506

The effects of visual privacy on work-process interactions in open-plan offices

A computational approach to measure interaction, generic and targeted visibility

GIZEM YENEL GULER & HALIME DEMIRKAN

BILKENT UNIVERSITY, ANKARA, TURKEY

ABSTRACT

Office design has transformed since the 20th century; however, the most notable change was the introduction of open-plan offices into workplace design. This study explores privacy and interaction in open-plan offices and it uses a computational approach to analyze the effects of visual privacy on work-process interactions in open-plan offices in order to fill this gap in research. This study also aims to discover how generic and targeted visibility affect work-process interactions. The study is conducted with designers who work in an architectural firm. Quantitative research techniques are used through space syntax methodology. Quantitative data were collected through the survey, linear integration map, generic visibility analysis, and targeted visibility analysis. In order to analyze generic visibility and linear integration, DepthMapX software is used as an instrument. Then, targeted visibility is analyzed after developing a new script for DepthMapX software, and written codes in Python are used as an instrument. Following the quantitative data collection, outputs of generic visibility and targeted visibility are compared with the linear integration map and the survey in order to understand how targeted visibility and generic visibility affect work-process interactions in open-plan offices. According to regression analyses, there is a positive moderate association between visual integration and work process interaction and a negligible association between targeted visibility ratio and work process interaction. This study indicates that generic visibility is more correlated with the work-process interaction in the open-plan offices compared to targeted visibility.

KEYWORDS

Open-plan offices, Visual privacy, Work-process interaction, Generic visibility, Targeted visibility

1 INTRODUCTION

The design of more creative and cost-efficient workspaces has become significant in the 21st century. Since open-plan offices were introduced into workplace design in the 1950s by Eberhard and Wolfgang Schennel (Oldham and Brass, 1979; Pierette et al., 2015), they were widely preferred because of increasing interaction and communication among employees with the elimination of interior walls (Pierette et al., 2015). However, integrated spaces in open-plan offices caused the invasion of visual privacy of employees. According to Sundstrom et al. (1980), architectural privacy "refers to the visual and acoustic isolation supplied by environment" (p.102) and is highly correlated with psychological privacy. Therefore, insufficient architectural privacy in consequence of interaction, noise or distraction negatively affects the environmental perceptions of employees. Moreover, Hernes et al. (2006) stated that spatial settings in offices affect the efficiency of work activities and interactions among employees. Therefore, the lack of visual privacy overshadows the main advantage of providing interaction among employees in open-plan offices. The possible impact of visual privacy on employee interactions remains an uncertain issue in open-plan offices. Thus, this study aims to fill this gap by deeply analyzing the association between visual privacy and employee interactions through space syntax methodology.

2 WORK ENVIRONMENTS

The existing literature on work environments with a focus on open-plan offices, was reviewed in terms of visual privacy and work-process interaction.

2.1 Open-plan Offices

The underlying reason of the open-plan office design is to create workspaces that are divided by furniture or partitions instead of walls (Pile, 1978). According to Hedge (1982), partitions were frequently used in order to divide the wide open-plan offices into smaller workspaces. Moreover, it is asserted that open-plan offices consist of individual workspaces in a large open space (Smith Jackson and Klein, 2009). These integrated workspaces were found to have both advantages and disadvantages in terms of the employees' perception of their workspace.

Open-plan offices have some positive effects on employees because of integrated spaces, such as communication, interaction, collaboration, flexibility, cost-saving, and creativity. The elimination of walls and high partitions in open-plan offices causes an increase in communication and interaction levels among employees (Kupritz, 2003). In other words, open-plan offices provide higher collaboration and teamwork opportunities for employees (Ding, 2008; Yekanialibeiglou et al., 2021). Besides increased communication resulted in more knowledge sharing among employees in open-plan offices (Boutellier et al., 2008). Also, the decreased number of walls in open-plan offices provides more flexible workspaces where employees could easily modify their furniture layout according to their daily needs at work (Yıldırım et al., 2019). Moreover, these

flexible workspaces enable employees to be more creative at work. In addition to flexibility, the elimination of walls causes employees to occupy fewer square meters (Brennan et al., 2002). Therefore, according to Hedge (1982), rental costs are reduced because of open-plan offices. Moreover, open-plan offices also increased employees' creativity as a result of flexible interior workplaces (Yekanialibeiglou et al., 2021).

On the other hand, open-plan offices have some negative effects on employees because of uncertain divisions, such as lack of visual and acoustical privacy, high noise, uncertainty about the possession of space, increased cognitive workload, dissatisfaction with workspaces, and decrease in work performance. Also, Block and Stokes (1989) stated that insufficient visual and acoustical privacy and high distraction have a negative impact on employees' perceptions of open-plan offices. Therefore, employees develop territorial behaviors in order to control their workspaces (Ayoko and Härtel, 2003; Kimmons and Austin, 2012). Moreover, according to De Croon et al. (2005), cognitive workload increases in open-plan offices. Therefore, employees are dissatisfied with their workspaces (Kim and de Dear, 2013). As a result of dissatisfaction, employees' work performance decreases in open-plan offices (Haapakangas et al., 2018). All these disadvantages are inevitable outcomes of the insufficient privacy in open-plan offices.

