By definition, for face-to-face interaction people must encounter one another; and they must be in the same space. In addition, to encounter people away from one's own workspace, one must move. Therefore, we ask if there are characteristics of workspaces that predict movement and encounter. However, even if such relationships can be established, not all encounters result in interactions. In urban settings, since movement of people is not always driven by an immediate sense of purpose or by a set of well-defined rules and regulations, movement may indeed generate face-to-face interaction through increasing chance-encounters. In contrast, in a controlled office setting, since movement and interaction are often purpose-driven and controlled by organizational rules and regulations, movement may increase chance-encounters, but not always result in interaction. In fact, a pattern of dense face-to-face interaction in an office setting may occur regardless of a persistent pattern of dense movement. These patterns of organizational rules and customs can be considered social

and behavioral "programs" that encourage or discourage such interactions. These programs operate at different scales within an organization. Individual workers might be called on to speak to work independently, interact with others in their work group or to go outside their work groups. Similarly, organizations appear to have different patterns of location of desired interaction. Some organizations seem to encourage visible, public interaction; others seem to push it deep in private or group spaces.

In addition, space generates its own form of invisible community: a "virtual community" based on mutual awareness among people of where interaction is likely to occur or where more people will be found on average (Hillier et al., 1987; Peponis et al., 1989). This virtual community helps guide where people go when they seek interaction.

Co-presence, on the other hand, provides direct visible evidence that one's environment is shared by others, and shows who may and may not be available for face-to-face interaction at any particular time. Of course, the pattern of co-presence and movement has important impacts that go beyond generating interaction. Like the way space creates a "virtual community, co-presence and movement can also create a sense of liveliness of a setting and a more general idea of what's going on and who the participants are. Some settings such as stock exchanges or newsrooms use co-presence and movement not only to share information and facilitate access to people but also to create a buzz. In contrast, in a back-office kind of environment, co-presence and movement may rarely create any interaction due to organizational programs.

Although the assumed relationships between spatial form and interaction have generated a great deal of investment in offices, there is relatively little empirical evidence linking these to actual outcomes. In this study, we explore how layout predicts movement and behavior, as shown in the solid frames in Figure 1.

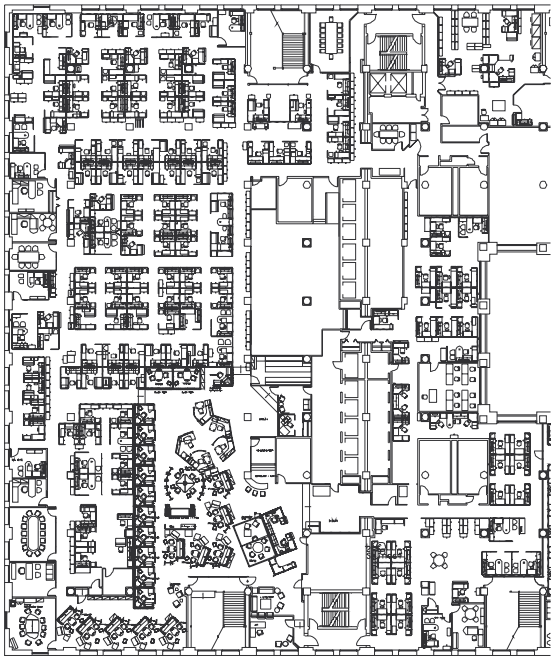
Case Studies

We studied four US federal offices that had been designed recently. Whereas all were viewed as encouraging communication and collaboration some managers described these as particularly important. Three of the offices are similar real estate operations for US government; the fourth is a federal clerk of court's office. Our first case study, Wanamaker 6, was the office setting of a public real estate organization that has several divisions

(Figure 2a). (The organization has now moved into new quarters.) Each of these divisions performs different functions and has several groups working on different projects. The nature of communications is not consistent across the organization but rather varies with the type of work a group performs. Diversity of functions also precludes any simple generalization about the nature and pace of work groups. This diversity is reflected in the physical boundaries and grouping within the office. Divisions have somewhat defined territories, but no territorial definitions exist for the smaller groups within the divisions. Apparently, the location of a division is based on its relationships with the administrator, rather than on its functional relationships with the other divisions. It is possible that the current practices of the organization, at the time of our study, did not require frequent physical exchanges between its divisions. However, group activities within a division were encouraged, according to the managers and the administrator. Consequently, we expected that behavioral patterns in the setting to be affected more by the local than the global structural and functional dynamics.

Our second case study, MLK 4, is the new office setting of the portfolio management division of another public real estate organization (Figure 2b). There are several groups in the division. The composition, size and functions of each group vary. The dynamics of the group structures and functions of the division does not lend itself to any consistent behavioral expectation, either at the local or at the global level. As a result, any observed consistency in behavior may be a consequence of the spatial properties of the setting, among other things. In addition, while the larger groups of the division have well-defined territories, no such territorial definitions exist for the teams within the groups. Furthermore, the functional relationships between the groups are not always explicit in the way they are laid out. Since the functions of groups are widely different, the leadership of the organization is less keen on the idea of collaboration between groups, even though interaction between individuals and groups are not discouraged in the setting.

