Designing Connected, Collaborative and Creative Workplaces:
ASID headquarters, DC. A comparative before-after field study

In a competitive knowledge work economy, the key engine that keeps organizations growing and innovating is their people. Organizations understand that their primary goal is to enhance the performance of their people, and the important value of the physical environment driving human performance has been increasingly well recognized. ASID headquarters has moved to a new office designed with flexibility and multiple open work spaces through designs and furnishings that eliminate hierarchy. Before moving in spring 2016, the office was in a coworking location renting a suite of shared offices each occupied by two to six employees. Based on the 3C research framework, the before and after field study findings demonstrate changes in employee experiences in indoor environmental quality satisfaction, place attachment, stress, social support, and perceptions of performance.

The 3C research model shown in Figure 1 outlines the research approach adopted and summarizes the concept of the study. *Connectedness* was interpreted as interior attributes in the physical setting contributing to workplace experience; *collaboration* was defined as an experience dimension of employees' daily interactions with each other and the environment in the collaborative setting. As a measure of the workplace's outcome product, *creativity* outcomes were used to understand organizational and individual performance dimensions.

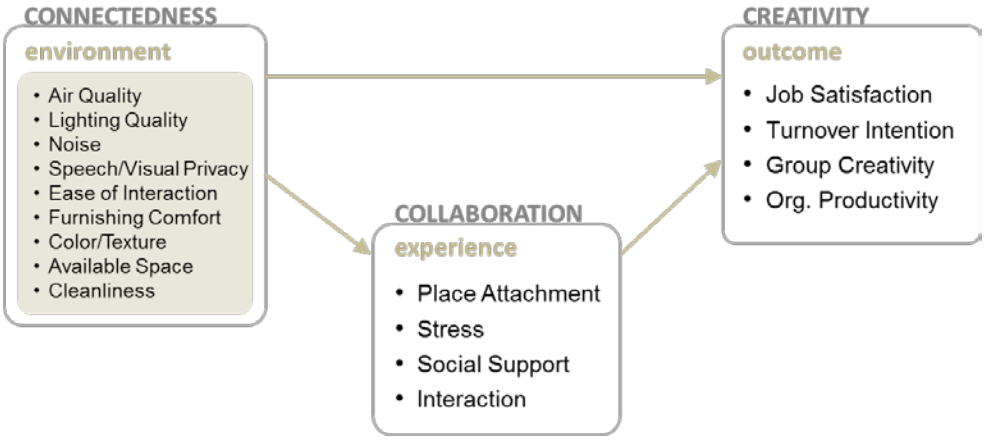


Figure 1. The Research model

A total of 40 employees participated in the study. Thirteen (35%) of the 40 participated in both phases of the study.

Table 1. Participant demographics

		Old office	New office	Total (repeated)	
Age, y	20-29	2	4	6	(0)
	30-39	13	14	27	(16)
	40-49	6	6	12	(8)
	50-59	1	5	6	(1)
	60-	1	1	2	(1)
Gender	Male	7	10	17	(5)
	Female	16	20	36	(8)
	total	23	30	53	(13)

Connectedness:
Perceived Indoor Environmental Quality

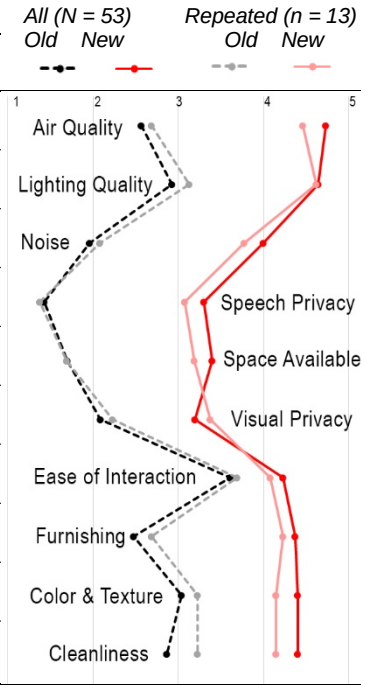
Paired-sample t-tests with the 13 employees participated in both the new and old office studies in addition to independent-sample t-tests (N = 53) were conducted to compare the environmental factor satisfaction ratings in the two office conditions. Whereas paired-sample t-tests specifically look at the 13 participants who experienced the two different office conditions so that the effects of individual tendencies in their responses are controlled, independent-sample t-tests have the advantages in increasing the reliability of the results and probability of finding a significant effect with a larger sample size of 53, of which 13 experienced both offices and 40 experienced either office.

We found significant differences in the satisfaction ratings for each indoor environmental quality (IEQ) factor between the old and the new offices. The results (Table 2) suggest that the new office does have a positive effect on employees' indoor environmental quality satisfaction throughout the measures. The biggest improvement was in air quality, speech privacy, noise, and furnishing.

Four lighting-related items, e.g., amount of light, visual comfort, artificial light, and natural light, are combined for their high correlations (r = .8~.9) with multicollinearity thus represented as Lighting quality scale (Cronbach's α =.96).

Table 2. T-test results: Indoor environmental quality satisfaction

	Independent-sample t-test (N = 53)				*Paired-sample t-test, repeated participants (n = 13)*			
	Old office *M (SD)*	New office *M (SD)*	*t-test*		Old office *M*	New office *M*	*t-test*	
Air quality	2.57 (.99)	4.73(.52)	6.58	****	2.69	4.46	5.47	****
Lighting quality	2.93 (1.18)	4.64 (.47)	9.52	****	3.13	4.62	5.22	***
Noise	1.96 (1.07)	4.00 (.83)	7.60	****	2.08	3.77	4.25	***
Speech privacy	1.43 (.73)	3.30 (.99)	7.91	****	1.38	3.08	5.92	****
Available space	1.70 (1.11)	3.40 (1.01)	5.60	****	1.69	3.19	4.09	***
Visual privacy	2.09 (1.28)	3.20 (.89)	3.57	***	2.23	3.38	3.25	***
Ease of interaction	3.61 (.99)	4.23 (.63)	2.65	*	3.69	4.08	1.24	ns
Furnishing	2.48 (1.24)	4.37 (.61)	6.71	****	2.69	4.23	3.83	***
Color & texture	3.04 (.93)	4.40 (.72)	5.78	****	3.23	4.15	2.98	*
Cleanliness	2.87 (1.10)	4.40 (.81)	5.60	****	3.23	4.15	2.52	*



*p < .05, ** p <.01, *** p < .001, **** p < .0001, ns: not significant.

