ENHANCING WORKSPACE PERFORMANCE:
predicting the influence of spatial and psychosocial factors on job satisfaction

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Abstract

There have been a number of recent studies exploring the effects of spatial behavior and layout characteristics on aspects of job satisfaction and performance. Rashid et al. (2006) described the effects of spatial behaviors (movement, interaction, and co-presence) and layout attributes (visibility, accessibility, and openness) on individual perceptions in the workplace. Shpuza and Peponis (2005) examined floorplate shapes and office layouts influencing circulation integration. Penn and Desyllas (1999), investigating laboratory designs, found that patterns of space use and movement generated by spatial configuration have a direct impact on the frequency of contact between workers that in turn influences "useful" communication. Most of these have drawn conclusions on the basis of correlations and simple regression models linking spatial variables to job satisfaction and performance. This paper explores such relationships and extends this analysis to develop a model demonstrating mediated predictive relationships between characteristics of spatial layout (connectivity and integration), and psychosocial measures (privacy, interaction support, sense of community, and job satisfaction).

The study [i] uses a survey questionnaire data of 329 employees at four U.S. federal offices. The spatial layout for each of the study sites is characterized by a set of spatial descriptors (Hillier & Hanson, 1984; Hillier, 1996) and it is examined using the program Spatialist [ii]. Building on these multiple variables, regression analysis is conducted to develop the predictive models and path analysis is applied to test their relative strength and fit.

Regression analyses indicate: (1) strong evidence of the influence of the scale measures of perceived privacy, interaction support, sense of community, and autonomy on overall job satisfaction; (2) trends of low perception of privacy compared to that of other psychosocial measures across all the four sites; and (3) a strong link between perception of interaction support and the extent of connection respondents have in their environment (connectivity), and between sense of community and accessibility in the immediate environment (local integration). Extended path analysis also suggests: (1) a strong model predicting a direct influence of connectivity on interaction support and that of interaction support on job satisfaction and (2) a linear model from local integration directly predicting sense of community that in turn impacts job satisfaction. The results illustrate the role of spatial attributes inherent to the layout and key psychosocial factors in enhancing job satisfaction in workplaces. The study also underscores the complexity

of understanding the aspects of spatial layout that enhance job satisfaction and ultimately work performance.

Background

With the increasing globalization of the marketplace and rising economic competition, organizations are looking for ways to become more efficient and more responsive to changing markets. In response, many companies have reorganized from traditional hierarchical to more decentralized team-oriented organizational structures, and look to the physical facility to reinforce these changes. A critical consideration at both the local (individual and group) and global (organization) level is not only the creation of spaces themselves, but the ways in which those spaces link together to constitute the fabric of the organization and the blueprint of opportunities for encounter.

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Spaces to facilitate the primary tasks of the work group are important, but equally as important is the design of space to support the other less formal activities of work. Workspace should reach beyond the facilitation of work tasks to support the social and cultural well being of the participants. Corporate investment in attracting highly trained knowledge-workers has resulted in increasing focus on worker retention. Job satisfaction, employee comfort and organizational commitment are important indicators of organizational success.

The spawning of numerous semi-independent team-based units requires that organizational goals and culture be transmitted across units. Informal communication is increasingly recognized for its role in the promulgation of 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” (Rashid et al., 2006)

Studies of the productivity of research and development teams suggest that communication is an important indicator of performance (Allen, 1977; Pelz & Andrews, 1966; Shilling & Bernard, 1964). Workers talk (face-to-face) with others who are in close proximity. Social relationships (social interaction, friendship formation, and informal group liaisons) are affected by the physical proximity and accessibility of workstations. These results have been corroborated by numerous studies (see Sundstrom, 1986, for a review). Beyond a distance of about 30 meters, workers are not likely to talk (directly) unless it is a particularly important matter (Allen, 1977). Physical distance, and physical barriers (such as doors, stairs, changes in corridor direction) will act as deterrents (Allen, 1977; Fernald, 1986; Hackman, 1987).

Research indicates that principles of spatial organization affect the generation and distribution of movement patterns in space, and the ways in which occupants encounter others in space (unplanned encounter) (Grajewski, 1993; Hillier et al., 1984; Hillier and Penn 1991; Peatross and Peponis, 1995; Penn, Desyllas & Vaughan, 1999; Peponis, 1985; Serrato and Wineman, 1999). Studies of effective project teams suggest that it is not uncommon to find that the most productive ideas germinate from informal interactions a member of a group has with others outside the group (Allen, 1977; Baker et al., 1967). Peters and Waterman, in their book In Search of Excellence, suggest that many of the best ideas produced by teams find their germination in unscheduled ‘serendipitous’ encounters with workers outside the team (Peters and Waterman, 1981).

Study Description

This paper is based on the study Linking Office Design to Work Performance: Environmental Predictors of High Work Performance. The work presented here specifically focuses on ways to enhance employee Job Satisfaction. We examine relationships among a set of psychosocial measures (based on workers' responses to our survey) and a set of objective measures of the spatial layout of the office.

Data for this study was collected at four federal offices. Our first site, Philadelphia 1, was a US government Public Building Services (PBS) operation with several divisions each performing separate functions and organized into several working groups. During the course of our study this organization moved to a new building in the same city. This became our second research site, Philadelphia 2. Our third site, Atlanta, was also a government PBS operation. Our fourth site is a federal clerk of court's office, St. Louis. These last two sites also housed several divisions composed of multiple work groups.