Our third case study, MLK 5, is the new office setting of the realty services division of the same public real estate organization (Figure 2c). In the division, there are three main groups, each composed of several teams. Each team is responsible for the planning and scheduling of its own. Within each team, members perform similar work independently and are not functionally dependent on one another. Only formal communications at regu-



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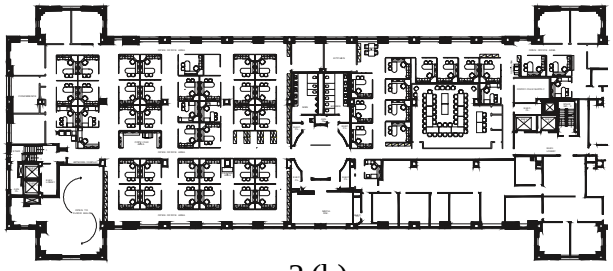

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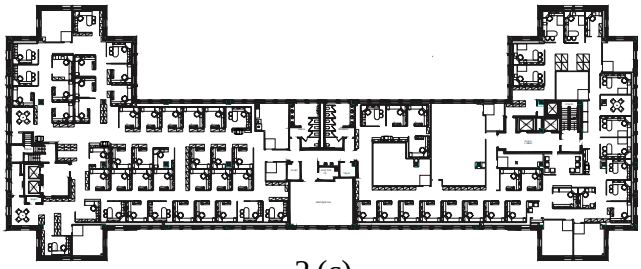

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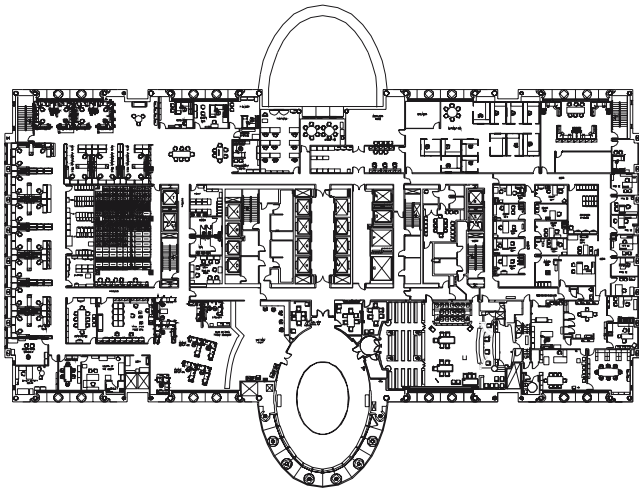


2 (d)

Figure 2: The floor layouts of the four office settings. (a) Wanamaker 6 (b) MLK4 (c) MLK5 (d) Eagleton 3

lar intervals, between individuals and teams, are required. Control by immediate supervision within a team may be necessary. The three main groups of MLK 5 have well-defined territories, but the teams do not have defined territories. The location of a territory is based on its functional relationships with the directors, as well as with the other groups. Even though the structural and functional logic of the division does not impose any immediate behavioral restrictions, predictable behavioral patterns may still exist between adjacent functionally related territorialities. The leadership of the organization recognizes the importance of interactions between individuals and groups in achieving organizational goals, and believes that the layout is capable of meeting different interaction requirements.

Our fourth case study, Eagleton 3, is the new setting of a clerk's office in a US District Courthouse (Figure 2d). The functions of the office are diverse. Likewise, the divisions of labor are numerous. There are several small groups in the office.

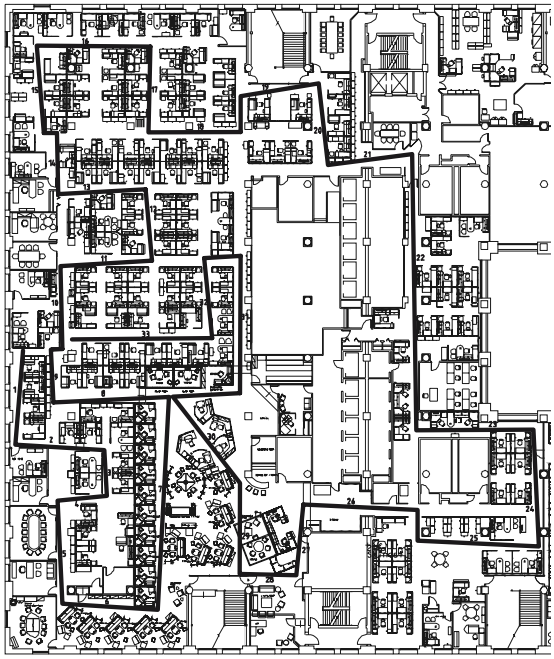
Members of some these groups have different roles and functions, and require intense interaction and physical proximity. Members of the other groups have similar roles and require no or very little interaction between themselves and others. As a result, behavioral patterns may vary from one group to another. The office setting is divided into several group territories. The location of a group territory is based on the strength of its perceived relationships with the other groups. Consequently, like MLK 5, some predictable behavioral patterns may exist between adjacent functionally related territoriality. Despite group or team differences, the current leadership recognizes that collaboration among individuals and groups is important for the success of an organization. It also acknowledges the fact that a collaborative environment must provide facilities to enhance and encourage formal as well as informal interactions between workers.