Gender difference

The sample contains greatly more women than men. The t-tests for two unequal samples found significant differences in satisfaction ratings for ease of interaction and lighting quality between two genders in both office conditions.

Men ($M(SD)_{old}$=4.14 (.38); $M(SD)_{new}$=4.60(.70)) reported significantly higher satisfaction in ease of interaction than women ($M\ (SD)_{old}$=3.36 (.38); $M(SD)_{new}$=4.05(.51)), in the old office $t(20)$=-2.50, p< .05 as well as in the new office $t(14)$=-2.2, p<.05. This was attributed to a strong gender effect among first-time participants in the new office, Men (*M(SD)*=5.00(.00)) were greatly more satisfied with ease of interaction than women (*M(SD)*=4.00(.45)), t(10)=-7.42, p<.0001. Similarly, a significant gender effect was observed in lighting quality in the new office condition among first-time participants, Men (*M(SD)*=4.0(.00)) were significantly more satisfied with lighting quality than women (*M(SD)*=4.48(.56)), t(10)=-.37, p=.01. Once the repeating participants are were included in the analysis, the gender effect was no longer significant.

Collaboration:

Workplace Experience

In this study, quality of workplace experience examined the employees' experience with one another and their workplace and more abstract perception of the physical and social environment, operationalized with place attachment, stress, and perceived social support, and with verbal and behavioral interaction.

To examine the effects of IEQ variables in two office environments on employee experience variables, a series of linear mixed models was used after controlling for unobserved individual heterogeneity in the form of random effects, i.e., effects of the same people participated in two conditions. IEQ variables were entered into the model as fixed effects. The effects of IEQ variables on place attachment, stress, social support perceptions, and behavioral interactions in addition to effects on employee's experience changes before and after the office relocation were tested (Table 4).

The impact of gender, age, and duration of tenure in the organization on the collaboration variables were tested using one-way analysis of variance (ANOVA) and simple regressions, which found no significant effect. However, when further examined, a significant effect was observed for place attachment and social support in the new office condition only among the first-time participants. In the new office condition, first-time participating men (*M(SD)*=4.30(.65)) reported significantly greater place attachment than women (*M(SD)*=3.17(.90), $t(11)$=-2.84*, p=.016. Similarly, only in the new office among first-time participant, men (M(SD)=4.13(.54)) reported significantly greater social support than women (*M(SD)*=3.35(.63), $t(12)$=-2.67*, p=.02.

Place Attachment

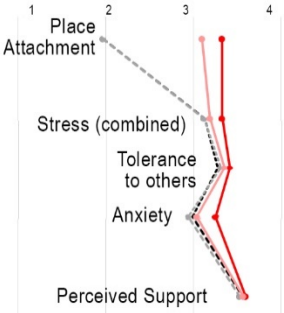
Place attachment is used as a measurable dimension for workplace identity, belongingness, and personal rootedness (Scannell & Gifford, 2010). Four items were used to make the placement scale (Cronbach's α = .94). The assumption was made that positive emotional bonding with a

place, which people may unknowingly experience, is likely to contribute to their well-being. Previous place attachment studies have established the impact of the physical environment on the well-being of the elderly (Tofle, Schwarz, Yoon, & Max-Royale, 2004).

T-test results (Table 3) demonstrate a significant difference in place attachment ratings between the two settings, $t(50)=5.43$, $p<.0001$, with the new office receiving greatly higher place attachment scores ($M(SD)=3.33(.99)$) than the old office ($M(SD)=1.97$ (.77)). Place attachment scores also significantly increased in the new office but to a slightly lesser degree for repeating participants.

Table 3. Comparing the old and new office group mean differences in workplace experience

Variable	Independent-sample t-test (N = 53)			Paired-sample t-test (n = 13)			*All (N = 53) repeated (n = 13)* Old New Old New
	Old office	New office	t-test	Old office	New office	t-test	
Place attachment	1.97(.77)	3.33 (.99)	5.59****	1.97	3.10	3.39**	
Stress	3.13 (.53)	3.33 (.51)	1.36ns	3.12	3.19	.42ns	
Tolerance	3.27 (.69)	3.41 (.38)	.72ns	3.31	3.35	.15ns	
Anxiety	2.99 (.55)	3.25 (.60)	1.63	2.94	3.04	.73	
Perceived support	3.56 (.62)	3.60 (.63)	.24ns	3.53	3.57	.22ns	
Audio volume	.012 (.0025)	.010 (.0029)	2.49*	.0118	.0089	-3.13**	
Body movement	.0077 (.0014)	.0078 (.0011)	.34ns	.0076	.0076	.06ns	
Interact. average	4311.21 (4139.92)	2475.83 (1884.45)	1.81^	4784.84	2179.97	-2.26*	



*p < .05, ** p < .01, *** p < .001, **** p < .0001, ns: not significant.