2.2 Privacy in Open-plan Offices

"Privacy is selective control of access to the self or to one's group" (Altman, 1975, p. 18). According to Meinel et al. (2017), privacy is the probability of being isolated from the existence or view of others. Grounded on this, people try to maintain social contact at optimum levels because too little social contact causes the feeling of isolation and too much social contact causes the feeling of crowding (Sundstrom, 1978). Privacy could be described in two approaches as, architectural and psychological privacy. Architectural privacy refers to visual and acoustical isolation in an environment. For example, conventional offices are architecturally more private than open-plan offices because workspaces in conventional offices are separated with walls that provide visual and acoustical isolation. However, psychological privacy is a state of feeling that occurs as a result of architectural privacy (Altman, 1975). That employees develop territorial behaviors in open-plan offices shows that architectural privacy may affect psychological privacy (Sundstrom et al., 1980),

Architectural privacy is also divided into two as visual and acoustical privacy. Visual privacy is experienced when the degree of closure decreases in spaces. As a result, occupants feel that they lose control over their personal spaces (Brand and Smith, 2005). Inadequate visual privacy in open-plan offices causes employees to be dissatisfied with their workspaces and employees' performance to decrease (Maher and von Hippel, 2005). In order to examine the relationship between visual privacy and employee satisfaction, Ding (2008) conducted a study that confirms the findings of Maher and von Hippel (2005). In Ding's study (2008), employees in open-plan offices stated that they feel unsatisfied with their open workspaces, and they prefer to change their workspaces when they feel insufficient visual privacy in their workspaces. Moreover, according to Haapakangas et al. (2008),

employees' dissatisfaction because of inadequate visual privacy in open-plan offices causes decreased productivity and concentration.

Also, acoustical privacy is an incapability to hear conversations (Lee and Jeon, 2014). Lack of acoustical privacy also has a negative effect on employees and employees' satisfaction in open-plan offices. According to Ding's study (2008), employees prefer to hold private phone calls and conversations without their colleagues hearing. As mentioned above, employees also prefer to change their workspaces when they need acoustical privacy in the open-plan office (Ding, 2008).

According to studies mentioned previously, privacy is a significantly essential factor in open-plan offices for employees' satisfaction, productivity, and well-being. Moreover, the lack of privacy also reduces the main advantage of providing interaction among employees in open-plan offices.

2.3 Interactions in Open-plan Offices

Implementing and exchanging ideas are necessary work activities in work environments, and employees need to interact with their colleagues in order to transfer their ideas, communicate and share knowledge (Baer, 2012; Peponis et al., 2007). Therefore, an increased interaction among employees provides some benefits to employees and develops the work processes in offices. Employees become more productive if they help others and interact with their colleagues (Whiting et al., 2008). In addition, according to Koys (2001), increased productivity and motivation of an employee means more productive teams. Interaction with colleagues also boosts employees' motivation and improves their mental well-being (Dimotakis et al., 2011).

Interactions in office environments are described in two groups, as social and work-process interactions (Peponis et al., 2007). Social interactions depend on personal choices; therefore, they are optional. On the other hand, work-process interactions are more obligatory and necessary. According to Peponis et al. (2007), work-process interactions are classified under four different headings according to their purposes; interactions for improvement, expert advice, innovation, and decision making. Interactions are also divided into two, namely as planned and unplanned interactions. Planned interactions are scheduled before the communication starts. Scheduled meetings in meeting rooms or employee' workplaces are examples of planned interactions (Peponis et al., 2007). However, unplanned interactions occur spontaneously in work environments and take place everywhere inside the office (Hillier and Hanson, 1984). These interactions are related to both work-processes or personal choices.

Two different interaction models were introduced into workplace design; the flow model and the serendipitous model (Peponis et al., 2007). According to the flow model, interaction increases when offices are arranged according to the flow of information. This model supports the idea that employees who interact more for work-process interactions have to sit close to each other (Peponis et al., 2007). This model becomes problematical when some employees interact with too

many colleagues. On the other hand, according to the serendipitous model, gathering areas in offices such as cafes and informal meeting spaces increase interactions among employees in open-plan offices (Peponis et al., 2007). Therefore, this model supports the design of these kinds of spaces that encourage interactions among colleagues in offices.

As mentioned above, the lack of privacy is the main drawback of open-plan offices, and it overshadows the foremost advantage of open-plan offices, interaction. Therefore, this study investigates the possible effects of privacy on employees' work-process interactions in open-plan offices through space syntax methodology.

3 SPACE SYNTAX METHODOLOGY

Hillier and Hanson developed space syntax methodology at the University College of London in the late 1970s to early 1980s. Space syntax methodology analyzes spatial configurations (Aknar and Atun, 2017). According to the space syntax methodology, spatial properties of spaces affect and define the social patterns in the built environment (Hillier, 2007). According to Hillier and Hanson (1984), sociological rules may be derived from the spatial properties of buildings and cities. In order to understand social properties and perform spatial network analyses, DepthMapX software was developed (Turner, 2001).

Space syntax methodology analyzes the directional changes in investigated spaces using connectivity and visual integration measures. "Connectivity measures the number of spaces immediately connecting a space of origin" (Hillier and Hanson, 1984, p. 103). On the other hand, visual integration measures the visual distance between different spaces (Hillier, 2007).

This study uses the visibility analysis to measure visual privacy in open-plan offices. Visibility in spaces is categorized as generic visibility and targeted visibility. Generic visibility analysis concentrates on all visible parts of a space from each location in a setting (Lu et al., 2009). In other words, visual integration and connectivity levels are measured for all areas in a setting. However, targeted visibility analysis deals with specific visual targets and which visual targets are visible from each location in a setting (Lu et al., 2009). Not each workspace in the open-plan offices has the same visual field, so determining the number of visible employees for each workspace becomes necessary to evaluate work-process interactions. According to Sailer et al. (2021), if employees see higher number of desks in their workplaces, they start to avoid sharing information with their colleagues. In other words, seeing higher number of desks negatively affects work-process interactions in open-plan offices. Therefore, partial visibility analyses are conducted using isovists in addition to generic visibility analysis.