Methodology

The study involved three stages. In the first stage, we analyzed the visibility, accessibility, and interconnectedness of the office layouts using the spatial descriptors derived from *space syntax* theories and methods. Space syntax provides a rigorous system for characterizing the overall layout of complex buildings and cities. In previous studies, space syntax descriptors have been good predictors of the number of people walking in urban settings (for details of the theories and techniques, see Hillier & Hanson, 1984; Hillier, 1996; for a complete list of references, see Space Syntax Symposium, 1997, 1999, 2001 & 2003, and http://www.spacesyntaxlaboratory.org/).

For our purpose, we represented each layout as a set of minimum number of longest sight lines needed to cover every space and to complete every circulation ring in the layout. In the space syntax literature, each of these sight lines is known as an *axial line*, and the complete set of lines covering the layout as an *axial map*. An axial map provides a rigorous way to describe how we see and move in a layout. Its importance lie in the simple facts that in space individuals prefer to move along a straight-line as represented by an axial line, unless there is a reason not to do so; and that the way individuals move in space is very often defined by the number of choices available from their line of movement as represented by the number of intersections of an axial line with other axial lines.

We used the *Spatialist* computer program, developed at Georgia Tech, to describe the relational pattern of the axial lines in an axial map



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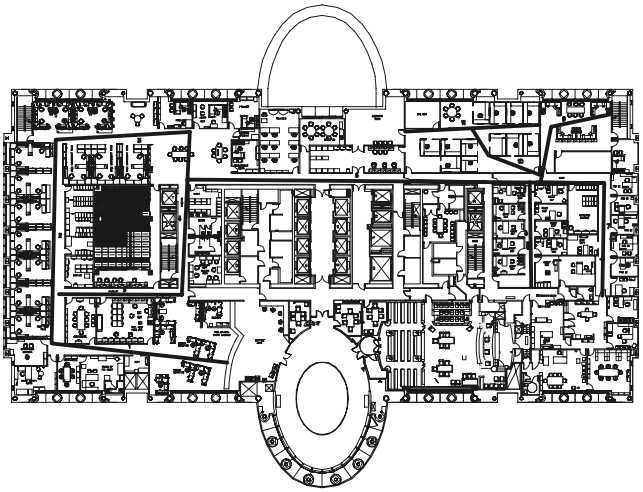

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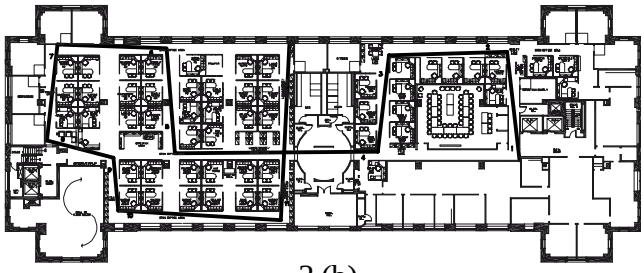

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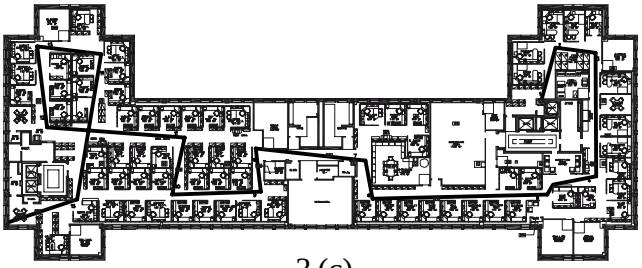


3 (c)

Figure 3: The behavior mapping routes of the four office settings. (a) Wanamaker 6 (b) MLK4 (c) MLK5 (d) Eagleton 3

(Peponis et al. 1998, 1998a, 1997). Two important descriptors of the axial structure are *connectivity* and *integration*. Connectivity of an axial line is the number of axial lines directly connected to the line. Connectivity as a local property of an axial line is interesting, because it describes the degree of choice present on the line: *The higher the connectivity of an axial line, the more is the choices of movement of the line*. Integration, on the other hand, is a global property describing the degree of connectedness of an axial line to all other axial lines of an axial map: *The higher is integration of an axial line, the easier it is to get to the line from all other lines*. Consequently, we expect a common area, which needs to be easily accessible from different parts of a layout, to be located on an axial line with high integration. If not, either that the common area is at a wrong place or that some organizational value other than social interaction dictates its location. The number and length of axial lines, representing the directions and reach of the visual field of a space, are also used in the study to de-

scribe the degree of local control available from the space.

In the second stage, we mapped three different behaviors along a predetermined route within each setting. Figures 3a - 3d show the routes of observation of the settings. The observed behaviors were 1) movement: the number of people moving on any segment of the route , 2) interaction: the number and locations of people seen engaged in face-to-face interactions, and 3) co-presence: the number of people, active and/or inactive, visible from any segment of the route,. For analyses, we normalized the observation data for 100'-long segments. For recording purposes, the researcher used an up-to-date floor plan layout with the route drawn on it. Based on the space syntax analysis of the layouts, integrated as well as segregated spaces of different types were included in the route. In total, 20-30 rounds of observation were made along any given route during different times of the work day.

