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the influence of design factors on psychological user satisfaction

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Office employee satisfaction: the influence of design factors on psychological user satisfaction

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Abstract

Purpose – Employees' satisfaction and productivity is one of the main interests of employers. Psychological comfort can cause dissatisfaction with their work. Thus, it is important to understand what factors contribute to employees' satisfaction in workplaces. The purpose of this paper is to identify the weight of contribution of each design parameter on increasing psychological satisfaction.

Design/methodology/approach – The study included 579 employees in five offices in The Netherlands through an online survey. The typologies of offices vary in terms of office layouts, orientations and façade. Additionally, a parameter of desk location was included as this factor may be associated with user satisfaction. Kruskal–Wallis H test, categorical regression, and logistic regression analyses were performed to examine the impact of these design parameters on psychological user satisfaction.

Findings – The results revealed the impact of design parameters on the psychological satisfaction. The parameters of office layouts and desk locations were the significant predictor factors for the probability of satisfaction variables (e.g. privacy, concentration, communication, social contact and territoriality). The parameters for optimal satisfaction were found in cellular office, north-west oriented workstation and 4 m away from a window.

Originality/value – Psychological comfort is an inevitable aspect in user satisfaction studies. This paper, therefore, measures and predicts the relationship between design factors and employees' satisfaction through case studies in The Netherlands. The findings help designers, architects, planners and facility managers to develop user-focussed office design principles supporting employees' work performance.

Keywords Employee satisfaction, Psychological satisfaction, Workplaces, Office design, User-focussed design, Evaluation

Paper type Research paper

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1. Introduction

User satisfaction becomes more and more important in office design. Environmental psychology has been studied by empirical research from the ergonomics field, which normally gives immediate responses towards the working environment. In Europe, the environmental psychology of office users has analysed at the individual and organisational level (Sundstrom and Sundstrom, 1986). A recent trend in the research field favours physical comfort of office users, which is also called satisfaction with working conditions assessed by post-occupancy evaluation. However, early studies by Altman (1975) developed the connection of physical environment and users through social–psychological analyses, including privacy and territoriality. Many studies have highlighted the importance of user satisfaction for promoting work performance and productivity (Tanabe *et al.*, 2015; De Been and Beijer, 2014). Voordt (2004) and Tanabe *et al.* (2015) stated that higher employee satisfaction in workplaces leads to increased productivity, whereas lack of privacy and territorialism can cause a decrease of satisfaction and productivity. Thus, it is essential to understand employees' perception and how workplaces are used for better support of office users.

The field of environmental psychology explores the association between human and physical conditions (Oseland, 2009). According to Oseland (2009), people seek an enclosed place for concentration on work. At the same time, they also seek social spaces for casual interaction with colleagues. The measurements of environmental satisfaction have been studied by some projects, for instance, The OFFICAIR project (Sakellaris *et al.*, 2016) and the COPE project (Veitch *et al.*, 2007). In spite of numerous studies regarding environmental satisfaction, Frontczak and Wargocki (2011) stated that the relationship between indoor environment and end-users' comfort is not fully identified. There may be more parameters that influence environmental user satisfaction.

A review by Rolfö *et al.* (2018) found that psychological workspace comfort, such as privacy and territoriality (De Croon *et al.*, 2005) and communication (Brennan *et al.*, 2002), affect occupants' satisfaction and performance, as well as physical office conditions (Brill and Weidemann, 2001). Some studies explored the impact of physical environmental factors on job satisfaction and productivity. For instance, Banbury and Berry (2005) compared the effect of noise on users' concentration between cellular and open-plan offices. Similarly, Kaarlela-Tuomaala *et al.* (2009) studied the different acoustic environment and the degree of users' concentration between those two office layouts. De Been and Beijer (2014) revealed that office type is a significant predictor for employees' productivity, concentration, communication etc. The studies regarding office layout often compare only cellular and open-plan types. However, De Been and Beijer (2014) included combi and flex office types in their study. Kwon *et al.* (2019b) found that prominent psychological variables are privacy, concentration, communication, social contact and spatial comfort (territoriality).