Work-process interactions are analyzed through a linear integration map for this study. In order to link all workspaces, the shortest and the longest lines are drawn by passing all circulation areas (Peponis et al., 2007). Connectivity levels are calculated according to the total number of

intersections with other lines on the plan (Figure 1). More intersections mean more interaction patterns for the selected space (Peponis et al., 2007).

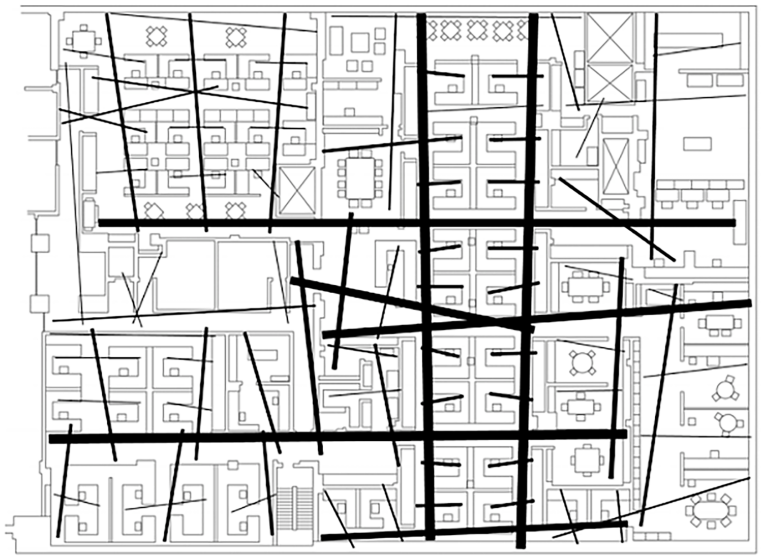

Figure 1. Linear integration map of ThoughtForm Company (*Source: Peponis et al., 2007, p. 830).*

4 RESEARCH QUESTIONS

Most recent studies on privacy in open-plan offices concentrate only on generic visibility, not on the visibility of specific visual targets. Privacy studies containing both generic visibility and targeted visibility analysis in various environments are limited (Lu, 2010; Lu et al., 2009; Lu and Seo, 2015; Lu and Zimring, 2012). Also, most privacy studies evaluate privacy and interactions through surveys and do not use computational methods. Therefore, this study is designed to answer the following research questions:

1. How does visual privacy affect work-process interactions in open-plan offices?
2. How do generic visibility and targeted visibility affect work-process interaction patterns in open-plan offices?

5 DATASETS AND METHODS

5.1 Participants

The study was conducted with the employees who work in an architectural company in Ankara, Turkey. Participants' workstations were located in the open-plan part of the office and assigned to employees by their administrators who are working in their private offices. Therefore, all participants in this study are non-administrative employees at the same hierarchical level. They mostly work individually at their assigned desks and they go to other colleagues' desks when they need to interact for work-processes. Moreover, participants' desks are not visually

connected with administrators' private offices. All participants were seated workers facing their computers, and according to this position of employees, visibility analyses were conducted. There were 15 participants, and the age range was 22-49 years. The mean age for the participants was 29.27 years (std. dev. 7.27). There were eleven females (73.3%) and four (26.7%) males. Twelve (80%) participants were architects, two (13.3%) were drafting technicians, and one (6.7%) was an interior architect. Participation was on a voluntary basis during the Covid-19 pandemic, and the personal information of participants was kept confidential.

5.2 Procedure

In order to answer research questions, first, surveys on work-process interactions are distributed to participants. Second, generic visibility is analyzed through DepthMapX software. Then, a new script for DepthMap software is developed and used to analyze targeted visibility. Following data collection, the outputs of visibility analyses are compared with the survey findings in order to understand how generic visibility and targeted visibility affect work-process interactions in open-plan offices.

5.3 Instruments

Interaction patterns in open-plan offices were derived through a survey. For the first part of the survey, employees are asked to indicate the number of their workspaces on the distributed plan of the open-plan office. Then, they were asked to indicate the desk number of their colleagues with whom they interact the most for work-processes. For the second part of the survey, participants were asked to describe the interaction characteristics that they mentioned in the first part of the survey. The duration, interaction types, and aim of interactions were obtained through the survey on work-process interactions. Obtained results were transferred into DepthMapX in order to create a linear integration map.

DepthMapX software was used to analyze generic and targeted visibility. Visual integration tool was used to determine the visual privacy levels through DepthMapX in the open-plan office. Following the generic visibility analysis, in order to evaluate targeted visibility, a new script was developed for DepthMapX. Codes were written in Python. Targeted visibility ratios for each workplace in the open-plan office were calculated individually with the new script. First, partial isovist analyses are conducted individually for each workplace in the open-plan office. Isovists are calculated while employees are facing their computers, and isovists in binocular vision limit (120 degrees) are taken into consideration (Diffrient et al., 1981). Then, the total number of grids in the pre-defined partial isovist field is calculated using the default grid size. Last, the number of visible employees for the defined isovist area is determined. Targeted visibility ratios of each workplace were calculated by the ratio of visible employees in the isovist area to the number of grids in that area through DepthMapX.