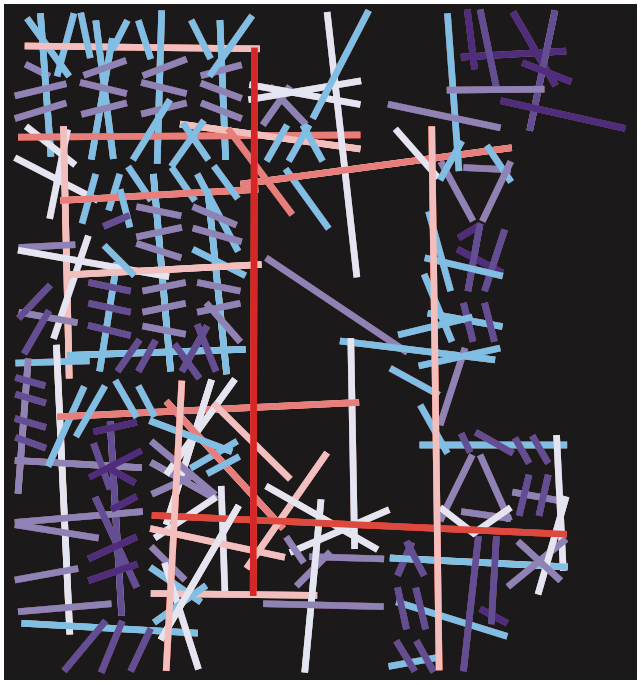
In the last stage of the study, we analyzed the relationships between the spatial and behavioral variables using descriptive statistics and multiple regression analyses.

Findings of the axial map analyses

Figures 4a - 4d show the axial maps of our four office layouts. The maps are colored using the integration values of the axial lines, ranging from white for high integration values to dark grey for low integration values. The details of the axial analyses of these and other office settings are reported elsewhere (Rashid & Zimring, 2003). Here, we present the key findings of the analyses.

Among the case studies, the organizations that particularly encourage interaction have fewer axial lines per workspace, e.g., 1.05 axial lines for MLK5 v 1.167 axial lines for MLK4 (Table 1). The appears to show a good fit between intention and layout: for a given number of people, the fewer the number of axial lines the higher the potential for interaction. In other words, for a given number of people, the number of interactions is likely to be higher if these people have offices along a single corridor instead of two or more corridors.

In addition, the organizations that encourage interaction have shorter axial lines per workspace, e.g., 37.03’ for MLK5 v 44.89’ for MLK4 (Table 1). Since the length of line is related to travel distance, it is more likely that shorter length of axial lines per workspace may result in higher interaction.



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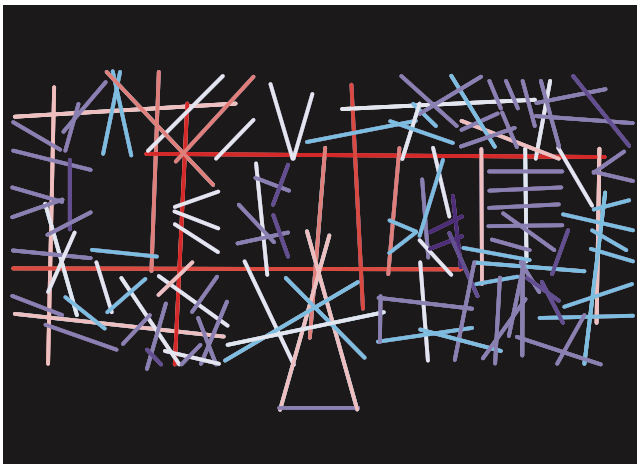

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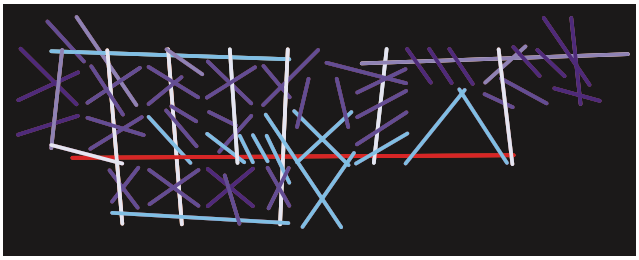


4 (b)

4 (c)

Figure 4: The axial maps of the four office settings colored using the integration values of the axial lines. (a) Wanamaker 6 (b) MLK4 (c) MLK5 (d) Eagleton 3

The organizations that encourage interaction also have higher degrees of interconnectedness of the axial structure (i.e., integration), e.g., 0.92 for MLK5 v 1.60 for MLK4 (Table 1). That is because a spatial network defined by a highly interconnected or integrated axial map provides more choices of movement, thus more opportunities for chance-encounter leading to interaction.

In these office settings, generally, the visible demarcations of territory such as clearly marked group boundaries are also reflected in the spatial structure. Easily discernible group territories have highly interconnected local axial structures cut across by fewer axial lines and have minimal connections with the global structure. The reason for such a territorial axial structure is that the number of choices available for movement across a territory increases as the number of axial lines that cut across the territory increases. Thus, to ensure the definition of a territory it is necessary to have a fewer number of axial lines cutting across the territory. In addition, a

territory may have a high sense of local coherence if the spatial network within the territory is well integrated.