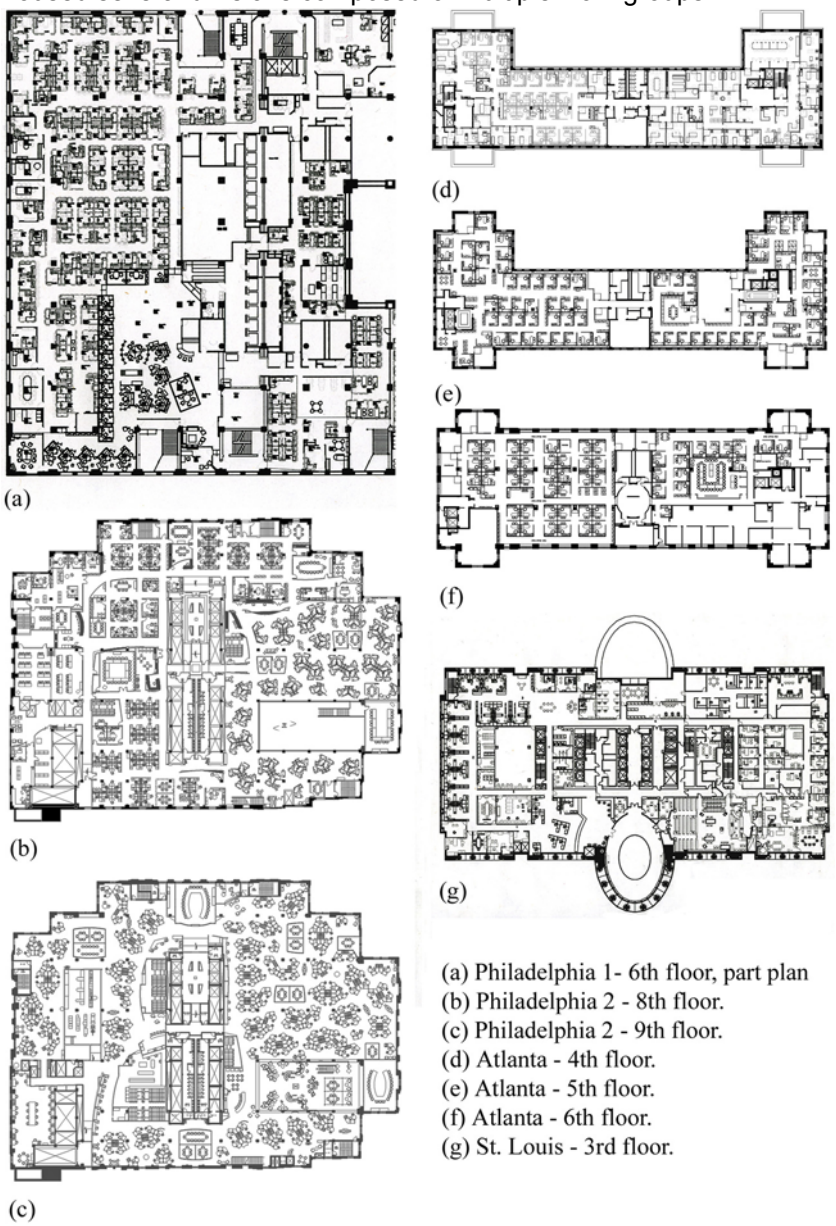

Figure 1:
The Floor Layouts of the Four USGSA Office Settings

The majority of the workers in the settings are professionals. Among other large groups are administrative staff and mid-level managers. Among the smaller groups are senior and low-level managers and trainees.

The number of workstations in our settings range from 57 (Atlanta, 6th floor) to 173 (Philadelphia-2, 8th floor). The layouts are predominantly open-plan types in rectilinear patterns. A significant number of the workstations in each setting are partitioned spaces with low height panels, either slightly above or slightly below the eye level. Often, the partitioned spaces are small in area with little or no variation among them. Each setting also has a few private offices with floor to ceiling partitions. In at least one of these settings, there are a few shared office spaces, with no or minimal partitions, arranged in clusters of three or four.

Methodology

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This paper examines the interrelationships between a set of psychosocial constructs represented by scalar measures derived from our questionnaire survey, a set of measures of the spatial layout of the office environment, and our outcome variable job satisfaction, also derived from the questionnaire survey.

Questionnaire Survey

A questionnaire survey was administered in each setting as a part of the larger workplace study being conducted at the Georgia Institute of Technology and the University of Michigan. The questionnaire addressed individuals' perceptions of the physical qualities of workplaces, departmental and/or group spaces and the building. There were questions about the nature of individuals' jobs and various aspects of their job satisfaction. There were also questions about individuals' perceptions of sense of community, organizational values and commitment.

From our survey, we have 83 respondents from Philadelphia-1; 126 respondents from Philadelphia-2; 66 and 54 respondents respectively from Atlanta and St. Louis; making the total respondent sample 329 for all the GSA locations. We considered the probability of clustering within each sample site, which poses difficulties for statistical inference in the general linear model. Independence of the responses obtained from the questionnaire survey was ensured using inter-cluster correlation (ICC) calculations (see appendix for detailed calculations). Table 1 illustrates the total employee count for each sample and each survey population and also describes the respondent breakdown in terms of response rate and distribution of gender and job categorization.