Table 4 shows the results from a series of linear mixed models for the entire sample while controlling for repeated people's effects. Significant main effects of ease of interaction, noise, lighting quality, speech privacy, visual privacy, and space available on place attachment were observed. In addition, a significant interaction effect of office condition and ease of interaction was observed; that is, representing the improvement in place attachment is due to the improved ease of interaction in the new office. Marginal significance of interaction effects with office setting for visual privacy and color/texture were also observed. Participants rating higher satisfaction in visual privacy and color/texture of the new office tend to have greatly higher place attachment, whereas this was not the case for the old office. This can be interpreted that stronger place attachment in the new office greatly contributed to employees having more appreciation for easier interaction as well as better visual privacy and color/texture in the new office.

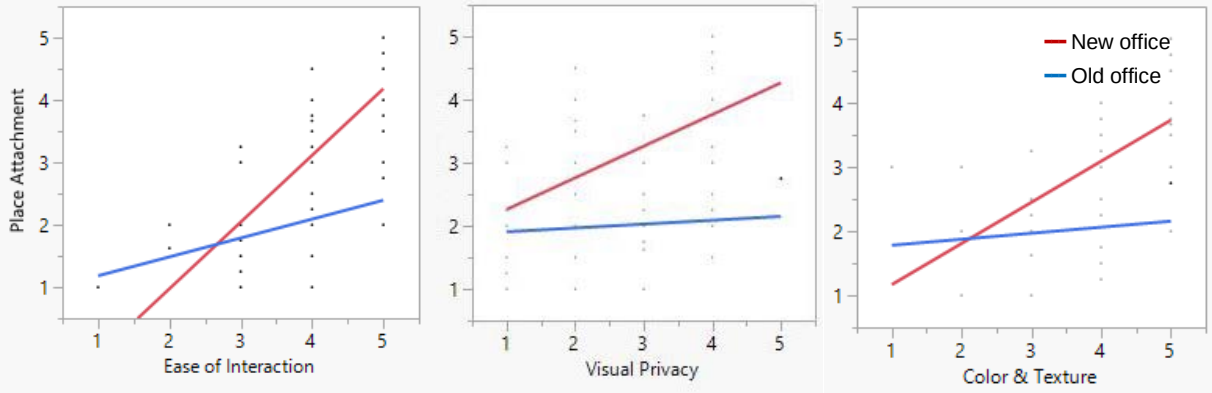


Figure 2. Interaction effects of new/old office setting and IEQ on Place attachment ratings

Table 4. Mixed model results: Effects of new/old office and IEQ on workplace experience after controlling for random effects of participants

Regression Models	Fixed Effects *B (SE)*			
	Intercept	Main effect		Interaction effect
		Old/New office	IEQ	Office × IEQ
DV: Place attachment				
Air quality	1.69 (0.85)*	.49 (.84)	.27 (.19)	-.03 (.19)
Lighting quality	.91 (.88)	-.45 (.88)	.42 (.20)*	.21 (.20)
Noise	1.60 (.46)***	.27 (.45)	.36 (.13)**	.01 (.14)
Speech privacy	1.75 (.36)****	.03 (.36)	.34 (.15)*	.14 (.16)
Available space	1.82 (.33)****	-.07 (.32)	.26 (.12)*	.21 (.12)
Visual privacy	1.77 (.38)****	-.08 (.37)	.30 (.13)*	.22 (.12)^
Ease of interaction	-.22 (.61)	**.47 (.11)*** **	**.71 (.15)**** **	**.39 (.15)****
Furnishing	1.45 (.67)*	-.34 (.67)	.29 (.16)^	.22 (.16)
Color & texture	1.09 (.61)	-.58 (.60)	.37 (.15)*	.27 (.15)^
Cleanliness	1.63 (.52)**	-.11 (.52)	.25 (.14)	.17 (.14)
DV: Stress Tolerance | Anxiety				
Air quality	2.63 (.51)**** 2.88 (.62) | 2.72 (.10)	-.19 (.47) -.19 (.62) | -.09 (.44)	.16 (.12) .12 (.14) | .12 (.12)	.03 (.11) .01 (.14) | .02 (.10)
Lighting quality	2.80 (.54)**** 3.20 (.68) | 2.45 (.48)	-.18 (.53) .22 (.68) | -.63 (.53)	.10 (.12) .05 (.15) | .15 (.13)	.05 (.12) -.05 (.15) | .16 (.12)
Noise	3.05 (.25)**** 3.74 (.34) | 2.44 (.27)	-.20 (.28) .10 (.35) | -.40 (.27)	.03 (.08) -.15 (.10) | .20 (.08)*	.09 (.08) .04 (.10) | .10 (.08)
Speech privacy	2.94 (.21)**** 3.50 (.27) | 2.42 (.21)	-.35 (.21) -.27 (.27) | -.40 (.20)*	.06 (.09) -.15 (.11) | **.25 (.09)****	.16 (.09) .20 (.12) | .12 (.09)
Available space	3.13 (.22)**** 3.31 (.27) | 2.64 (.22)	-.00 (.21) .06 (.26) | -.24 (.21)	.03 (.08) .15 (.11) | .16 (.08)*	.03 (.08) -.07 (.12) | .08 (.07)
Visual privacy	3.19 (.23)**** 3.64 (.28) | 2.72 (.24)	.12 (.22) .29 (.28) | -.09(.20)	.02 (.08) -.10 (.09) | .16 (.08)*	-.01 (.07) -.06 (.09) | .03 (.06)
Ease of interaction	3.07 (.40)**** 3.68 (.53) | 2.40 (.45)	-.36 (.40) .05(.53) | -.38 (.40)	.03 (.10) -.09 (.13) | .18 (.11)	.11 (.10) .01 (.13) | .11 (.10)
Furnishing	2.91 (.40)**** 3.44 (.50) | 2.33 (.38)	-.29 (.40) .17 (.40) | **-.78 (.37)***	.07 (.10) -.02 (.12) | **.18 (.09)^**	.09 (.10) -.02 (.12) | **.21 (.01)***
Color & texture	1.85 (.41)**** 3.30 (.50) | 2.28 (.36)	-.15 (.40) .03 (.12) | -.48 (.31)	.10 (.10) .03 (.13) | .21 (.09)*	.05 (.10) -.09 (.13) | .12 (.08)
Cleanliness	2.98 (.36)**** 3.34 (.42) | 2.64 (.34)	.14 (.33) .26 (.43) | .01 (.28)	.08 (.09) .01 (.11) | .14 (.08)	-.03 (.09) -.06 (.11) | -.00 (.07)