These studies mainly compared psychological satisfaction between different office layouts. However, more physical design factors might need to be included in the studies of user satisfaction. Moreover, the relationship between various design factors (e.g. orientation, WWR and distance of desk location from window) and psychological satisfaction in offices is rarely known, and very few studies investigated this relationship. Therefore, the aim of this study is to answer the research questions: How do office design factors influence user satisfaction with their psychological comfort? And can the relationship be predicted and used to develop user-focused design principles? Answering these questions, this study examines the relationship between different design parameters and psychological user satisfaction and investigates the significant design parameters that highly contribute to

increasing employees' satisfaction. This paper also offers an overview of influential parameters for the workspace design based on the psychological satisfaction.

2. Methodology

2.1 Study design

This research is conducted in four renovated offices and one non-renovated office in The Netherlands. The office buildings were selected using the following criteria: the main consideration of office renovation was energy efficiency, the office was occupied at least one year after renovation, and the building received energy label A or similar value (see Figure 1). Digital questionnaires, and to a certain extent hard-copy questionnaires, were used to collect data about the user satisfaction of the employees in the five buildings.

Figure 2, constructed by Kwon *et al.* (2019b), illustrates the main ten factors of user satisfaction with physical and psychological comforts, based on the studies by De Been and Beijer (2014), Vischer (2008), Tucker and Smith (2008) and Leifer (1998). The ten factors are classified according to three dimensions: physical comfort, functional-influential comfort and psychological comfort. Factors in the physical category are related to the environmental office performances such as heating, cooling, ventilation, lighting and noise. The functional

	Case A	Case B	Case C	Case D	Case E
Case					
WWR	≤ 30%	≤ 80%	≤ 50%	≤ 50%	≤ 30%
Built year	1973	1971	1975	1960s	1960
Adaptation	2010 – 2011	2012	2008	2012	
Energy label improvement	F to A (EPC)	G to A (EPC)	Energy label A, BREEAM Very good	BREEAM Excellent	No information

Figure 1.
Information about the case study buildings, modified after Kwon *et al.* (2019a)

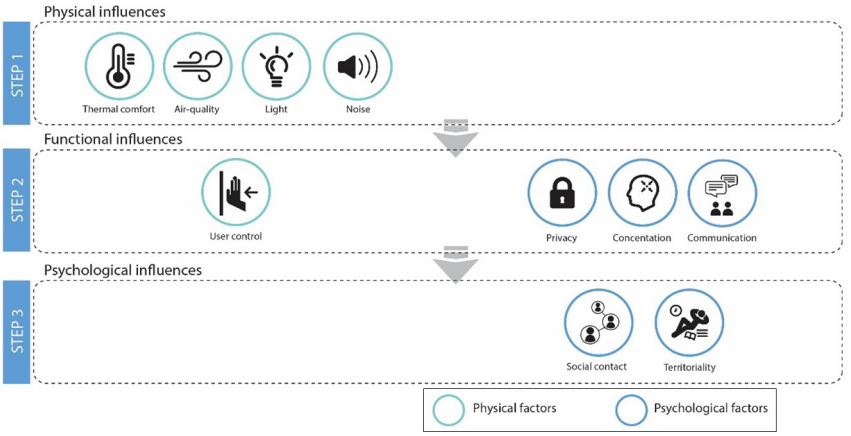

Figure 2.
Classification of physical and psychological factors based on the dimensions of comfort, modified from Kwon *et al.* (2019b, p. 14)

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category indicates the factors influenced by the functional performance of workplaces such as office layouts. Lastly, the psychological category indicates satisfaction factors influenced by employees' perception. A previous paper revealed the relationship between physical satisfaction factors and design parameters (Kwon *et al.*, 2019a). This paper deals with five psychological satisfaction factors.