Table 1:
The Sample Distribution from the Four USGSA Sites

	Philadelphia-1	Philadelphia-2	Atlanta	St. Louis	Total
Sample Size	83	126	66	54	329
Employee Surveyed	173	256	176	68	673
Response Rate	47.98 %	49.22 %	37.50 %	79.41 %	48.89 %
Male	42.50 %	42.70 %	37.50 %	37.50 %	40.80 %
Female%	57.50 %	57.30 %	62.50 %	62.50 %	59.20 %
Manager	25.30 %	18.50 %	15.80 %	10.60 %	18.50 %
Professional	53.30 %	58.30 %	61.40 %	31.90 %	53.30 %
Staff	21.30 %	23.10 %	22.80 %	57.40 %	28.20 %

About 30% of our sample in the new facility, Philadelphia-2 (38 out of 126 respondents), had also responded to our initial survey at the first site, Philadelphia-1. To study the impact of this subset of our sample population on our research results, a comparative analysis was conducted between (a) all the respondents in Philadelphia-2 and (b) all the respondents in Philadelphia-2 except the 38 respondents, who

had also responded in Philadelphia-1. The comparative study revealed that the significant relationships found in the regression analyses with all the respondents remain consistent even when those 38 respondents were removed.

The survey questionnaire includes sets of questions that constitute thirteen psychosocial scales. The scales and their questions, each with responses on a 5-point Likert-type scale, are shown in Table 2.

Table 2:
Psycho-Social Measurement Scales

Scale	Individual Questions
Privacy	
7_8	Don't Mind Visual/Physical Control by Supervisor
7_11 ®	Don't Have Enough Privacy From Others
7_12	Adjustable Workspace to Increase Privacy
7_13 ®	Co-Workers Can Hear Conversations
7_14 ®	Co-Workers Can Hear Telephone Conversations
7_15 ®	Don't Have Enough Privacy to do Job Well
Interaction Support	
11_4	Building Provides Opportunities for Informal Conversations
11_6	Office Provides for Teamwork/Impromptu Meetings
11_7 ®	Have Difficulty Finding People I Need to do Job
11_10 ®	Have to Go Out of Way to Obtain Information From Co-Workers
11_12	Department Layout Supports Teamwork
11_13	Department Layout Supports Impromptu Meetings
Autonomy	
24_10 ®	Little Input in Tasks I do
24_11	Can Determine How to do Work
24_14	Control of Job Tasks
Job Satisfaction	
23_11	Informal Talking is One Reason Enjoy Work
24_6	Look Forward to Coming to Work Every Morning
24_16	Satisfied with Pay
24_18	Satisfied with Fringe Benefits
24_19	Satisfied with Job Security
24_31	Overall Satisfied with Job
23_9 ®	Too Much Bickering and Fighting at Work
23_12	Enjoy Co-Workers
23_17	Communications Seem Good at Work
24_1	Like the Things I do at Work
24_2	Job is Enjoyable
24_3 ®	Feel That I Don't Know What's Going on in Organization
24_5 ®	Too Much to do at Work
24_13 ®	Work Assignments aren't Fully Explained
24_17 ®	Too Much Paperwork
24_21 ®	Sometimes Feel Job is Meaningless
24_23 ®	Rules/Procedures Make Doing Good Job Difficult
24_27	Efforts are Seldom Blocked by Red Tape
25_11 ®	Goals of Organization are Not Clear
Sense of Community	
23_1	Sense of Community in Department
23_4 ®	Co-Workers Interrupt Work
23_7	People Treat Me Well at Work
23_16	People Respect Me at Work

Spatial Layout

The spatial layout for each of our study sites was characterized by a set of spatial descriptors derived from space syntax theories and methods (see Hillier & Hanson, 1984; Hillier, 1996). Syntax analysis techniques can be applied to two dimensional building plans or urban layouts to produce quantitative measures of the characteristics of spatial layout. The analysis represents a spatial system as a series of smaller spatial units or as a system of lines of potential movement between these spatial units. For each of these representations, syntax analysis involves the study of patterns of connections, both in terms of

the relationship of each spatial unit or line to its immediate neighbors measured by variables such as “connectivity,” and by the relationship of each spatial unit or line to the entire set of lines that constitute the spatial system being studied, measured in terms of "integration." Taking lines as an example, as a global measure, integration describes how easily (traversing the fewest number of lines) all other lines can be reached from a given line.

For this study we used the computer-based program Spatialistii to examine three objective measures of spatial layout of the office: Connectivity, Local Integration and Global Integration. In this study, ‘Connectivity’ represents the extent to which the corridor segment next to the workstation is connected to other corridors. ‘Integration’ represents the extent to which the corridor segment next to the workstation is well connected globally to all the other corridor segments in the system. This measure can be applied at the level of the ‘neighborhood’, referred to as ‘Local Integration’, or at the level of the entire spatial system, referred to as ‘Global Integration’.