DV: Perceived Support				
Air quality	2.71 (.51)****	-.09 (.44)	.12 (.12)	.92 (.10)
Lighting quality	3.34 (.67)****	-.31 (.66)	.05 (.15)	.08 (.15)
Noise	3.26 (.32)****	.12 (.32)	.13 (.09)	-.98 (.09)
Speech privacy	3.07 (.24)****	-.51 (.22)*	.14 (.08)	.17 (.08)*
Available space	3.68 (.26)****	.24 (.26)	-.12 (.09)	-.03 (.09)
Visual privacy	2.93 (.25)****	-.67 (.23)**	.21 (.08)*	.21 (.08)**
Ease of interaction	2.69 (.45)****	-.02(.07)	.25 (.11)**	.33 (.10)**
Furnishing	3.72 (.48)****	.01 (.48)	-.04 (.12)	.02 (.12)
Color & texture	3.45 (.49)****	.11 (.49)	.04 (.12)	-.03 (.12)
Cleanliness	3.44 (.40)****	-.50 (.37)	.01 (.10)	.14 (.10)
DV: Interaction (sociometer) Body movement, Speech (audio), Interaction combined				
Air quality	.01 (.00)**** .01 (.00)** 4974.96 (2768.94)	.00 (.00) -.00 (.00) -1708.06 (2619.80)	-.00 (.00) .00 (.00) -544.56 (643.22)	-.00 (.00) .00 (.00) 357.99 (612.90)
Lighting quality	.01 (.00)**** .01 (.00)*** 3602.98 (3160.77)	.00 (.00) .00 (.00) -2757.55 (3160.77)	.00 (.00) -.00 (.00) -149.79 (715.49)	.00 (.00) -.00 (.00) 486.24 (684.11)
Noise	.01 (.00)**** .01 (.00)*** 3525.50 (1641.04)*	.00 (.00) -.00 (.00) -670.43 (1611.48)	.00 (.00) .00 (.00) -6.06 (480.09)	.00 (.00) .00 (.00) -101.49 (491.84)
Speech privacy	.01 (.00)**** .01 (.00)*** 2963.09 (1481.62)*	-.00 (.00) -.00 (.00) -46.95 (1465.69)	-.00 (.00) .00 (.00) 426.94 (775.82)	.00 (.00) .00 (.00) -579.36 (784.30)
Available space	.01 (.00)**** .00 (.00)**** 1696.28 (1321.66)	.00 (.00) .00 (.00) -1868.70 (1288.96)	.00 (.00) .00 (.00) 595.78 (458.49)	.00 (.00) .00 (.00) 142.14 (454.54)
Visual privacy	.01 (.00)**** .00 (.00)**** 1742.53 (1315.78)	.00 (.00) .00 (.00) -1646.90 (1270.52)	.00 (.00) .00 (.00) 5494.13 (436.85)	.00 (.00) .00 (.00) 127.76 (418.32)
Ease of interaction	.01 (.00)**** .01 (.00)**** 2413.96 (2640.91)	.00 (.00) -.00 (.00) -2444.97 (2663.19)	-.00 (.00) -.00 (.00) 218.55 (635.58)	-.00(.00) -.00(.00) 352.38 (646.47)
Furnishing	.01 (.00)**** .01 (.00)**** 2233.57 (2459.02)	-.00 (.00) -.00 (.00) -2815.60 (2441.60)	-.00 (.00) -.00 (.00) 212.24 (587.02)	.00(.00) -.00(.00) 464.72 (595.08)
Color & texture	.01 (.00)**** .01 (.00)*** -1451.46 (2162.02)	-.00(.00) -.00 (.00) 2271.87 (2087.98)	.00 (.00) .00 (.00) 1417.63 (549.83)**	.00 (.00) .00 (.00) -1056.37 (535.76)*
Cleanliness	.01 (.00)**** .01 (.00)**** 805.18 (2141.92)	-.00 (.00) -.00 (.00) -1845.961 (2163.12)	.00 (.00) .00 (.00) 672.46 (520.13)	.00 (.00) .00 (.00) 105.48 (531.83)

*p < .05, ** p < .01, *** p < .001, **** p < .0001.

Stress

Stress is the most widely discussed subject in relation to mental health and wellness of employees in the workplace. Stress is higher among knowledge workers due to the nature of knowledge work based on the complexity and high focus. Scientific studies suggest that stress affects the body and mental health, and it wastes the potential energy of knowledge workers (Brown & Leary, 1995; Carson, Bartlett, Brown, & Hopkinson, 1995), directly influencing their performance. Whereas stress is a multidimensional concept and can be affected in many different forms and sources inside and outside the workplace, the physical environment and its characteristics are known to affect stress levels.

This study adopted Burrell's short stress index (Danielsson & Bodin, 2008), then exploratory factor analysis was conducted to identify the two dimensions, one related to tolerance of others (Cronbach's α = .71) and the other related to anxiety (Cronbach's α = .65). In addition to the two dimensions as subscales, the eight items scale of the unidimensional stress scale (Cronbach's α =.73) was also used for analysis.