2.2 Questionnaires

Post-occupancy evaluation (POE) was used to assess building-related occupants' feedbacks, as the POE tool is useful to investigate how the building performance or environment affect occupants (Vischer, 2002). The questionnaires included design factors such as desk location, orientation, window-to-wall ratio (WWR) and office layout (see Table I). Demographic information was also collected through the online questionnaires (see Table II). Psychological user satisfaction was measured by the following questions: "How satisfied are you with the following conditions?" regarding privacy during work at your workstation, opportunity to concentrate on your work, opportunities to communicate for work, social contact with colleagues in the office and feeling of territoriality. To investigate the degree of user satisfaction with psychological comfort in the work environment, the following

Categories	Question	Answer
Design factors		
Desk location	Where is your desk located?	1 = 0-2 m away from windows 2 = 2-4 m away from windows 3 = Over 4 m away from window
Orientation	Which direction does your window face?	1 = South-east, 2 = South-west, 3 = North-east and 4 = North-west
WWR	What types of windows does your workplace have? (choose what comes closest to your situation)	1 = 30%, 2 = 50%, 3 = 80%
Office layout	What type of office layout do you work at?	1 = Cellular 2 = Open plan 3 = Combi-office 4 = Flexible office
Psychological satisfaction parameters		
Better work environment	What are the most important issues for better work environment?	1 = Privacy 2 = Concentration 3 = Communication 4 = Social contact 5 = Territoriality
Satisfaction	How satisfied are you with the following conditions? (privacy, concentration, communication, social contact and territoriality)	1 = Extremely dissatisfied 2 = Dissatisfied 3 = Neither dissatisfied nor satisfied 4 = Satisfied 5 = Extremely satisfied

Table I.
Questions about physical condition of workplaces

question was asked: "How satisfied are you with the following conditions?", applying five psychological satisfaction variables and "what are the most important issues for better work environment?". These variables measure the degree of satisfaction using a five-point Likert scale ranging from 1 = extremely dissatisfied, 2 = dissatisfied, 3 = neither dissatisfied nor satisfied, 4 = satisfied and 5 = extremely satisfied.

2.3 Responses

A total of 718 occupants were approached, 579 (79.5 per cent) completed the survey and 139 (19.4 per cent) were counted as missing cases. The gender balance between male and female was almost 50 per cent, and the age of 30-49 accounted for over half of the total responses. The age group of over 60 years was the smallest group at 5.2 per cent. The respondents' group was composed of 66.7 per cent of full-time employees and 33.3 per cent part-time (see Figure 3). The average working hours of the part-time group was 20-30 h per week.

2.4 Statistical data analysis

Statistical Package for the Social Sciences version 24 was used for all statistical analyses with multiple statistical methods. The survey recorded the degree of satisfaction on an ordinal scale. A mean satisfaction score and percentile were used to understand how satisfied users were with psychological variables in their work environment. First, Cronbach's Alpha was tested to determine if the Likert scale was reliable. Second, the normality was checked by one-sample Kolmogorov–Smirnov test, before conducting the Kruskal–Wallis H test (KWH), which determines that the satisfaction variances are correlated with nominal dependent variables. This test assesses the difference among independent sample groups in non-normally distributed data (Vargha and Delaney, 1998). As a following up test of the KWH test, a non-parametric post-hoc test was conducted by pairwise comparison to examine which groups show differences. Next, categorical regression (CATREG) with optimal scaling technique was used to identify the predictors

Categories	Question	Answer
Demographic information		
Gender	What is your gender?	1 = Male and 2 = female
Age	What is your age group?	1 = 18-29, 2 = 30-39, 3 = 40-49, 4 = 50-59 and 5 = over 60
Contract type	What is your contract type?	1 = Full-time and 2 = part-time

Table II. Questions for demographic information

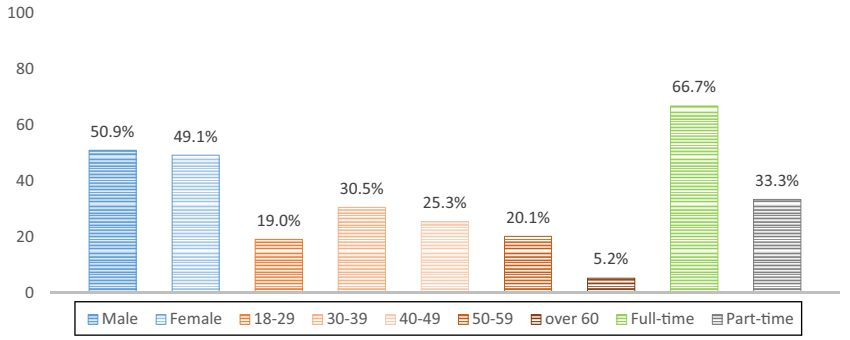

Figure 3. Demographic information of respondents

(independent variables) of satisfaction (dependent variables) and relative contributions with the variance explained by R^2 (Ibem *et al.*, 2015).