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Research indicates that these measures of spatial organization affect the generation and distribution of movement patterns in space, awareness and interaction patterns (Hillier and Penn 1991; Peatross and Peponis, 1995; Peponis, 1985). Grajewski (1993) reports strong correlations between interaction (the number of people talking as a proportion of the number of people observed) and integration (a measure of global spatial layout) in six office environments in the UK, the USA and Sweden. Serrato and Wineman (1999) investigated the relationship between the layout of two research and development facilities and communication patterns among research scientists. Although the layout of the two units was fundamentally different, the strongest predictor of communication for both units was found to be the extent to which scientists were linked to locally integrated corridors (local spatial layout) and the interface of this local system with the global spatial system. Penn and his colleagues (Penn, Desyllas & Vaughan, 1999) trace the spatial culture of two organizations, an energy utility and an advertising agency, not only through detailed behavioral mapping but also through qualitative measures. While the study confirms that densities of movement are strongly correlated to integration (global spatial layout), it further suggests a relationship between integration and what is perceived to be useful communication.

Analysis

Regression Analysis

We applied regression analysis to explore the contributions of our physical layout measures and our psychosocial scale measures to the prediction of workers’ Overall Job Satisfaction. Initial correlation analyses indicated the extent to which pairs of our variables are associated and the magnitude of that association. However, these relationships are not predictive. Regression analysis was used here to provide an understanding of the predictive effects of sets of our psychosocial scale measures and our spatial layout variables.

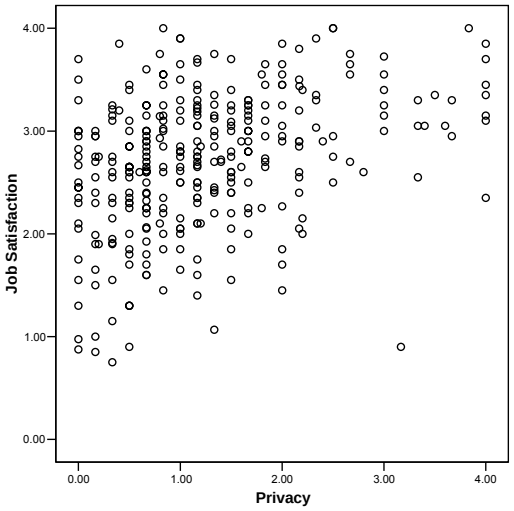
For this analysis we combined our four site location data sets into one combined data set. Since we were particularly interested in the contributions of spatial layout variables to Job Satisfaction, we focused on four of the psychosocial scale measures that might be affected by changes in spatial layout. We show first the correlation scatter-plots, indicating the relationship between the paired variables, and then we enter these variables into a regression model, to predict Job Satisfaction.

Scale – satisfaction relationships

Focusing on the Job Satisfaction scale, correlation analyses between Job Satisfaction scale and various other constructed psycho-social scales (as explained in Table 2) indicate that high levels of satisfaction with job are associated with positive perceptions of other aspects of the workplace, such as Privacy, Interaction Support, Sense of Community, and Autonomy. The strength and direction of these relationships are illustrated in the scatter-plots shown in Figure 2 and also summarized in Table 3.

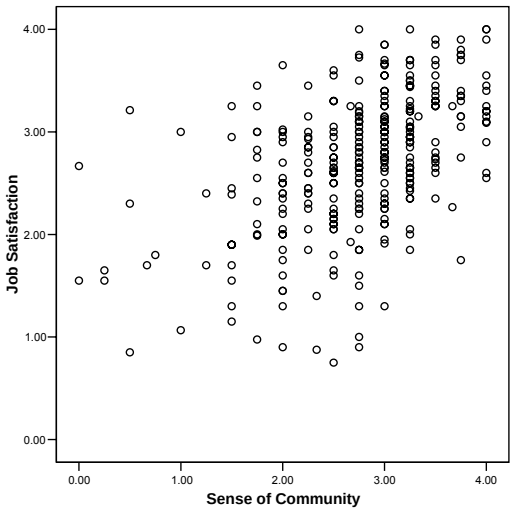
Figure 2:
Scatter-Plots Indicating Correlation Between Various Scale Variables

Privacy – Job Satisfaction



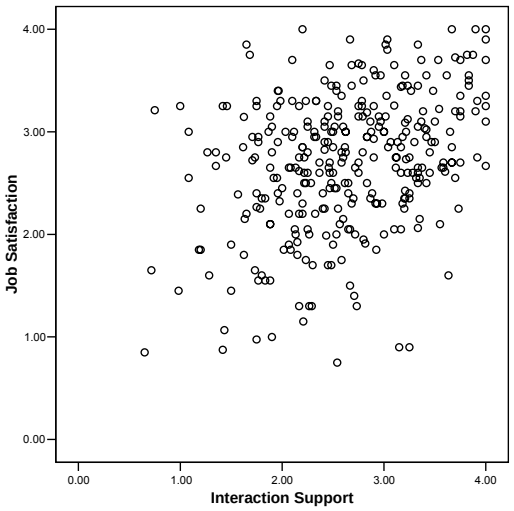
r = .363 (significant at .01 level)