Table 5. Factor analysis for stress scale

	Factor 1 Tolerance	Factor 2 Anxiety
I get easily frustrated with people who are slow	.649	.316
I hate standing in line	.635	.139
I get frustrated with drivers easily	.587	.142
I get frustrated with people who are fumbling and sloppy	.478	.122
I can find myself hurrying, even when I have plenty of time	.238	.606
	.090	.538
I eat quickly and I am usually done first	.124	.515
I am at a high speed and I push myself hard	.189	.503
People tell me slow down and take it easy		

As expected, there was no significant difference observed in stress levels in the two conditions (Table 3). A linear mixed model results indicate significant main effects of speech privacy ($p < .01$), noise, visual privacy, available space, and color/texture ($p < .05$) on the anxiety dimension of stress (Table 4). A significant interaction effect of office condition and furniture/furnishing was observed, suggesting that the anxiety level change between the two conditions is attributed to higher satisfaction with the comfort of the office furnishing (e.g., chair, desk, computer, equipment) in the new office. Interestingly, anxiety level ratings are significantly higher in the new office than the old office, contributing to more satisfying IEQ especially for furnishing.

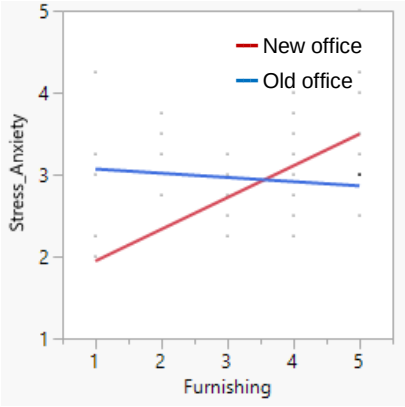


Figure 3. Interaction effects of new/old office and furnishing on Stress/Anxiety

Effects of gender, age, and duration of tenure in the organization were examined using t-test and simple linear regression. The only measure approaching to a significant level was gender on the tolerance subscale of stress, $t(50) = 7.76$, $p = .08$. A t-test result showed that men ($M = 3.12$, $SD = .86$) tend to be more tolerant of other people than women ($M = 3.47$, $SD = .56$).

Perceived Social Support

The assumption that well-designed office environments would promote positive social behaviors and support among employees was tested. Perceived social support was measured with eight items (Cronbach's α = .82) on social attachment and perceptions of fellow/supervisor support in the company.

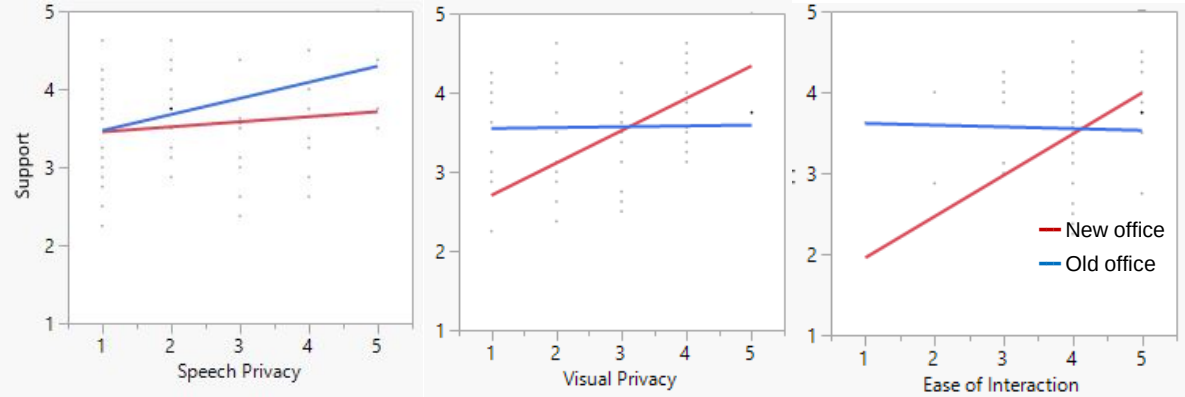


Figure 4. Interaction effects of new/old office setting and IEQ on perceived social support

As shown in Table 3, there was no significant difference in perceived social support ratings in the two conditions. Linear mixed model results show significant effects of visual privacy and ease of interaction ($p < .01$), and speech privacy ($p < .05$) on perceived social support. From the linear mixed model results, significant interaction effects of office condition with ease of interaction, visual privacy, and speech privacy contributing to social support perception were observed, demonstrating that perceptions of greater support are linked to better interaction, more satisfying visual privacy, and speech privacy in the new office (Figure 4).

Behavioral Interaction

The effects of the two office conditions were analyzed using body movement, verbal conversation volume, and interaction detected by the social sensing wearable device data.

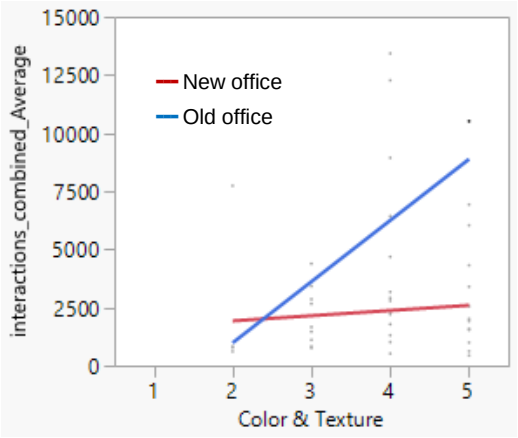


Figure 5. Interaction effects of new/old office and Color/texture on Interactive Behaviors

A series of independent-sample and paired-sample t-tests were conducted to examine possible changes in body movements, verbal communication volume, and interaction between the two office conditions. Calculated from Bluetooth, infrared, and microphone data, average interactions and audio volumes were significantly lowered in the new office compared with the old office; however, the amount of body movements did not change.