Subsequently, binary logistic regression analysis was used to predict the models for occupants' satisfaction with the given psychological variables. This analysis has been applied in previous studies (De Kluizenaar *et al.*, 2016; Au-Yong *et al.*, 2014). The independent variables (predictors) were design factors, and the dependent variables were the satisfaction with psychological parameters. To conduct the binary logistic regression, the degrees of satisfaction were recoded with the value of "not satisfied" = 0 and "satisfied" = 1. Goodness of fit of the models was evaluated by the Hosmer–Lemeshow test, which was over the 5 per cent level, revealing that the psychological satisfaction could be explained by the models. The associations are shown as odds ratios (OR) with 95 per cent of confidence interval (CI 95 per cent). In general, an OR indicates the likelihood of increasing the value of dependent variables. However, the independent variables are nominal scale and the dependent ones are ordinal scale; thus, ORs are used to compare the relative relationship between the design parameters and the satisfaction.

3. Results

3.1 Overview of measured satisfaction degrees

The Cronbach's alpha of satisfaction parameters was 0.817, which means a high level of reliability. Figure 4 shows a summary of the percentile scores in each psychological satisfaction category. The figure also compared the percentile scores between renovated and non-renovated offices. Overall, the mean values of each satisfaction variable were less than four. The highest mean value was recorded for the "social contact with colleagues" (mean: 3.80), and the lowest one was "opportunity to concentrate on work task" (mean: 2.78).

	Categories	Number of participants	Mean (SD)	Quartile range
				1 2 3 4 5
				P_{25} P_{50} P_{75}
Overall	Privacy	579	2.92 (1.10)	
	Concentration	579	2.78 (1.16)	
	Communication	579	3.42 (1.02)	
	Social contact	579	3.80 (0.91)	
	Territoriality	579	3.09 (0.98)	
Renovated offices	Privacy	579	2.86 (1.06)	
	Concentration	579	2.72 (1.12)	
	Communication	579	3.42 (1.00)	
	Social contact	579	3.81 (0.89)	
	Territoriality	579	3.05 (0.97)	
Non-renovated offices	Privacy	579	3.25 (1.26)	
	Concentration	579	3.15 (1.32)	
	Communication	579	3.41 (1.14)	
	Social contact	579	3.77 (1.06)	
	Territoriality	579	3.33 (1.03)	

Figure 4.
Quartile ranges by psychological categories from 1 (extremely dissatisfied) to 5 (extremely satisfied)

Although the occupants in non-renovated offices were slightly more satisfied than those in renovated offices, there was no big difference between the two conditions.

Figure 5 shows the percentage of responses on each satisfaction variable. In detail, 36 per cent of the occupants were dissatisfied with "privacy" and 43 per cent with "concentration". On the other hand, around 60 per cent of the occupants were satisfied with the opportunity of "communication", and three quarter of the occupants were satisfied with "social contact". In terms of "territoriality", most people tended to be neither satisfied nor dissatisfied, and they were rarely dissatisfied. Remarkably, around 18 per cent of the occupants were extremely satisfied with "social contact", and only less than 10 per cent of occupants were extremely satisfied with the rest of the variables, whereas occupants were extremely dissatisfied with privacy and concentration with 11 per cent and 16 per cent, respectively.

3.2 Differences of psychological satisfaction between groups

The Kolmogorov–Smirnov test indicated that satisfaction degrees did not follow a normal distribution (p-value <0.05), and therefore normality was rejected. The groups were compared through the KWH test (non-parametric). The result of the KWH test showed the differences of psychological satisfaction depending on the groups of the design factors (see Table III).