Sense of Community – Job Satisfaction



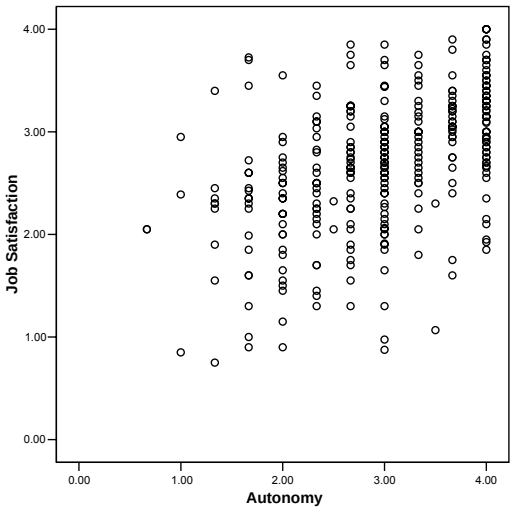
r = .501 (significant at .01 level)

Interaction Support – Job Satisfaction



r = .354 (significant at .01 level)

Autonomy – Job Satisfaction



r = .485 (significant at .01 level)

	Job Satisfaction r	Job Satisfaction r^2
Privacy	.363	.132
Interaction Support	.354	.125
Sense of Community	.501	.251
Autonomy	.485	.235

Table 3:
Summary of Correlation Analysis Among Scale Variables (all buildings)

All the r-values are significant at 0.01 level (2-tailed)

From the previous correlation table we can conclude that the scale-satisfaction relationships are fairly strong and highly significant. Because of this established relation, these scale variables are used as explanatory variables in a regression model to predict their influence on the outcome variable - Job Satisfaction.

Outcome Variable = Job Satisfaction (JS)

Explanatory Variables = Scale variables

Privacy (P), Interaction Support (IS), Sense of Community (SC), and Autonomy (A)

Table 4:
Regression coefficients of various scale variables in the four USGSA office locations

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	Privacy	Interaction Support	Sense of Community	Autonomy	R	R^2
Philadelphia-1	+ .156 (.041)	Not significant	+ .340 (.0001)	+ .282 (.001)	.671	.450
Philadelphia-2	+ .206 (.003)	Not significant	Not significant	+ .329 (.0001)	.660	.436
Atlanta	+ .154 (.027)	+ .320 (.005)	+ .223 (.044)	+ .292 (.003)	.726	.526
Courthouse	Not significant	+ .315 (.013)	+ .304 (.005)	Not significant	.671	.450
All Buildings	+ .145 (.0001)	+ .137 (.003)	+ .239 (.0001)	+ .264 (.0001)	.648	.420

In each cell of the above table, the value indicates the non-standardized coefficient of each explanatory variable. The coefficient informs us about the amount of change in the outcome variable (satisfaction) due to one unit change in each of the explanatory variables. The adjacent value in parenthesis demonstrates the significance of the explanatory variable in terms of the p-value. The table also shows the regression models for each of the four sites individually as well as for the combined sample of all the sites together (all Buildings).

For the combined sample, “all Buildings”, we can conclude that, for each unit increase in “Privacy,” there is a .145 unit increase in “Job Satisfaction;” for each unit increase in “Interaction Support,” there is a .137 unit increase in “Job Satisfaction;” for each unit increase in “Sense of Community,” there is a .239 unit increase in “Job Satisfaction;” and for each unit increase in “Autonomy,” there is a .264 unit increase in “Job Satisfaction.” All of the coefficients are significant at the .05 level. In this case, the regression model will be

JS = .723 + .145 (P) + .137 (IS) + .239 (SC) + .264 (A) + Error

From the regression analysis we can infer that the regression model predicting the influence of the four explanatory variables (privacy, interaction support, sense of community, and autonomy) on the outcome variable (job satisfaction) is strong and significant. Considering the possible R-values between zero and one, all the R-values for this model are greater than .5 indicating a strong and significant model. The model is robust for all the individual sites and the four sites combined as well. This strength of the model favors the use of path analysis, shown in the next section.

Spatial layout – scale relationships

From the results as shown in the Table 5, we find that the spatial layout variables have some relationship with two of the four scale variables of our regression model: Interaction Support and Sense of Community. For the significant relationships, all the r-values are significant at the .05 level. Though these are significant correlations, the r-values indicate that the relationships between the spatial layout variables and scale variables are weak. There were no significant

relationships of the spatial layout variables with our scale variables of Privacy and Autonomy. Since there is strong theoretical evidence that the spatial variables (syntax variables) might likely predict Privacy, we retained this variable in our path analysis model. However, the Autonomy scale was not included in the subsequent path analysis.

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Table 5:
Summary of correlation analysis between syntax variables and scale variables (all buildings)

	Privacy	Interaction Support	Sense of Community	Autonomy
Connectivity	Not significant	.157	Not significant	Not significant
Global Integration	Not significant	.118	Not significant	Not significant
Local Integration	Not significant	.139	.114	Not significant
Length	Not significant	.169	Not significant	Not significant

Path Analysis

Path analysis is an extension of regression modeling and requires that the usual assumptions of regression be satisfied. Path analysis assesses the relative importance of various direct and indirect causal paths from a set of predictor variables to the dependent variable (in this case, Overall Job Satisfaction). The regression weights predicted by the model are compared with the observed correlation matrix for the variables, and a goodness-of-fit statistic is calculated.