Audio volume data from the microphone sensor also demonstrates a significant difference between the two groups that is participants in the old office (*M*(*SD*)=.012(.0025)) were communicating in significantly louder voice than the participants in new office (*M*(*SD*)=.010 (.0029)), $F(1.43)=5.98$, $p<.05$. This tendency was stronger for those who participated in both office conditions, using even softer voices in the new office compared to with their voices in the old office, $t(11) = -3.13$, $p < .01$.

Average face-to-face and group interactions detected by infrared and Bluetooth sensors were reduced in the new office. Whereas this tendency is approaching significance, $t(23) = 1.81$, $p = .08$ with the entire participants, the decrease in interactions among participants in the new

office was statistically significant for those who participated in both the old and new office conditions, t(11) = -2.26, $p < .5$.

Creativity:

Workplace Performance Outcome

Workplace performance outcome in this study reflects the quality of the usage outcome from the workplace. How the employees of the organization see their own performance, their workgroup's, and that of the organization was measured with job satisfaction, turnover intention, perceived creativity, and the organization's productivity, which is directly related to the organization's performance and return on investments for the environment.

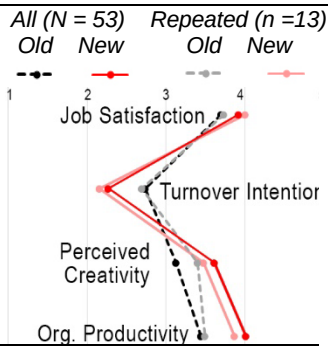
Job Satisfaction

Job satisfaction is defined as satisfaction with the psychosocial work environment and attitude toward work itself. A job satisfaction scale was developed to measure the psychosocial work environment with multiple items regarding (a) support from the organization (b) opportunities to grow (c) leadership, and (d) cooperation, and the scale was tested for reliability (Cronbach's α = .89).

Results of an independent-sample t-test shows no significant difference in job satisfaction between the two office conditions reported by the entire participants and old and new office groups; a paired-sample t-test results also did not show a significant change in job satisfaction by the employees who participated both office studies (Table 6). However, both t-test results have a consistent trend that job satisfaction scores are higher in the new office.

Table 6. Comparing the old and new office group mean differences in workplace outcome

	Independent-sample t-test (*N* = 53)			Paired-sample t-test (*n* = 13)		
	Old office	New office	t-test	Old office	New office	t-test
Job Satisfaction	3.70 (.69)	4.00 (.72)	-1.55 ns	3.73	3.92	.72 ns
Turnover Intention	2.74 (1.14)	2.16 (1.04)	1.84 ^	2.69	2.27	-.99 ns
Perceived Creativity	3.13 (.82)	3.48 (.74)	1.57 ns	3.40	3.61	.97 ns
Org. Productivity	3.44 (.57)	3.87 (.69)	-2.42 *	3.49	4.01	2.42 *



*$p < .05$, ** $p < .01$, *** $p < .001$, **** $p < .0001$.

Table 7. Linear mixed model results: Effects of Office and IEQ on Workplace Outcome after controlling for random effects of participants

Regression models	**Fixed Effects** *B(SE)*			
	Intercept	Main effect		Interaction effect
		Old/New office	IEQ	Office × IEQ
DV: Job Satisfaction				
Air quality	2.82 (.62)****	-.30 (.62)	.27 (.62)^	.04 (.14)
Lighting quality	3.25 (.69)****	-.57 (.69)	.12 (.15)	.16 (.15)
Noise	3.29 (.34)****	.23 (.34)	.23 (.10)*	-.10 (.10)
Speech privacy	3.74 (.28)****	.30 (.28)	.09 (.12)	-.10 (.12)

Available space	3.64 (.27)****	-.04 (.27)	.07 (.09)	.05 (.09)
Visual privacy	3.05 (.28)****	-.48 (.27)	.27 (.09)**	.18 (.09)^
Ease of interaction	2.33 (.54)****	-.72 (.52)	.37 (.13)**	.24 (.13)^
Furnishing	3.75 (.50)****	.22 (.50)	.04 (.12)	-.03 (.12)
Color & texture	3.50 (.48)****	-.06 (.48)	.09 (.12)	.04 (.12)
Cleanliness	3.52 (.41)****	-.55 (.41)	.05 (.10)	.18 (.10)
DV: Turnover Intention				
Air quality	3.46 (.96)***	-.54 (.96)	-.32 (.22)	.16 (.22)
Lighting quality	3.59 (1.07)**	.49 (1.07)	-.27 (.24)	-.14 (.24)
Noise	3.63 (.55)****	.06 (.55)	-.39 (.16)*	.01 (.16)
Speech privacy	2.48 (.46)****	-.44 (.46)	-.04 (.19)	.08 (.20)
Available space	2.79 (.42)****	-.31 (.42)	-.16 (.15)	.06 (.15)
Visual privacy	3.23 (.45)****	-.00 (.45)	-.29 (.15)^	-.05 (.15)
Ease of interaction	2.93 (.84)***	.18 (.84)	-.12 (.21)	-.11 (.21)
Furnishing	3.02 (.76)***	-.64 (.76)	-.22 (.19)	0.17 (.19)
Color & texture	2.93 (.76)***	-.13 (.76)	-13 (.19)	-.02(.19)
Cleanliness	2.63 (.64)***	.73 (.64)	.01 (.16)	-.28 (.16)
DV: Perceived Creativity				
Air quality	2.44 (.72)**	.05 (.66)	.24 (.17)	-.04 (.15)
Lighting quality	2.64 (.80)***	-.18 (.77)	.15 (.18)	.06 (.17)
Noise	3.02 (.42)****	.48 (,42)	.14 (.42)	-.15 (.13)
Speech privacy	2.89 (.33)****	.15 (.32)	.19 (.14)	-.07 (.14)
Available space	3.00 (.32)****	-.09 (.29)	.08 (.11)	.07 (.11)
Visual privacy	2.63 (.34)****	-.44 (.31)	.21 (.12)^	.17 (.10)
Ease of interaction	2.27 (.61)***	-.17 (.57)	.25 (.15)	.06 (.15)
Furnishing	3.86 (.58)****	1.03 (.58)^	-.11 (.14)	-.23 (.14)
Color & texture	3.08 (.58)****	.07 (.56)	.06 (.15)	-.01 (.14)
Cleanliness	3.07 (.49)****	.34 (.45)	.07 (.13)	-.06 (.11)
DV: Perceived Organization Productivity				
Air quality	3.11 (.59)****	.52 (.56)	.19 (.14)	-.14 (.13)
Lighting quality	3.06 (.65)****	.06 (.63)	.16 (.64)	.00 (.14)
Noise	3.51 (.34)****	.51 (.33)	.09 (.19)	-.13 (.01)
Speech privacy	3.77 (.27)****	.50 (.27)^	-.01 (.11)	-.11 (.11)
Available space	3.27 (.25)****	-.05 (.24)	.13 (.09)	.07 (.08)
Visual privacy	2.92 (.27)****	-.27 (.25)	.25 (.09) **	.14 (.08)
Ease of interaction	2.82 (.50)****	-.26 (.49)	.20(.12)	.11 (.12)
Furnishing	3.80 (.47)****	.69 (.47)	-.01 (.12)	-.14 (.12)
Color & texture	3.43 (.47)****	.17 (.46)	.06 (.12)	.00 (.12)
Cleanliness	3.07 (.50)****	.34 (.46)	.07 (.13)	-.06 (.11)