According to our findings, in these office settings, the degree of accessibility, as defined by integration, distinguishes different functional categories of space (Table 2). In general, public spaces are located along the most integrated spaces, while private spaces are located along less integrated spaces (Table 2). When space types are ranked by privacy requirements from private to public, the higher the privacy requirements of a space, the lower the integration and connectivity values of the axial line on which the space is located, e.g., 2.17 and 7.846 for circulation spaces v 1.345 and 3.00 for managers in MLK4 (Table 2); and the fewer the number of axial lines cutting across the space. Axial lines with lower integration and connectivity values are physically and visually less accessible at the global as well local levels. As mentioned above, the number of choices of movement within a territory depends on the number of axial lines cutting across the territory. As a result, privacy of a territory is enhanced if the territory is cut across by fewer lines.

In general, integration of the spaces of the top executives (e.g., directors) depended on the interaction relations of the executives to their subordinates rather than on interacting with the organization as a whole. For example, even though MLK5 as an organization encourages more interaction than MLK4, directors in MLK5 are located on less integrated lines than they are in MLK4, e.g., 0.748 for MLK5 v 1.345 for MLK4 (Table 2). This seems to reflect a different culture in MLK5 than in MLK4, where directors in MLK5 appear to interact more with peers and managers rather than with staff.

In all cases but one, the higher the organizational status of a person, the lower the integration value, or the lower the degree of accessibility. In the exceptional case (Eagleton 3), the status of a person is related more to the amount of local control (defined in terms of length and connectivity) of the than to the amount of global accessibility (defined in terms of integration) of her office (see above for explanations). In this setting, the offices of the managers and first-line supervisors are globally more accessible suggesting that they may have less privacy in terms of global accessibility. However, a high degree of local control made available to these people from their locations may compensate for their lack of privacy in the layout (Table 2).

Except in one case, there are very strong correlations between the local and global spatial

Table1: Summary of the spatial properties of the office layouts

	Total no. of work-spaces	Total no. of axial lines	No. of axial lines per work-space	Sum of all axial lines	Length of axial lines per work-space	Mean Conn-ectivity	Mean Integra-tion	Mean length of axial lines
Wanamaker 6	244	253	1.037	8449	34.62	3.510	1.242	33.395
MLK 4	60	70	1.167	2693.35	44.89	3.03	1.60	38.48
MLK 5	76	80	1.05	2814.93	37.03	3.00	0.92	35.20
Eagleton 3	92	127	1.38	5653.89	61.45	3.417	1.44	44.52

Table 2: Rank order of different categories of spaces of the office layouts based on the spatial properties of the axial map

		Rank Order			
		1	2	3	4
Wanamaker 6	Mean Integration	CIR (1.442)	COM (1.376)	D&M (1.199)	WS (1.189)
	Mean Connectivity	CIR (7.885)	COM (5.724)	D&M (4.189)	WS (2.855)
	Mean Length	CIR (71.961)	COM (59.673)	D&M (39.504)	WS (26.132)
MLK 4	Mean Integration	CIR(2.17)	COM(1.621)	WS(1.403)	D&A(1.345)
	Mean Connectivity	CIR(7.846)	D&A(3.00)	COM(2.8)	WS(1.846)
	Mean Length	CIR(84.56)	D&A(49.726)	COM(37.248)	WS (26.7)
MLK 5	Mean Integration	CIR(1.058)	COM(0.929)	WS(0.896)	D&A(0.748)
	Mean Connectivity	CIR(6.048)	COM(3.929)	WS(2.558)	D&A(1.8)
	Mean Length	CIR(57.731)	COM(46.468)	WS(30.47)	D&A(28.788)
Eagleton 3	Mean Integration	CIR (1.897)	M&S (1.665)	COM (1.477)	WS (1.327)
	Mean Connectivity	CIR (8.053)	M&S (4.364)	COM (3.294)	WS (2.35)
	Mean Length	CIR (97.030)	M&S (56.904)	COM (47.456)	WS (34.014)

CIR= Circulation, COM= Common Areas/Facilities, D&M = Directors and Managers, M&S = Managers and Supervisors, WS = Workstations

variables of the layouts. The intelligibility, defined at the correlation of local connectivity and global integration, of the layouts is quite high (Table 3). This suggests that people can make reasonable judgments about global layout based on what they can see locally. In addition, the circulation cores as (i.e.,) map well onto the circulation systems defined by the geometry of these layouts. (The circulation core includes about 15% most integrated lines as shown in the white lines in Figure 4.) In other words, if a corridor is placed at a geometrically important location, it is also well connected to other spaces in the layout. Furthermore, when mapped on the layouts, the axial structures of the layouts usually follow the logic of territoriality. In sum, the structure of space of our four settings is well defined in relation to some very important functional and cultural demands of the organizations.