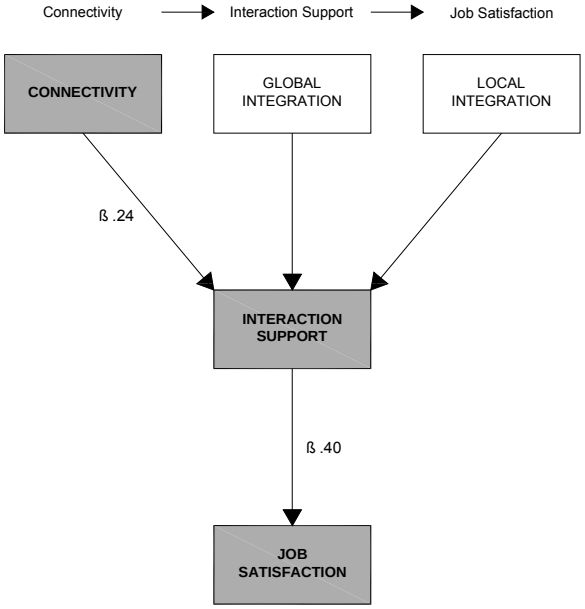
An important parameter for path analysis is to make sure that there is an adequate sample size. In order to achieve this, we used our combined sample (322 respondents – seven cases were omitted from our original combined sample due to missing data) from the four sites taken together. Path analysis of combined samples considers the four sites as four clusters. Path analysis is effective if and only if interclass correlation within each cluster is minimal. In other words, one has to ensure that within each cluster, in this case, within each work site, there is enough variability among the responses. This variance within each of the four samples was checked in order to confirm that the effects we studied would indeed be predicted from the 322 response values rather than from an effect of four values representing one for each of the four clusters (see Appendix A for these calculations).

Path analysis results confirmed the influence of the scale measures of perceived privacy, interaction support, sense of community, and autonomy on overall job satisfaction. For our sample of GSA employees, higher reported levels of perceived privacy, interaction support, sense of community, and job autonomy were all strongly related to higher levels of reported job satisfaction for each of the four locations.

Our measures of spatial layout (Connectivity; Local Integration; and Integration) were not predictive of overall job satisfaction directly. However, path analysis indicates two weak but significant relationships. The first path suggests that increases in Connectivity are linked to increased Interaction Support and ultimately Job

Satisfaction. Occupants of offices along corridor segments that are well connected to neighboring corridors are more likely to be satisfied with 'interaction support'. More connected corridor segments will have more travel along them, and thus provide increased opportunities for interaction.

Figure 3:
Path Analysis I



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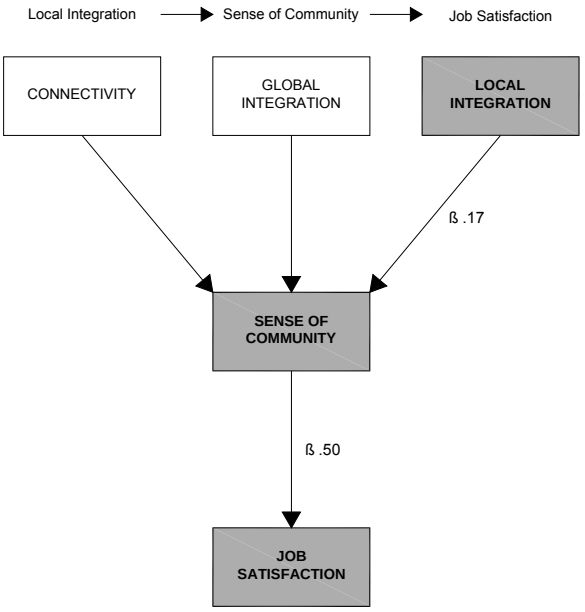
A causal link was also found between Local Integration and Sense of Community. Though the correlation coefficient was weak, the relationship was highly significant. This suggests that occupants of offices in local areas that are well connected to each other (highly connected networks where each space is connected to all others) will have higher perceived 'sense of community' and ultimately higher Job Satisfaction.

Figure 4:
Path Analysis II



Discussion and Conclusions

The correlation and regression analyses provide strong evidence of the influence of the scale measures of perceived privacy, interaction support, sense of community, and autonomy on overall job satisfaction. For our sample of GSA employees, higher reported levels of perceived privacy, interaction support, sense of community, and job autonomy were related to higher levels of reported job satisfaction for each of the four locations.

The mean levels of perceived Sense of Community and Autonomy were found to be relatively stable across the four locations. In contrast, the mean values of the Privacy and Interaction Support scales varied across locations.

From the comparison of the four case locations, there was strong evidence indicating other important trends.

a) Respondents' perceptions of Privacy tended to be significantly lower than their perceptions of the other scale measures for all the locations.

b) There were significant differences in the mean values of the measures of Privacy and Interaction Support across the four locations. There were no significant differences across the four locations for Sense of Community and Interaction Support.

c) Mean levels of Job Satisfaction were found to be relatively constant across the four locations indicating an interesting relationship among the variations of the scale measures. With respondents' perceptions of Sense of Community and Autonomy being relatively consistent across the sites, differences in perceptions of Privacy and Interaction Support affected overall job satisfaction. However, the comparative analysis indicated that perceptions of Privacy and Interaction Support for each location moved in opposite directions. Thus these differences nullified each other resulting in a relatively constant mean value of overall Job Satisfaction.