^marginally significant $p < .07$, * $p < .05$, ** $p < .01$, *** $p < .001$, **** $p < .0001$.

The linear mixed model results shown in Table 7 present marginally significant interaction effects of office and visual privacy and ease of interaction on job satisfaction. More satisfying

visual privacy and ease of interaction in the new office contributed to the significantly higher job satisfaction in the new office compared with the old office (Figure 6).

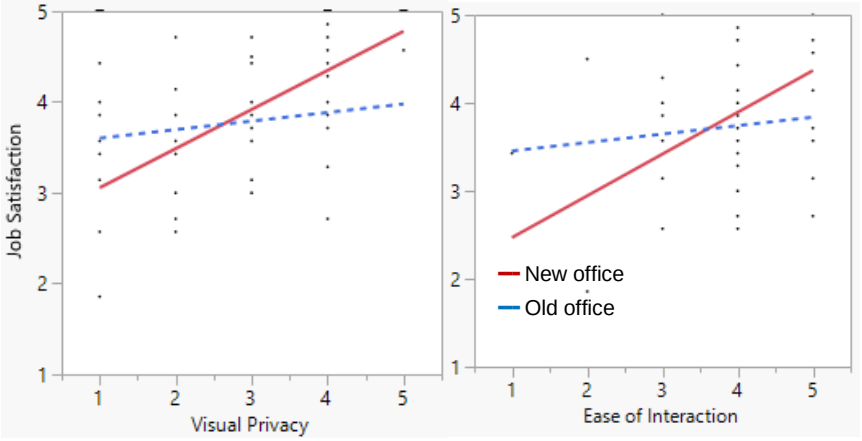


Figure 6. Interaction effects of new/old office and IEQ on job satisfaction

Turnover Intention

Turnover intention, referring to employee intention to voluntarily leave or change jobs or companies, is known to have a strong direct relationship to actual turnover behavior (Wells, Minor, Lambert, & Jennifer, 2016). Employee turnover can cost an organization 33% (U.S. Bureau of Labor Statistics) of an employee's total compensation. It is costly and also adversely influences employee morale, which can affect their daily performance. With its explicit nature, two question items adopted from previous studies were used for this study.

From a t-test, the mean difference between the two offices in turnover intentions is approaching conventional significant levels (p = .07), indicating that participants of the old office reported significantly higher turnover intention ($M(SD)$=2.74 (1.15)) than the new office participants ($M(SD)$=2.16 (1.04)). After controlling for job demands and control, a regression analysis showed the office condition had a significant effect on turnover intention (R^2=.28, $F(3,45)$=5.93, p=.0017). A series of simple linear regression analysis were performed to determine predictors of turnover intention. Results also confirmed perceived environmental quality has a positive effect (R^2=.12, $F(1,48)$=6.36, p=.015) and job demands have negative effects (R^2=.13, $F(1,47)$=6.83, p=.012) on turnover intention.

Workplace Experience and Workplace Outcome

From the sociometeric badge data it appears that changes in average interaction and audio volume significantly influenced higher job satisfaction ratings in the new office.

Significant effects of place attachment on job satisfaction, creativity, and organizational productivity were observed. As expected, social support was a significant contributing factor to job satisfaction, turnover intention, creativity, and organizational productivity in this study as well. A significant effect of stress on creativity was observed. In particular, the tolerance subdimension significantly affected creativity as well as organizational productivity.