No significant differences were found among the three categories (30, 50 and 80 per cent) of the WWR group. On the other hand, there were statistically significant differences on satisfaction according to the groups of "desk location", "orientation" and "layout". The post-hoc test was carried out after the KWH test, with only these three design parameters. The test was conducted to check where the differences occurred between the groups. Results from the post-hoc test showed that there were differences between the occupant groups sitting 0-2 and 2-4 m away from windows for privacy, concentration, communication and social contact and between groups sitting 0-2 and over 4 m away from windows for the variable of territoriality. The orientations of South-west (S.W) and South-east (S.E), S.W and North-east (N.E) and S.W and North-west (N.W) also showed different satisfaction responses. Lastly, differences between the layouts of cellular and open and cellular and flex-office were observed.

3.3 Exploring design factors related to psychological satisfaction

Table IV shows the relative contribution of design parameters to predict user satisfaction. The range of R^2 was between 5.6 and 14.2 per cent, which shows how well the model fits the

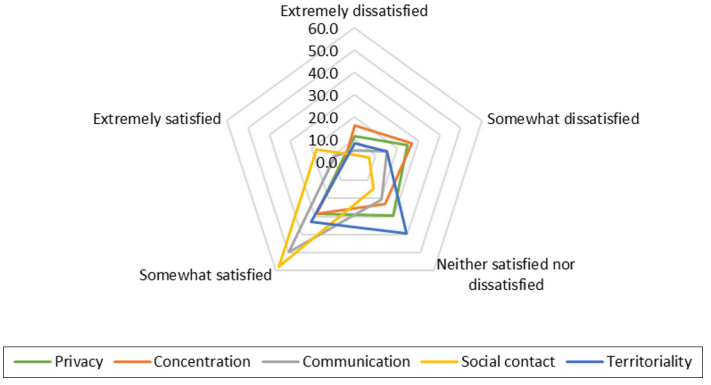

Figure 5. Percentages of measured satisfaction degrees

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Independent variables	Dependent variables	p-value	Post-hoc test
Desk location	Privacy	*0.002*	0-2-2-4 m
	Concentration	*0.024*	0-2-2-4 m
	Communication	*0.010*	0-2-2-4 m
	Social contact	*0.002*	0-2-2-4 m
	Territoriality	*0.009*	0-2-over 4 m
Orientation	Privacy	$p < 0.001$	S.W-S.E, S.W-N.E and S.W-N.W
	Concentration	$p < 0.001$	S.W-S.E, S.W-N.E and S.W-N.W
	Communication	$p < 0.001$	S.W-S.E, S.W-N.E and S.W-N.W
	Social contact	*0.006*	S.W-S.E
	Territoriality	*0.001*	S.W-S.E and S.W-N.E
Layout	Privacy	$p < 0.001$	Open-cellular and flex-cellular
	Concentration	$p < 0.001$	Open-cellular and flex-cellular
	Communication	0.084	
	Social contact	0.833	
	Territoriality	*0.005*	Open-cellular
WWR	Privacy	0.378	
	Concentration	0.156	
	Communication	0.232	
	Social contact	0.131	
	Territoriality	0.340	

Note: p-values in bold highlighted are statistically significant ($p < 0.05$)

Table III.
Differences on psychological satisfaction variables between design factors

Dependent	Independent	β	Importance	p-value	R^2	p-value
Privacy	Desk location	0.112	0.068	*0.004*	0.142	$p < 0.001$
	Orientation	0.145	0.188	$p < 0.001$		
	Layout	*0.326*	*0.744*	$p < 0.001$		
	WWR	0.018	−0.001	*0.779*		
Concentration	Desk location	0.092	0.077	*0.009*	0.115	$p < 0.001$
	Orientation	0.207	0.423	$p < 0.001$		
	Layout	*0.248*	*0.489*	$p < 0.001$		
	WWR	0.081	0.012	*0.045*		
Communication	Desk location	0.101	0.160	*0.006*	0.068	$p < 0.001$
	Orientation	*0.172*	*0.507*	$p < 0.001$		
	Layout	0.153	0.335	$p < 0.001$		
	WWR	0.032	−0.002	0.600		
Social contact	Desk location	0.138	0.383	*0.001*	0.056	0.001
	Orientation	*0.154*	*0.457*	$p < 0.001$		
	Layout	0.061	0.036	0.104		
	WWR	0.090	0.124	*0.012*		
Territoriality	Desk location	0.044	−0.004	0.537	0.077	$p < 0.001$
	Orientation	0.112	0.202	*0.001*		
	Layout	*0.243*	*0.774*	$p < 0.001$		
	WWR	0.037	0.027	0.404		