d) A trend was observed regarding the relationship between perceived Privacy and our spatial layout measure of Connectivity. Locations with higher Connectivity had lower values of Privacy. This trend appears reasonable given the implications of a workspace with high Connectivity. Higher connectivity means greater connections with neighboring spaces, typically resulting in higher levels of movement and higher concentrations of people. This would likely affect employee's perceptions of Privacy. Although we observed this relationship as a trend in the data, it was not found to be a statistically significant relationship for this sample. It would be useful to further investigate this relationship in further studies.

e) We did not find significant variability across the four settings in the spatial measure of Integration. This suggests that each of the four settings was characterized by similar accessibility as a global system (from each spatial segment to all other spatial segments in the system). We suspect, on the basis of previous research, that if we had found variability across the sample settings, we might have observed a significant relationship between Integration and Sense of Community. This spatial characteristic may also affect Interaction Support. Since there was no variability across the sample settings for Integration, we were unable to examine potential effects.

Our measures of spatial layout (Connectivity; Local Integration; and Integration) were not predictive of overall job satisfaction directly.

However, we did find some weak but significant relationships to the scale measures of Interaction Support and Sense of Community. On the basis of the correlation analyses, we found that there was a positive correlation between Interaction Support and Connectivity.

Occupants of offices along corridor segments that are well connected to neighboring corridors are more likely to be satisfied with 'interaction support'. More connected corridor segments will have more travel along them, and thus provide increased opportunities for interaction. A similar positive correlation was also found between Sense of Community and Local Integration. Though the correlation coefficient was weak, the relationship was highly significant. This suggests that occupants of offices in local areas that are well connected to each other (highly connected networks where each space is connected to all others) will have higher perceived 'sense of community'. These two findings suggest that offices should be designed with highly connected local neighborhoods constructed of well-connected corridor segments.

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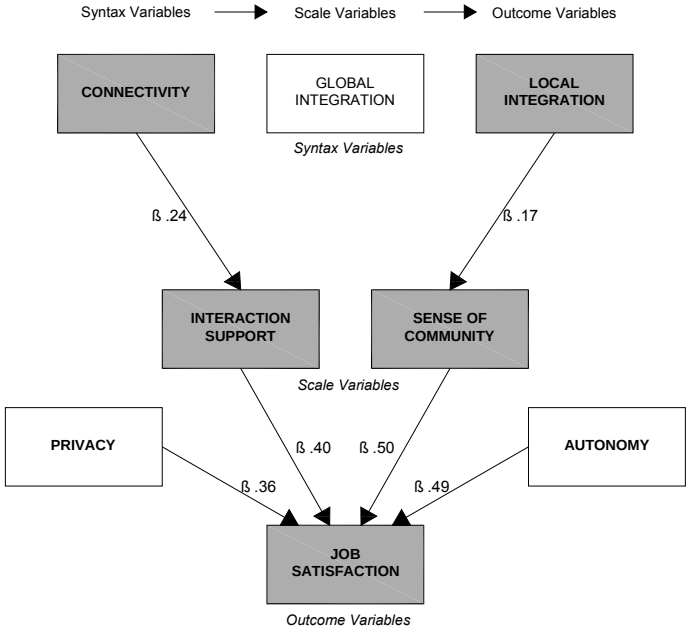
Our predictive model can be summarized using the following path analysis chart diagram:

Figure 5:
Path Analysis Summary Chart



Another finding illustrated in this model is a weak negative relationship between Connectivity and Privacy. Although this relationship was not significant, we can see a trend in the results (see Figure 6). Occupants of offices along well-connected corridor segments are likely to be less satisfied with privacy. Open-ended survey questions indicate that workers at all four of the office sites are most dissatisfied with privacy. Responses to the survey scale, Satisfaction with Privacy, were low at all four sites. This result raises a quandary for designers: how to provide the connectivity to enhance interaction, yet the privacy for concentrated work.

On the basis of our analysis we have developed a robust model for affecting job satisfaction: improving workers' perceptions of privacy, interaction support, sense of community, and autonomy will enhance overall job satisfaction. For the office designer, the question arises as to how spatial design variables affect this model. Although we found no direct affects of spatial variables on job satisfaction, spatial design did affect workers' Sense of Community and perceptions of Interaction Support. It was found that higher Connectivity (connection to neighboring spaces) supports improved perceptions of Interaction Support and higher Local Integration (the extent to which spaces

within the local neighborhood are easily accessible from one another) provides employees with a greater Sense of Community.