Table 3: Correlations of spatial variables of the office layouts

	Wanamaker 6	MLK 4	MLK 5	Eagleton 3
Integration & Connectivity	**0.699**	**0.777**	0.240	**0.902**
Integration & Length	**0.732**	**0.640**	0.341	**0.838**
Length & Connectivity	**0.791**	**0.875**	**0.943**	**0.942**

Table 4: Workspace and population data of the office settings

Work settings	Total number of workspaces	Occupancy Rate (as % of the total number of workspaces)	Attendance Rate (as % of the number of occupied spaces)
Wanamaker 6	195 (100%)	174 (89.23%)	104.5 (60.05%)
MLK 4	60 (100%)	58 (96.67%)	31 (53.44%)
MLK 5	75 (100%)	69 (92%)	38.16 (55.30%)
Eagleton 3	88 (100%)	71(80.68%)	48(67.6%)

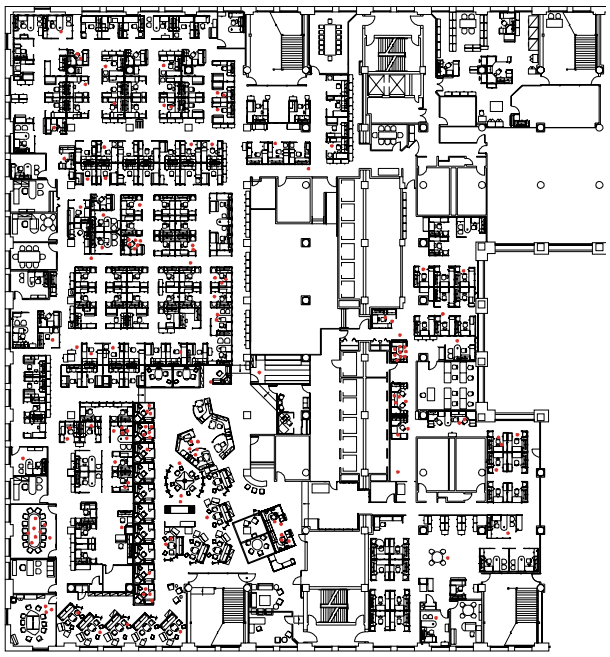
Table 5: Interactions in the office settings

Office Setting	Interactions at different locations				All Locations along the route
	Individual workspaces	Designated areas and/or meeting rooms	Corridors	Common and/or service areas	
Wanamaker 6	109 (**80.74%)**	15 (11.11%)	7 (5.18%)	4 (2.96%)	135 (100%)
MLK 4	60 (**75%)**	0 (0%)	17 (**21.25%)**	3 (3.75%)	80 (100%)
MLK 5	77(**55%)**	13(9.28%)	31(**22.14%)**	19(13.58%)	140(100%)
Eagleton 3	99 (**66.44%)**	5 (3.35%)	12 (8.05%)	33 (**22.15%)**	149(100%)

Findings of the descriptive analyses of the observation data

Our field observations suggest that the settings are quite comparable. For example, in all settings the occupancy rate of workspaces (i.e., the number of occupied workspaces expressed as percentage of the total number of workspaces) is quite high, but the attendance rate (i.e., the average number of workers present in a setting expressed as percentage of the number of occupied workspaces) is lower (Table 4). In other words, despite organizational differences, the observed similarities of the occupancy and attendance rates of our offices suggest that some generalization of our field observations may be possible.

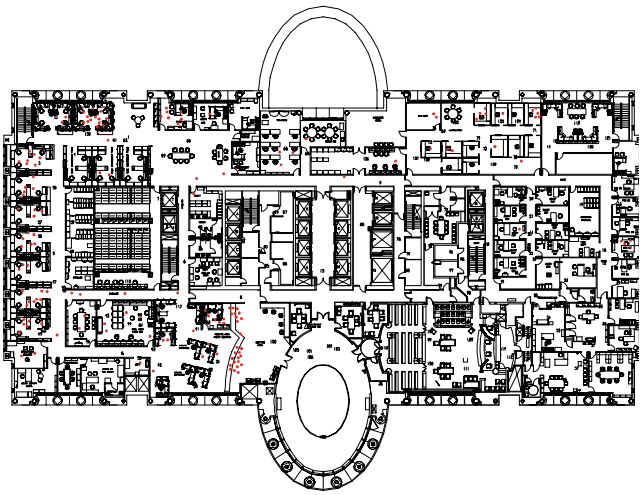
The observed interaction patterns in the office settings show both similarities and dissimilarities (Table 5). According to our data, the majority of interactions occur in individual workspaces in all four settings. (Similar findings are reported in Brill et al., 2001.) Interactions in individual spaces occur despite the fact that three of our four settings are new, designed as collaborative work environment in order to encourage interactions outside individual workspaces. Consequently, in these settings, individuals have much smaller offices than what they would have previously. In addition, all these new settings have generous corridors, common ar-



5 (a)

5 (b)

Figure 5: The locations of the observed interactions in the four office settings. (a) Wanamaker 6 (b) MLK4 (c) MLK5 (d) Eagleton 3



5 (d)

5 (c)

eas, and teamwork areas.

However, the settings show considerable differences in where interaction occurs outside of the private workstations, perhaps the *spatial cultures of interaction* (Figures 5a -5d). At least three different interaction cultures are evident in our four study settings. Wanamaker 6 has a *workspace culture*, because there is no other important interaction locus in this setting apart from individual workspaces. MLK 4 and MLK 5 have a *corridor culture*, because in addition to individual workspaces corridors also act as an important interaction locus in these settings. About 21.25% and 22.14% of all observed interactions occur in the corridors of MLK 4 and MLK 5, respectively. Finally, Eagleton 3 has a *common area culture*, because in addition to individual workspaces common areas also act as an important interaction locus in the setting. About 22.15% of all observed interactions, both formal and informal, occur in common areas of Eagleton 3.