Notes: p-values in bold highlighted are statistically significant ($p < 0.05$); $^{\beta}$coefficients and importance in bold highlighted mean the largest satisfaction coefficient

Table IV.
Relative contribution of design parameters (results from categorical regression analysis)

data. Overall, WWR was not a statistically significant design factor for the satisfaction with psychological comfort, except for the satisfaction with "concentration" and "territoriality". "Desk location", "orientation" and "layout" were the significant predictors for psychological user satisfaction in the work environment. The largest coefficient of "privacy", "concentration" and "territoriality" occurred in "layout", $\beta = 0.326$, $p < 0.001$, $\beta = 0.248$, $p < 0.001$ and $\beta = 0.243$, $p < 0.001$, respectively. "Orientation" was the greatest contribution factor for the satisfaction with communication of $\beta = 0.172$, $p < 0.001$ and social contact of $\beta = 0.154$, $p < 0.001$.

Figure 6 illustrates the influential weight of design parameters based on Table IV. According to Figure 6, "layout" must be considered as the most important design factor for "privacy", "concentration" and "territoriality" and relatively low contribution for "communication". In contrast, the factor was not statistically significant for "social contact". "Orientation" was the second significant design factor of all satisfaction variables. In contrast, WWR was only presented as a statistically significant factor to concentration and social contract.

Figure 7 presents the tendency of user satisfaction according to the nominal design parameters. The *x*-axis represents the order of the independent variables of each design factor, and the *y*-axis represents the transformed dependent variables. The β values in

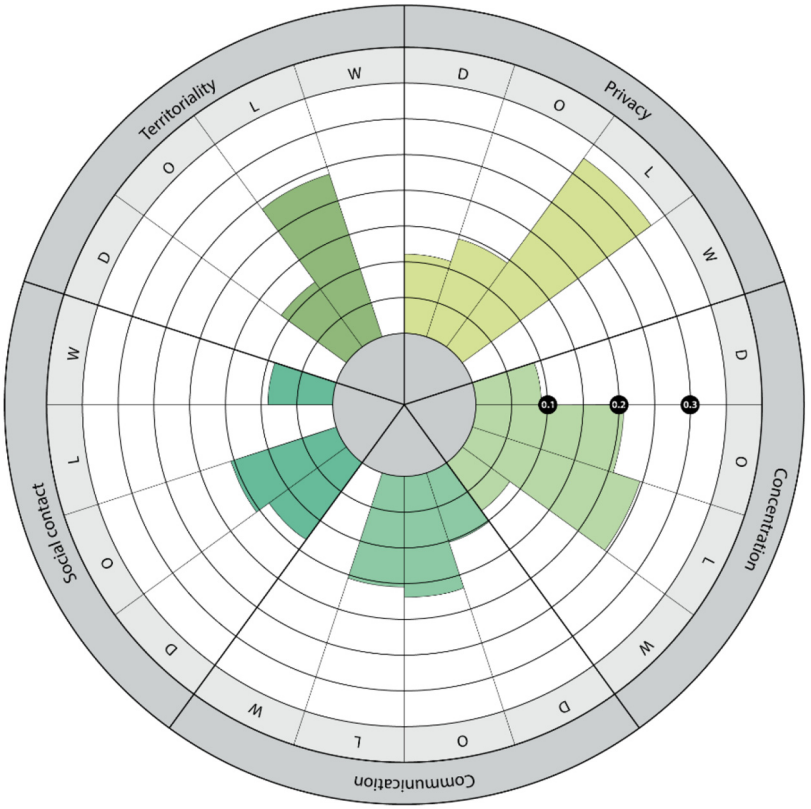


Figure 6.
Influential weight of design parameters on psychological satisfaction factors