6 RESULTS

6.1 Work-process Interaction Diagram

Interaction patterns were defined through a linear integration map. First, main circulation roads were drawn. Second, workspaces that participants indicated were connected by drawing lines. A map that represents the work-process interaction in the selected open-plan office was obtained (Figure 2). Thicker lines indicated higher integrations that determine the interaction density in a setting (Grajewski, 1993).

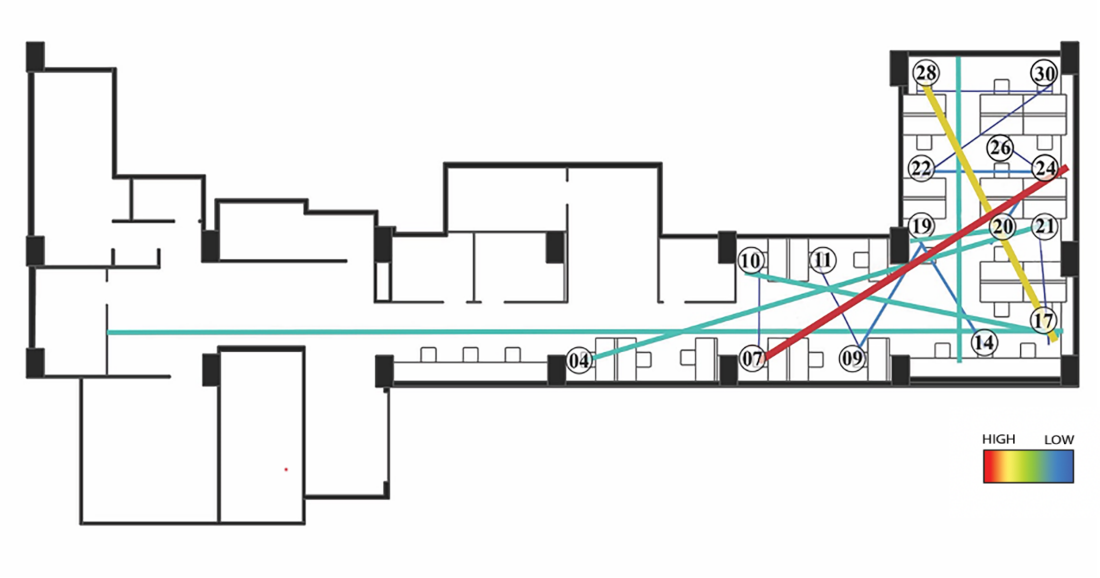

Figure 2. Work-process interaction diagram of the open-plan office.

In addition to the work-process interaction map, as shown in Table 1, connectivity and visual integration levels were obtained as numbers. Connectivity levels representing the total numbers of other lines intersected by each line were gathered for regression analyses and transferred to SPSS for regression tests.

Table 1. Obtained integration and connectivity levels through linear integration map of the workspaces.

Workspace Number I	Workspace Number II	Integration	Connectivity
4	21	4.878401	10
7	24	9.756802	13
9	19	2.660946	7
10	07	2.090743	4
11	09	2.25157	5
14	19	3.252267	7
17	10	4.878401	10
19	20	2.927041	6
20	24	2.660946	5
21	17	2.251570	4
22	30	1.951360	4
24	22	2.927041	6
26	24	1.951360	3
28	17	5.854081	11
30	28	1.721789	3

Also, characteristics of the interaction that they indicated on the survey were obtained through the survey on work-process interactions (Table 2).

Table 2. Work-process interaction characteristics in the open-plan office (n=15).

	Frequency	Percentage
Duration of the indicated interaction (minutes)		
0-10	6	40
11-20	7	46.7
21-3	2	13.3
The number of employees who take place in the indicated interaction		
Three or fewer employees	9	60
More than three employees	6	40
Organizing before the interaction		
Planned	3	20
Unplanned	12	80
The types of the interaction		
Work-process interaction	8	53.3
Social interaction	0	0
Both	7	46.7
The main reason to interact		
Expert advice	0	0
Improvement	11	73.3
Decision making	4	26.7
Innovation	0	0
The team of the employee who is interacted		
Same team	14	93.3
Different team	1	6.7

According to the answers of the survey, the duration of the indicated interaction is mainly between 11-20 minutes (n=7, 46.7%). The majority of employees indicated that their interactions were with three or less than three employees (n=9, 60%). Indicated interactions were mostly unplanned interactions (n=12, 80%). Participants commonly stated that they interact with other employees of the office related to work-processes (n=8, 53.3%), and the main aim of these interactions was an improvement (n=11, 73.3 %). Lastly, most employees from the same team interacted with each other (n=14, 93.3%).

6.2 Generic Visibility Analysis Findings

Visual integration HH (stands for Hillier and Hanson) levels were obtained to determine visual privacy levels in the open-plan office. As a result of generic visibility analysis, maps of color spectrum that describes visual integration visually were obtained. While the red parts on the map demonstrate higher visual integration values, the blue ones demonstrate lower. According to color evaluations on the map (Figure 3), employees at desks 21, 22, 24, 28, and 30 have the lowest visual integration values, while employees at desks 14 and 17 have the highest visual integration levels in the open-plan office.