Findings of the statistical analyses of the behavioral observation and space syntax data

According to our statistical analyses, there are good-to-strong correlations between movement and interaction in two cases and no correlations in the other two (Table 6). The findings are interesting in the light of the fact that the research community often takes it for granted that movement generates interaction for reasons explained earlier. We suspected that the relationship would be weaker in controlled settings such as the office environment, where interaction may be more driven by organizational need rather than chance encounter. Our confirm this suspicion, and suggest that the relationship between movement and interaction cannot be generalized in office settings without understand the organizational program. In some office settings, interactions may be an organizational necessity and may show no relations to movement, while in others it may have causal relations to movement. One may need to study each setting separately to determine the effects of movement on interaction in the setting.

There are very strong correlations between co-presence and interaction in all four cases (Table 6). Even though the correlations between co-presence and interaction are slightly reduced when controlling for movement, this mediating effect is not strong. In other words, interaction is related to co-presence regardless of movement.

The previous space syntax work showed strong positive correlations between movement and integration in urban settings (Hillier et al., 1993; Peponis et al., 1989). Accordingly, if there are strong correlations between integration, connectivity and length of axial lines in a setting, we may find strong correlations between connectivity, length and movement as well. The findings of our study partially support the previous work. The spatial variables showed good correlations to movement in two cases, while in the other two cases the correlations were very weak (Table 7).

In addition, the spatial variables generally showed negative or very weak correlations with interaction and co-presence (Table 7). In other words, where there was a relationship people consistently engaged themselves in *fewer* interactions in spaces with higher integration, connectivity and length than they did in spaces with less integration, connectivity and length. It is as if, they avoided interactions in spaces with more visibility and accessibility in these settings, even though each of our organizations ostensibly encouraged interactions in public spaces.

Table 6: The effects of movement and co-presence on face-to-face interaction in the office settings

	Wanamaker 6	MLK 4	MLK 5	Eagleton 3
Movement & Interaction				
Correlation	0.132 (p=.4656)	0.144 (p=.672)	**0.839** (p<.0001)	**0.501** (p=.1166)
Partial Correlation with respect to Co-presence	-0.061	-0.011	0.498	0.365
Co-presence & Interaction				
Correlation	**0.904** (p<.0001)	**0.861** (p=.0007)	**0.889** (p<.0001)	**0.741** (p=.009)
Partial Correlation with respect to Movement	0.902	0.858	0.682	0.692
Co-presence & Movement				
Correlation	0.174 (p=.3333)	0.174 (p=.609)	**0.785** (p=.0005)	0.369 (p=.2647)
Partial Correlation with respect to Interaction	0.130	0.099	0.158	-0.005

Table 7: Correlations between spatial variables and observed behaviors in the office settings

	Wanamaker 6	MLK 4	MLK 5	Eagleton 3
Integration & Movement	0.325 (p=.064)	**0.769** (p=.0056)	0.393 (p=.1477)	**0.412** (p=.2077)
Connectivity & Movement	0.222 (p=.215)	**0.643** (p=.0327)	0.125 (p=.6584)	**0.618** (p=.0428)
Length & Movement	0.235 (p=.189)	**0.531** (p=.0931)	0.226 (p=.4178)	**0.663** (p=.0261)
Integration & Interaction	-0.252 (p=.157)	-0.131 (p=.7013)	0.188 (p=.5026)	-0.273 (p=.4171)
Connectivity & Interaction	-0.221 (p=.217)	-0.078 (p=.82)	-0.053 (p=.8504)	-0.058 (p=.8649)
Length & Interaction	-0.130 (p=.471)	-0.289 (p=.3887)	0.051 (p=.8559)	0.025 (p=.9420)
Integration & Co-presence	-0.182 (p=.310)	-0.112 (p=.7432)	0.186 (p=.5063)	**-0.554** (p=.0768)
Connectivity & Co-presence	-0.163 (p=.363)	0.041 (p=.9049)	0.146 (p=.6042)	-0.395 (p=.2298)
Length & Co-presence	-0.132 (p=.464)	-0.313 (p=.3484)	0.248 (p=.3737)	-0.240 (p=.4771)

Discussion

Most previous office research has focused either on comparing generic office types, such as the impact of working in cellular versus open-plan offices, or on characteristics of individual workstations, such as the degree of enclosure they provide or the availability of windows (e.g., Block & Stokes, 1989; Brennan et al., 2002; Campbell & Campbell, 1988; Finnegan & Solomon, 1981; Hedge, 1982; Marans & Spreckelmeyer, 1982; Oldham, 1988; Oldham & Brass, 1979; Oldham & Fried, 1987; Oldham & Rotchford, 1983). However, the mechanisms for linking office design to interaction remained unclear. In particular, with a few notable exceptions (e.g., Hillier & Penn, 1991; Penn et al., 1997; Serrato & Wineman, 1997, 1999; Wineman & Serrato, 1998), much office research appeared to have left out an important factor: the overall layout of the office. This is evident in the fact that of all the studies on office settings reported in the "Environment and Behavior" journal since the early 1970s, only a few studies provide the drawings of office layouts (e.g., Becker et al., 1983; Ornstein, 1999). Most