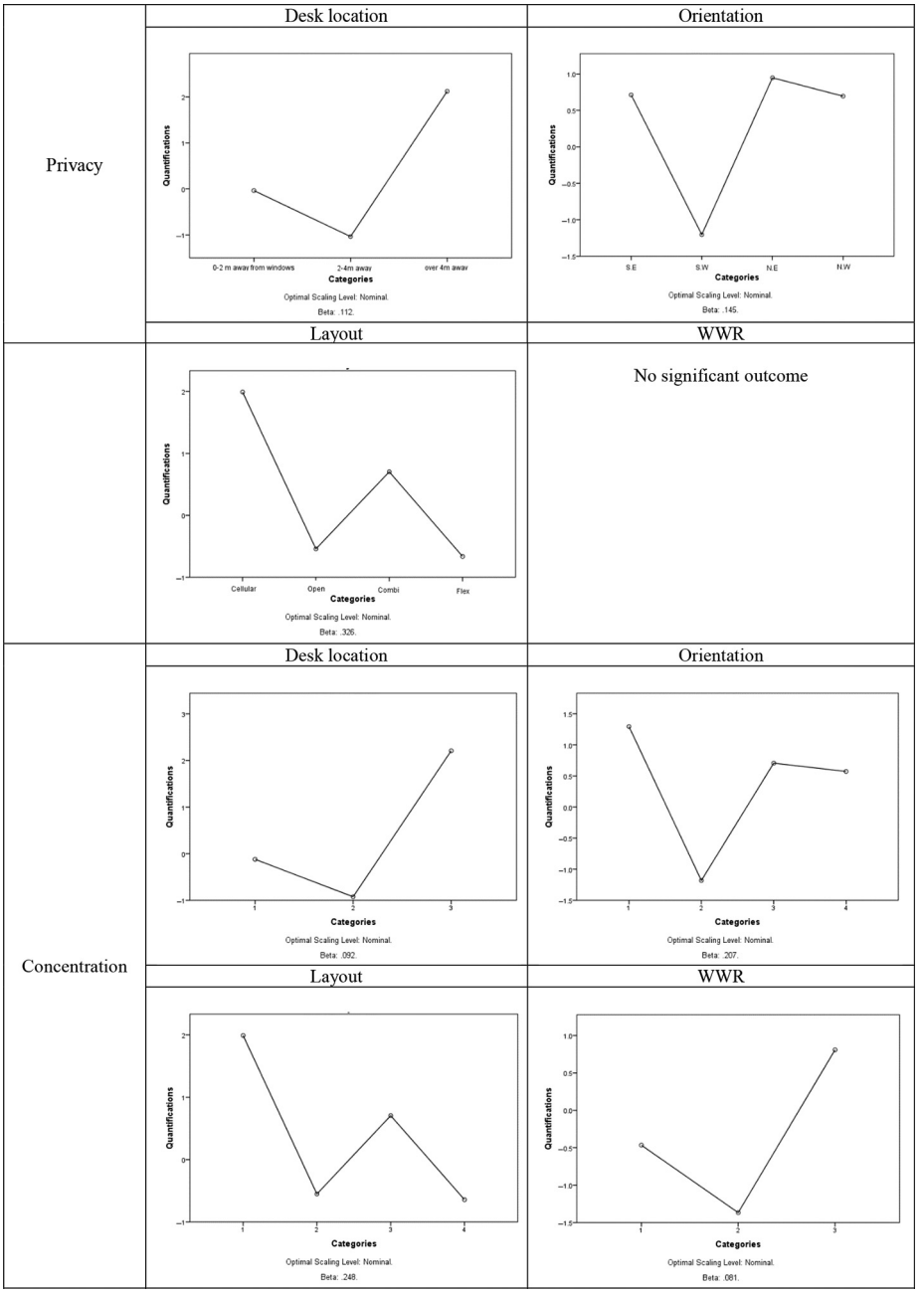
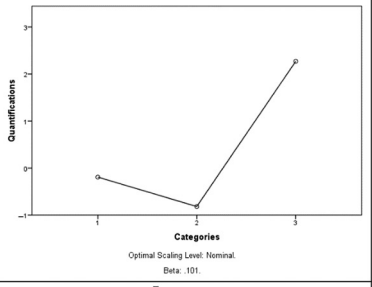
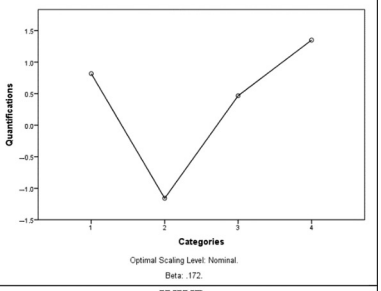
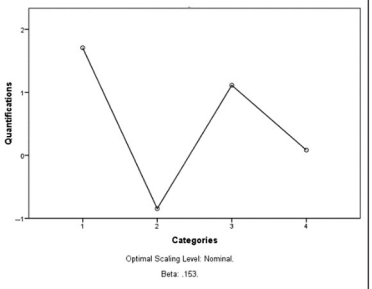
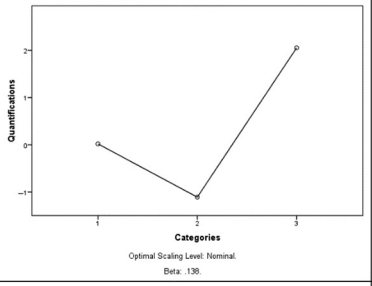
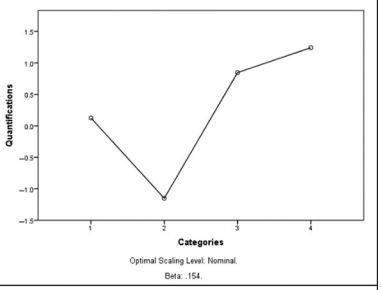
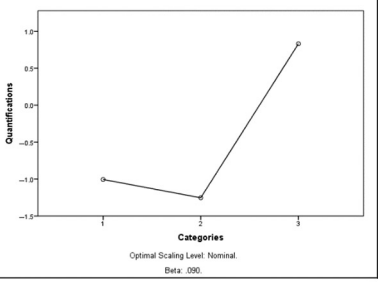