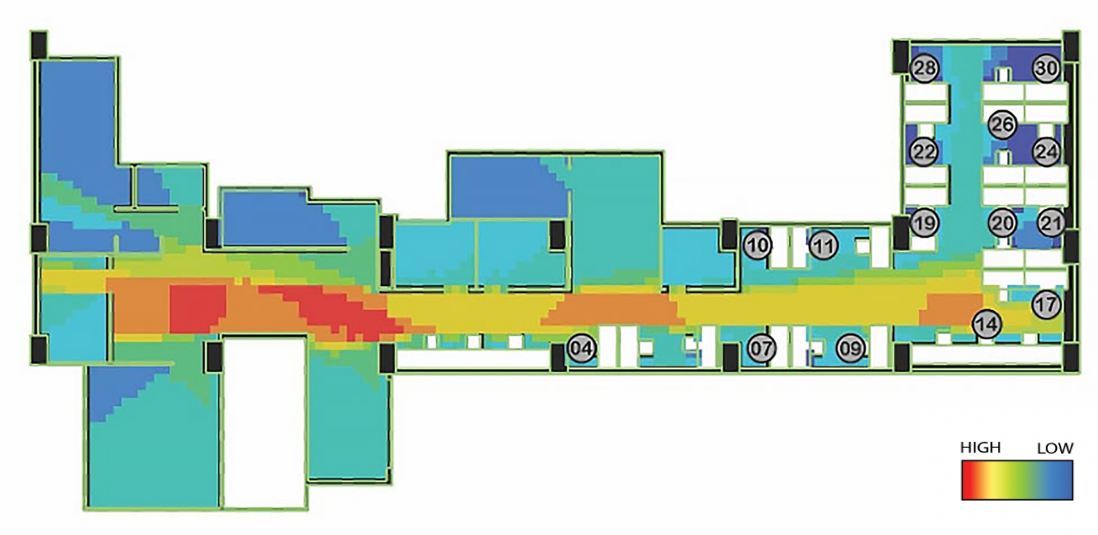

Figure 3. Generic visibility analysis for visual integration of the open-plan office.

Visual integration levels were obtained as tables, besides maps of color spectrum (Table 3). Numerical values provide more accurate results, and confirm the results of the maps of color spectrum. Desk 14 (Visual Integration HH:9.002390) and desk 17 (Visual Integration HH=8.617596) have the highest visual integration levels in the selected open-plan office. Therefore, they have the lowest visual privacy levels in the office. Desks 28 (Visual Integration HH:3.356725) and desk 30 (Visual Integration HH: 3.353262) have the lowest visual integration

levels. Therefore, they have the highest visual privacy in the office. These values were also transferred into the SPSS for regression analyses.

Table 3. Obtained Visual Integration HH and Connectivity levels of the workspaces by DepthMapX.

Workspace Number	Visual Integration HH	Connectivity
4	5.590693	288.000000
7	5.126730	78.00000
9	4.898833	173.000000
10	4.769467	46.000000
11	5.111616	181.000000
14	9.002390	551.000000
17	8.617596	548.000000
19	4.261989	65.000000
20	5.203662	212.000000
21	3.455281	52.000000
22	3.382042	75.000000
24	3.364977	51.000000
26	3.378527	73.000000
28	3.356725	70.000000
30	3.353262	63.000000

6.3 Targeted Visibility Analysis

The employees that were visible from each workplace in the selected open-plan office was obtained through targeted visibility analysis. Unlike generic visibility analysis, targeted visibility analysis was carried out individually. Targeted visibility ratios of 15 workspaces and the total number of employees from these workspaces were obtained (Table 4).

Table 4. Obtained targeted visibility ratios and the number of visible agents of the workspaces.

Workspace Number	Targeted Visibility Ratio	Visible Agents
4	36.664	18
7	27.558	22
9	28.014	20
10	31.742	17
11	30.691	7
14	0	0
17	23.633	24
19	22.468	16
20	23.942	17
21	23.088	16
22	27.132	17
24	30.952	19
26	20.71	9
28	26.892	25
30	28.929	25

According to the results of targeted visibility analysis, desks 4 and 10 have the highest targeted visibility ratios, respectively. Therefore, employees at desks 4 and 10 are more likely to see other employees in the open-plan office. On the other hand, employees at desks 14 and 26 have the lowest targeted visibility ratios, respectively. These targeted visibility ratios of 15 employees were also transferred to the SPSS for regression analyses.

6.4 Regression Analyses

According to regression analysis between visual integration and work-process interaction levels, there is a positive moderate association between visual integration and work-process interaction (β=0.39, SE=0.44, p<0.149). In other words, work-process interactions increase if visual integration increases, as represented in the scatter plot diagram (Figure 4). An increase in visual integration level of 1 percent is correlated with an increase of 0.68 work-process interaction. On the other hand, visual integration and visual privacy are inversely correlated. Therefore, there is a negative relationship between visual privacy and work-process interactions.