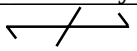
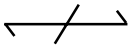
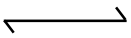
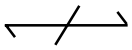
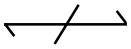
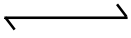
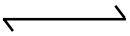
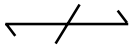
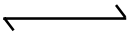
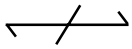
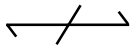
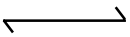
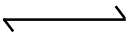
people's experience with built settings is that different settings show different patterns of movement. Some settings seem to concentrate movement along a few key corridors or spaces, while others seem to spread movement out more equally among all spaces. In this paper, we reported on a study of four work settings where we used space syntax theories and methods to address the questions of how patterns of overall layout affect movement, co-presence and face-to-face interactions in offices.

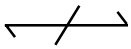
Our study of the four offices, each wanting to increase organizational performance through increased interaction (i.e., communication), revealed several interesting aspects. The space syntax analyses of the layouts showed that these organizations laid out their spatial settings not only to increase face-to-face interactions, but also to meet such cultural demands as privacy, territoriality, and hierarchy of the organizations. In other words, they did not sacrifice their basic needs in order to promote interaction, teamwork and collaboration.

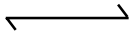
The behavioral observations showed that in these settings most interactions occurred in individual workspaces. This occurred despite the facts that the organizations encouraged interactions in semi-public and public territories, and that they made enough spatial investments at strategic locations to generate, sustain, and enhance a collaborative work environment. Similar findings were reported in other studies as well (Brill et al., 2001). The fact that people prefer to interact in individual workspaces when other choices are available in semi-public and public territories may point to the importance of control, privacy, status and security during interactions. In this context, the idea of the *spatial culture of interaction*, proposed in the paper, may be important in finding the right kind of balance between interactions in private and public territories of office settings. The idea helps us to see that different organizations require different locations of interactions besides individual workspaces. Designers may promote the spatial culture of interaction of an organization by investing in the right kind of spaces, or may destroy it by investing in the wrong kind of spaces.

A summary of the findings of our statistical analyses is given in Table 8. In the table, a two-head arrow represents good correlation and a two-head arrow with a forward slash represents no correlation between the variables. As the table shows, over all, Eagleton 3 is the only setting where the causal model relating space and behavior worked well. In other words, it is the only case where spatial variables showed good correlations to movement and co-pres-

Table 8: Summary of the findings of the statistical analyses of spatial and behavioral data

Wanamaker 6	{Integration, Connectivity, Length}		Movement		Interaction
MLK 4	{Integration, Connectivity, Length}		Movement		Interaction
MLK 5	{Integration, Connectivity, Length}		Movement		Interaction
Eagleton 3	{Integration, Connectivity, Length}		Movement		Interaction
Wanamaker 6	{Integration, Connectivity, Length}		Co-presence		Interaction
MLK 4	{Integration, Connectivity, Length}		Co-presence		Interaction
MLK 5	{Integration, Connectivity, Length}		Co-presence		Interaction
Eagleton 3	{Integration, ~~Connectivity~~, ~~Length~~}		Co-presence		Interaction

 No correlation exists bewteen the variables

 Good correlation exists bewteen the variables

ence, and movement and co-presence showed good correlations to interaction.

In other cases, we found significant gaps in the model. In general, space failed to show any consistent causal relation to behaviors in these settings. The relationships between movement and co-presence, and movement and interaction were not consistent in these settings, either. However, the relationships between co-presence and interaction were consistent in all of our settings, and the effects of movement on these relationships were negligible. This is important because it suggests that co-presence is important for interactions in an office setting, and that an office setting with more co-presence may instigate more interactions than a setting with less co-presence, even if the latter shows more movement than the former.

The pattern of findings, however, does not challenge the overall causal model but rather suggests the importance of organizational programs. For example, in Wanamaker 6 and MLK5, there were no consistent relationships between the spatial variables and behaviors even though their layouts met the basic cultural demands of the organizations (see the findings of the space syntax analyses above). One reason why space failed to sustain behavior in these cases may be that the decision-makers of these organizations implemented the new officing ideas in their spatial layout before the accumulated organizational codes changed. From our studies it was impossible

to determine whether the relative lack of interaction in public space represented active resistance to the new officing strategies by staff or management, or whether management had not done an adequate job in altering the hierarchies, territorialities, and control that limit the flow of ideas and collaboration. If a manager uses the increased visibility in these new offices to increase visual control, it would be natural to assume that worker would not be comfortable chatting in visible group space, even if it serves valuable organizational purposes. Our study would suggest that no office setting is sufficient on its own to generate, sustain, and increase interaction without the necessary changes in the attitudes, programs and policies of the organization.

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[1] The perception that office design shapes interaction is of course not new, but in the past has often been interpreted as using design to facilitate structured and predictable interaction. The first modern office buildings such as the 1904 Larkin Building designed by Frank Lloyd Wright were organized to reflect the flow of paper work (mail orders in the Larkin Building) and to support supervision.