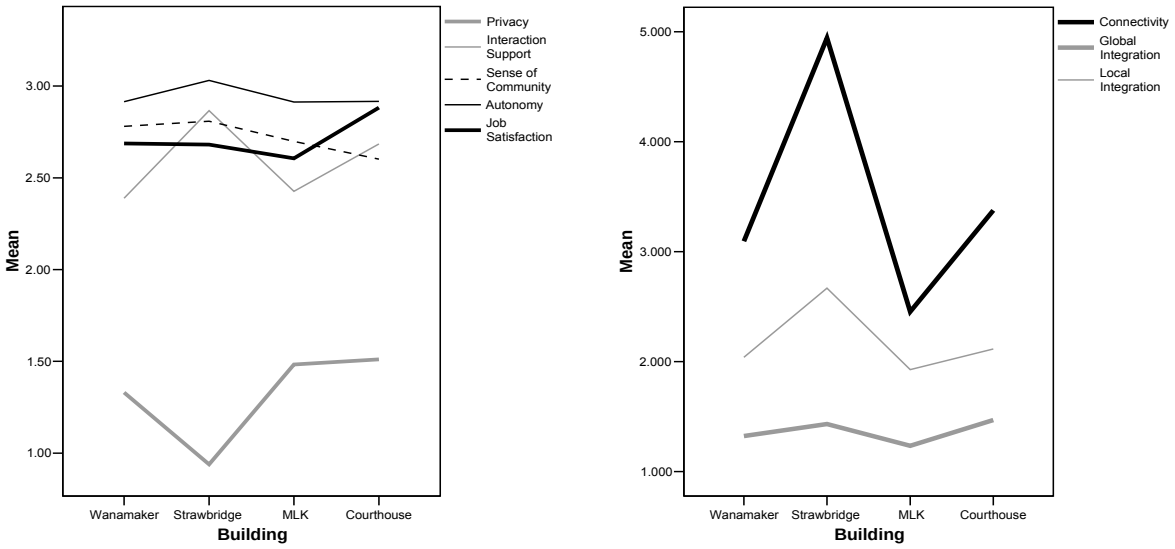


Figure 6:
Graphs of mean values of scale variables and syntax variables

Design strategies that enhance Connectivity and Local Integration include the following:

a) Create circulation spaces with multiple connections.

b) Minimize the number of dead end circulation spaces.

c) Design 'neighborhoods' as networks of well-connected circulation spaces.

d) Group offices into well connected 'office pods' so that members of the group can interact easily with one another. At the same time multiple pods should be well connected so that there is a healthy support system among the pods.

The conflict arises in trying to maximize connectivity for interaction support, yet preserve privacy. Connectivity is the number of connections of the corridor segment to other corridor segments. It may be that an optimum can be reached with an adequate number of connections to support interaction, yet not so many that increased circulation traffic compromises privacy. Or that the well-connected corridor is somewhat separated (one or more corridor segments) from the workspace to preserve privacy. Since privacy was rated unsatisfactory across all four of our study sites, a lack of perceived privacy appears to be a major problem. Our analysis does indicate that in locations with high connectivity, privacy will be low; but we also found that with low connectivity many workers were also not satisfied with privacy. It suggests there are other strong variables, potentially including other types of spatial variables (visibility control, for example), affecting workers' perceptions of privacy.

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Appendix: Calculation of Inter-cluster Correlation

Clustering poses difficulties for statistical inference in the general linear model. In this case the Inter-cluster correlation (ICC) is calculated as follows:

$$ICC = \frac{MS_{treatment} - MS_{error}}{MS_{treatment} + (\tilde{n} - 1)\, MS_{error}}$$

For unequal group sizes such as in this case, n is replaced by

$\tilde{n} = M_n - [sd^2 (n_j)/gM_n)]$, where M_n is the mean number of cases per group, $sd^2 (n_j)$ is the variance of the number of cases per group, and g is the number of groups.

In this case, our treatments are the different buildings that is

$MS_{treatment} = MS_{building}$

N for Philadelphia-1 Building = 82; N for Philadelphia-2 Building = 123;

N for Atlanta Building = 65; N for St. Louis Courthouse = 52.

$\Sigma N_i = 82 + 123 + 65 + 52 = 322$

$\Sigma N_i^2 = (82)^2 + (123)^2 + (65)^2 + (52)^2 = 28782$

In this case,

$$\tilde{n} = \frac{1}{k - 1} \left(\Sigma N_i - \frac{\Sigma N_i^2}{\Sigma N_i}\right)$$

$$\tilde{n} = \frac{1}{4 - 1} \left(322 - \frac{28782}{322}\right)$$

$$\tilde{n} = \frac{1}{3} (232{,}625)$$

$\tilde{n} = 77{,}54$

Based on tests of between-subjects effects [iii] in all the four case buildings, we find that:

Mean Square of the effect of treatment/buildings =

$MS_{treatment} = MS_{building} = ,772$

Mean Squared Error = $MS_{error} = ,439$

So,

$$ICC = \frac{MS_{treatment} - MS_{error}}{MS_{treatment} + (\tilde{n} - 1)\, MS_{error}}$$

$$ICC = \frac{,772 - ,439}{,772 + (77{,}54 - 1)\, ,439}$$

$ICC = ,0097 < < < ,01$

This low value of ICC ensures that the total sample of 329 respondents from the four GSA work locations is not characterized by inter-cluster correlations within each group. This result indicates that the four samples can be combined into one large sample set of 329 respondents for our path analyses.

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ii. Spatialist is a computer-based analysis program developed at Georgia Tech by Peponis, Wineman and others, and licensed through the Georgia Tech Research Corporation (see Peponis et al. 1998a, 1998b, 1997).

iii.

Tests of Between-Subjects Effects

Dependent Variable: Job Satisfaction

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	2148.471	1	2148.471	2858.451	.000
	Error	2.425	3.226	.752[a]		
building	Hypothesis	2.316	3	.772	1.757	.155
	Error	139.677	318	.439[b]		

a. .939 MS(building) + .061 MS(Error)

b. MS(Error)