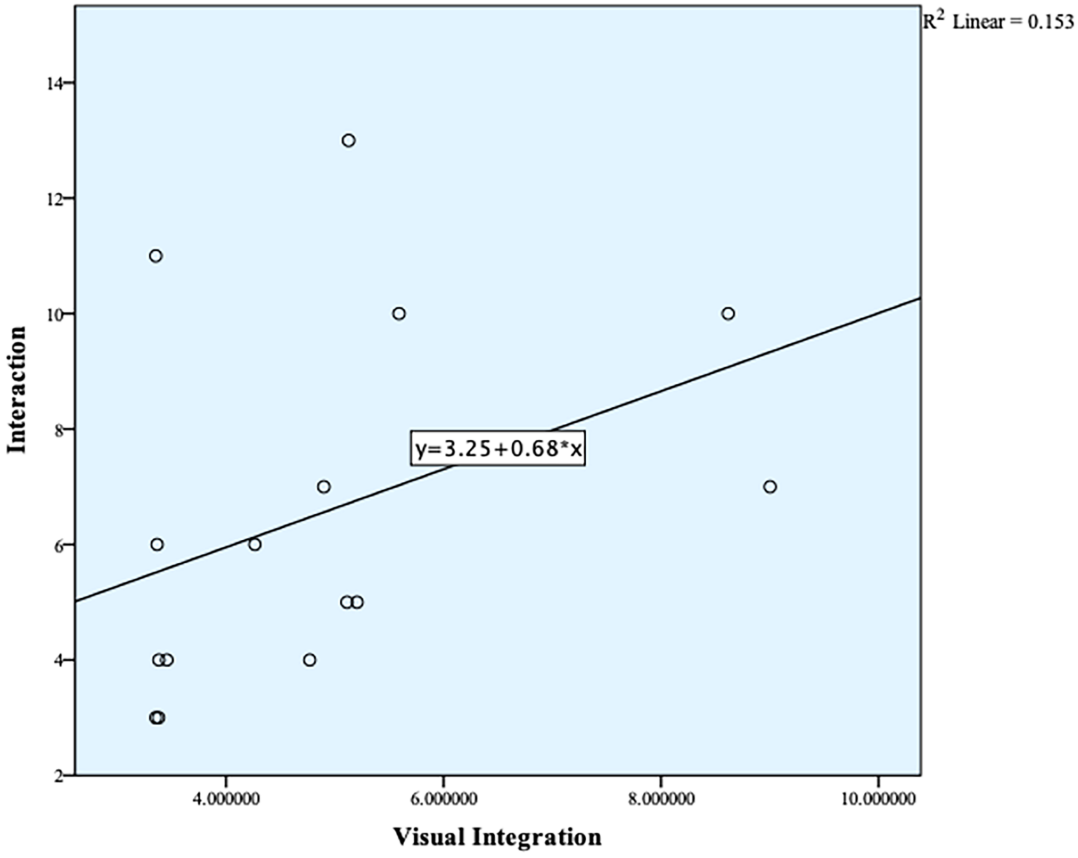

Figure 4. Scatter plot diagram with regression line.

According to regression analysis between targeted visibility ratios and work-process interactions, there is a negligible association between the targeted visibility ratio and work-process interaction (β=0.07, SE=0.11,p<0.803). In other words, work-process interactions increase if targeted visibility ratios increase, as represented in the scatter plot diagram (Figure 5). An increase in targeted visibility ratio of 1 percent is correlated with an increase of 0.03 work-process interaction.

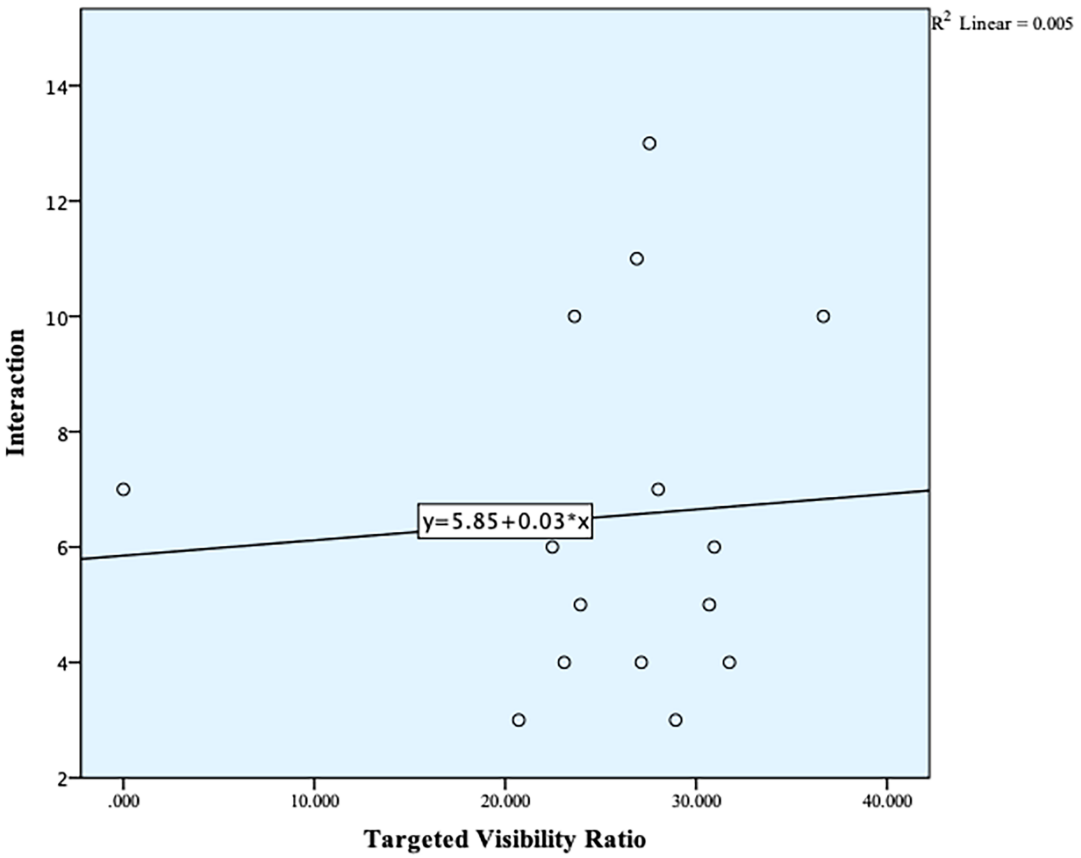

Figure 5. Scatter plot diagram with regression line.