Table 8. Linear mixed model results: Effects of office and IEQ on Workplace Outcome after controlling for random effects of participants

Regression models	**Fixed Effects** *B(SE)*					
	Intercept	Demand	Control	Main effect		Interaction effect
				Old/New office	IEQ	Office × IEQ
DV: Job Satisfaction						
Place attachment	2.62 (.32)	-.24 (.12)*	.37(.10)**	-.04 (.11)	..27(.10)*	..02(.11)
Stress	3.24(.75)	-.28(.12)*	.37(.11)**	.15(.09)	.07(.17)	.04(.17)
Tolerance	3.44(.72)	-.25(.12)*	.37(.11)**	.16(.09)	-.01(.13)	-.02(.14)
Anxiety	3.07(.77)	-.30(.13)*	.39(.11)**	.13(.09)	.13(.16)	.08(.17)
Perceived support	.84(.42)	-.15(.08)*	.24(.08)**	.14(.06)*	.75(.09)****	-.02(.10)
Audio volume	3.47(.75)****	-.29(.14)*	.41(.12)**	.14(.10)	-6.84(39.94)	14.09(40.19)
Body movement	3.23(1.03)**	-.29(.14)*	.70(.12)**	.15(.10)	25.76(90.22)	-39.52(89.84)
Interact. average	3.65(.54)****	-.33(.11)**	.32(.10)**	.24(.09)**	9.5e-5(3.4e-5)**	8.7e-5(3.4e-5)*
DV: Turnover Intention						
Place attachment	2.41(1.06)	.60 (.19)**	-.42(.18)*	-..21(.19)	-.17(.18)	-.21(.19)
Stress	2.95(1.25)*	.64(.21)**	-.42(.18)*	-.26(.15)	-39(.29)	-.13(.29)
Tolerance	2.7(1.21)*	.58(.14)**	-.37(.18)*	-.27(.14)^	-.31(.22)	-.13(.22)
Anxiety	.27(1.12)*	.61(.22)**	.61(.22)*	-.27(.15)	-.24(.27)	-.03(.27)
Perceived support	3.80(1.29)**	.50(.19)*	-.39(.19)*	-.33(.14)*	-.49(.25)^	.23(.26)
Audio volume	3.28(1.26)*	.57(.21)*	-.47(.19)*	-.35(.16)*	-119/97(69.06)	-63.97(69.02)
Body movement	3.33(1.53)*	.63(.20)**	-.49(.19)*	-.26(.14)	-183.39(136.62)	-230.66(134.11)
Interact. average	1.84(1.05)	.58(.23)*	-.39(.30)^	-.33(.17)^	-6.7e-5(6.6e-5)	-7.7e-5(6.4e-5)
DV: Creativity						
Place attachment	1.51(.78)	.04(.15)	.22(.13)	-.07(.13)	.33(.13)*	-.15(.13)
Stress	.43(.89)	-.00(.13)	.27(.13)*	.07(.07)	.56(.20)**	-.15(.19)
Tolerance	.85(.80)	.01(.14)	.30(.13)*	.09(.07)	.39(.15)*	-.15(.16)
Anxiety	1.27(.98)	-.00(.16)	.24(.13)	.11(.09)	.35(.21)	-.14(.19)
Perceived support	.35(.91)	.04(.14)	.13(.13)	.18(.09)	.65(.17)***	.06(.18)
Audio volume	3.04(.94)**	.02(.17)	.29(.15)	.06(.11)	-78.10(47.13)	38.59(44.15)
Body movement	2.49(1.28)	-.05(.18)	.25(.16)	.17(.11)	.79(117.3)	5.7(104.4)
Interact. average	2.43(.77)**	-.04(.17)	.20(.14)	.25(.11)*	9.4e-5*(4.9e-5)^	9.6e-5(2.5e-5)*
DV: Org. Productivity						
Place attachment	2.87(.56)	-.27(.09)	.26(.09)	-.02(.09)	.33(.09)***	-.05(.09)
Stress	2.94(.76)***	-.33(.12)	.28(.11)*	.18(.07)*	.28(.17)	.04(.17)
Tolerance	2.91(.66)****	-.32(.11)**	.27(.11)*	.18(.07)*	.28(.13)*	-.00(.14)
Anxiety	3.63(.76)****	-.31(.12)*	.28(.11)*	.20(.08)*	.05(.16)	.17(.16)
Perceived support	2.22(.66)	-.27(.10)**	.15(.10)	.20(.07)**	.53(.12)****	.09(.13)
Audio volume	4.00(.59)****	-.32(.11)**	0.32(.22)***	.22(.07)**	-29.49(29.53)	67.80(28.06)*
Body movement	3.52(.81)****	-.40(.10)***	.32(.10)**	.25(.07)**	68.09(73.59)	34.37(68.41)
Interact. average	4.31(.47)****	-.40(.10)***	.20(.09)*	.31(.07)***	8.5e-5(2.9e-5)**	9.7e-5(2.8e-5)**

References

Brown, D., & Leary, J. (1995). Findings from the Claybury study for community psychiatric nurses. In J. Carson, L. Fagin, & S. Ritter (Eds.), *Stress and Coping in Mental Health Nursing* (pp. 115–138). London, UK: Chapman & Hall.

Carson, J., Bartlett, H., Brown, D., & Hopkinson, P. (1995). Findings from the qualitative measures for community psychiatric nurses. In J. Carson, L. Fagin, & S. Ritter (Eds.), *Stress and Coping in Mental Health Nursing*. London, UK: Chapman & Hall.

Danielsson, C. B., & Bodin, L. (2008). Office Type in Relation to Health, Well-Being, and Job Satisfaction Among Employees. *Environment and Behavior*, *40*, 636–668. http://doi.org/10.1177/0013916507307459

Scannell, L., & Gifford, R. (2010). Defining place attachment: A tripartite organizing framework. *Journal of Environmental Psychology*, *30*(1), 1–10. http://doi.org/10.1016/j.jenvp.2009.09.006

Tofle, R., Schwarz, B., Yoon, S.-Y., & Max-Royale, A. (2004). Color in Health Care Environments. San Francisco, CA: Coalition of Health Environments Research.

Wells, J., Minor, K., Lambert, E., & Jennifer, T. (2016). A Model of Turnover Intent and Turnover Behavior Among Staff in Juvenile Corrections. *Criminal Justice and Behavior*, *43*(1), 1558–1579.