7 CONCLUSIONS

Generic visibility, targeted visibility, and interaction levels were analyzed through space syntax methodology using DepthmapX to understand how generic visibility analysis and targeted visibility analysis affect work-process interactions in open-plan offices. According to regression analyses, there is a positive moderate association between visual integration and work process interaction and a negligible association between targeted visibility ratio and work process interaction. Therefore, this study indicates that generic visibility is more correlated to the work-process interactions in the open-plan offices compared to targeted visibility. In other words, calculating all visible areas from a specific point is more determinant than calculating the

visibility of specific targets to estimate interactions in open-plan offices. Also, there is a negative correlation between visual privacy and work-process interaction as both visual privacy indicators, generic visibility, and targeted visibility, are positively correlated interaction levels. Therefore, increased visual privacy results in decreased interaction among employees in open-plan offices.

This paper has some limitations; mainly inferences were drawn from a single case due to the Covid-19 pandemic. Further research might repeat the study with other cases to generalize the outcomes of this study. Repeating the analysis with different cases will provide additional information to our understanding of the effects of visual privacy on work-process interaction in offices. Another limitation of the study is the size of the selected open-plan office. The setting of the study is a small-sized open-plan office. In a further study, the effects of generic visibility and targeted visibility on work-process interactions could be studied in medium-sized or large-sized open-plan offices. Also, offices different from the architecture firms could be studied to understand if various occupations have different needs for interaction and privacy.

REFERENCES

Aknar, M. and Atun, R. A. (2017). 'Predicting movement in architectural space', *Architectural Science Review,* 60(1), 78–95. doi: 10.1080/00038628.2016.1254594

Altman, I. (1975). *The environment and social behavior: Privacy, personal space, territory and crowding.* Monterey, CA: Brooks/Cole Publishing Company.

Ayoko, O.B. and Härtel, C.J.J. (2003). 'The role of space as both a conflict trigger and a conflict control mechanism in culturally heterogeneous workgroups', *Applied Psychology: An International Review*, 52(3), 383-412. doi: 10.1111/1464-0597.00141

Baer, M. (2012). 'Putting creativity to work: The implementation of creative ideas in organizations', *Academy of Management Journal,* 55, 1102–1119. doi: 10.5465/amj.2009.0470

Block, L.K. and Stokes, G.S. (1989). 'Performance and satisfaction in private versus nonprivate work settings', *Environment and Behavior*, 21(3), 277-297. doi: 10.1177/0013916589213003

Boutellier, R., Ullman, F., Schreiber, J. and Naef, R. (2008). 'Impact of office layout on communication in a science-driven business', *R&D Management*, 38(4), 372-391. doi: 10.1111/j.1467-9310.2008.00524.x

Brand, J. L. and Smith, T. J. (2005). 'Effects of reducing enclosure on perceptions of occupancy quality, job satisfaction, and job performance in open-plan offices', *In Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting*, 49, 818-822. doi: 10.1177/154193120504900806

Brennan, A., Chugh, J.S. and Kline, T. (2002). 'Traditional versus open office design: A longitudinal field study.', *Environment and Behavior*, 34(3), 279-299. doi: 10.1177/0013916502034003001

De Croon, E., Sluiter, J., Kuijer, P.P. and Frings-Dresen, M. (2005). 'The effect of office concepts on worker health and performance: A systematic review of the literature', *Ergonomics,* 48(2), 119-134. doi: 10.1080/00140130512331319409

Diffrient, N., Tilley, A.R., and Harman D. (1981). *Humanscale 1/2/3*. MIT Press.

Dimotakis, N., Scott, B., and Koopman, J. (2011). 'An experience sampling investigation of workplace interactions, affective states, and employee well-being', *Journal of Organizational Behavior*, 32(4), 572-588. doi: 10.1002/job.722.

Ding, S. (2008). 'Users' privacy preferences in open plan offices', *Facilities,* 26(9/10), 401-417. doi: 10.1108/02632770810885751

Grajewski, T. (1993). 'The SAS head office – spatial configuration and interaction patterns', *Nordic Journal of Architectural Research, 2*, 63-74.

Haapakangas, A., Helenius, R., Keekinen, E. and Hongisto, V. (2008). 'Perceived acoustic environment, work performance and well-being – Survey results from Finnish offices', *Proceedings of the 9th International Congress on noise as a public health problem, ICBEN,2008*. Foxwoods, CT.

Haapakangas, A., Hongisto, V., Varjo, J. and Lahtinen, M. (2018). 'Benefits of quiet workspaces in open-plan offices – Evidence from two office relocations', *Journal of Environmental Psychology*, 56, 63–75. doi: 10.1016/j.jenvp.2018.03.003

Hedge, A. (1982). 'The open plan office: A systematic investigation of employee reactions to their work environment', *Environment and Behaviour*, 14, 519-42. doi: 10.1177/0013916582145002

Hernes, T.T., Bakken, P. and Olsen, O. (2006). Spaces as process: Developing a recursive perspective on organisational space. In S. Clegg, & M. Kornberger (Eds.), *Space, Organizations and Management Theory,* (pp. 33-63). Copenhagen: Liber and Copenhagen Business School Press.

Hillier, B. and Hanson, J. (1984). *The social logic of space*. Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511597237

Hillier, B. (2007). *Space is the machine: A configurational theory of architecture*. UK: Press Syndicate of the University of Cambridge.

Kim, J. and de Dear R. (2013). 'Workspace satisfaction: The privacy-communication trade-off in open-plan offices', *Journal of Environmental Psychology,* 36, 18-26. doi: 10.1016/j.jenvp.2013.06.007

Kimmons, J.V. and Austin, T. (2012). 'Territory and privacy in academic workspaces', *In Proceedings of the Fourth Annual General Business Conference*. Huntsville, TX: Sam Houston State University.

Koys, D. J. (2001). 'The effects of employee satisfaction, organizational citizenship behavior, and turnover on organizational effectiveness: A unit-level, longitudinal study', *Personnel Psychology,* 54, 101–114. 10.1111/j.1744-6570.2001.tb00087.x

Kupritz, V. W. (2003). 'Accommodating privacy to facilitate new ways of working', *Journal of Architectural and Planning Research, 20*(2), 122-135.

Lee, P.J. and Jeon, J.Y. (2014). 'A laboratory study for assessing speech privacy in a simulated open-plan office', *Indoor Air,* 24, 307-314. doi: 10.1111/ina.12083

Lu, Y. (2010). 'Measuring the structure of visual fields in nursing units', *Health Environments Research & Design Journal (HERD)*, *3*(2), 48–59. doi: 10.1177/193758671000300205

Lu, Y., Peponis, J. and Zimring, C. (2009). 'Targeted visibility analysis in buildings—correlating targeted visibility analysis with distribution of people and their interactions within an intensive care unit', *Proceedings of the 7th International Space Syntax Symposium.* Stockholm, Sweeden.

Lu, Y. and Seo, H.-B. (2015). 'Developing Visibility Analysis for a Retail Store: A Pilot Study in a Bookstore', *Environment and Planning B: Planning and Design, 42*(1), 95-109. doi: 10.1068/b130016p

Lu, Y. and Zimring, C. (2012). 'Can intensive care staff see their patients? An improved visibility analysis methodology', *Environment and Behavior*, *44*(6), 861–876. doi: 10.1177/0013916511405314

Maher, A. and von Hippel, C. (2005). 'Individual differences in employee reactions to open-plan offices', *Journal of Environmental Psychology*, 25(2), 219-229. doi: 10.1016/j.jenvp.2005.05.002

Meinel, M., Maier, L., Wagner, T.F. and Voigt, K. (2017). 'Designing creativity-enhancing workspaces: A critical look at empirical evidence', *Journal of Technology and Innovation Management*, 1(1), 1-12.

Oldham, G. and Brass, D. (1979). 'Employee reactions to an open plan office: A naturally occurring quasi-experiment', *Administrative Science Quarterly*, 24(2), 267-284.

Peponis, J., Bafna, S., Bajaj, R., Bromberg, J., Congdon, C., Rashid, M., Warmels, S., Zhang, Y. and Zimring, C. (2007). 'Designing space to support knowledge work', *Environment and Behavior, 39,* 815–840. doi: 10.1177/0013916506297216

Pierette, M., Parizet, E., Chevret, P. and Chatillon, J. (2015). 'Noise effect on comfort in open-space offices: Development of an assessment questionnaire', *Ergonomics,* 58(1), 96-106. doi: 10.1080/00140139.2014.961972

Pile, J. F. (1978). *Open office planning: a handbook for interior designers and architects*. New York: Whitney Library of Design.

Sailer, K., Koutsolampros, P. and Pachilova, R. (2021). 'Differential perceptions of teamwork, focused work and perceived productivity as an effect of desk characteristics within a workplace layout', *Plos One*, 16(4). doi: 10.1371/journal.pone.0250058

Smith-Jackson, T.L. and Klein, K.W. (2009). 'Open-plan offices: Task performance and mental workload', *Journal of Environmental Psychology, 29*(2), 279-289. doi: 10.1016/j.jenvp.2008.09.002

Sundstrom, E. (1978). Crowding as a sequential process: Review of research on the effects of density on humans. In A. Baum, & Y. Epstein (Eds). *Human Response to Crowding*. Hillsdale, N.J.: Erlbaum.

Sundstrom, E., Burt, R.E. and Kamp, D. (1980). 'Privacy at work: Architectural correlates of job satisfaction and job performance', *Academy of Management Journal*, 23(1), 101-117.

Sundstrom, E. (1986). *Workplaces: The psychology of the physical environment in offices and factories.* New York: Cambridge University Press.

Turner, A., 2001. 'Depthmap: a program to perform visibility graph analysis', In *Proceedings of the 3rd International Symposium on Space Syntax*, 31, 31-12.

Whiting, S. W., Podsakoff, P. M. and Pierce, J. R. (2008). 'Effects of task performance, helping, voice, and organizational loyalty on performance appraisal ratings', *Journal of Applied Psychology,* 93, 125–139. doi: 10.1037/0021-9010.93.1.125

Yekanialibeiglou, S., Demirkan, H. and Denti, L. (2021). 'Enhancing creativity in activity-based offices: A critical incident study of knowledge workers', *Creativity and Innovation Management*, *30*(4), 763-782. doi: 10.1111/caim.12464

Yıldırım K., Güneş E. and Yilmaz G.P. (2019). 'The effects of workstation partition heights on employees' perceptions in open-plan offices', *Journal of Corporate Real Estate,* 21(2), 148–166. doi: 10.1108/jcre-03-2018-0010