Figure 7.
The relationship between physical design factors and user satisfaction

(*continued*)

Communication	Desk location	Orientation
		
	Layout	WWR
		No significant outcome
Social contact	Desk location	Orientation
		
	No significant outcome	

(*continued*)

Figure 7.

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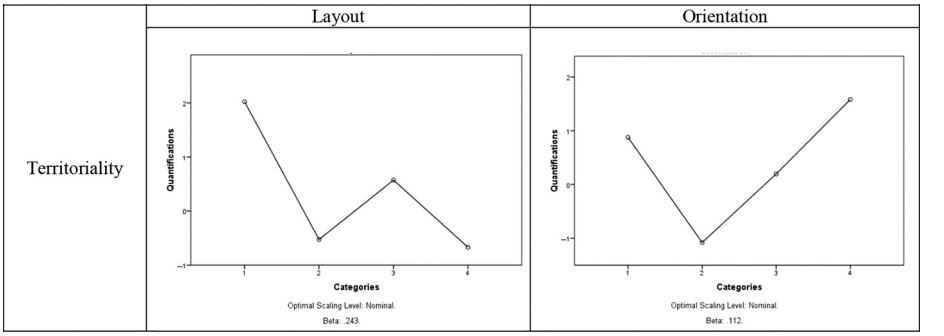

Figure 7.

Table III were positive, and therefore the higher *y*-axis values indicate the higher predicted satisfaction level. The design factors which were not significant for a certain satisfaction variable were eliminated. In detail, the desk location over 4 m away from windows was predicted to increase user satisfaction with psychological comfort variables, except for territoriality. However, the contribution weight of "desk location" was not as high as other design factors. The most notable outcome in the categorical regression analysis was "office layout". The probability of higher satisfaction with privacy, concentration and territoriality was shown in the order of cellular > combi > open > flex-office, whereas the probability of higher satisfaction with communication was presented as following the order of cellular > combi > flex > open-plan office.

3.4 Predicted psychological user satisfaction

To predict the impact of design parameters on psychological user satisfaction, a binary logistic regression was conducted. The data were recoded to dependent variables (satisfied and not satisfied), and each design parameter was analysed as dummy variables. This analysis validated the categorical regression result and used the enter method to include the predictors that significantly contributed to the regression model. In Table V, the significance of regression models was tested by the Omnibus test (p <0.05). The model explained 4-12 per cent (Nagelkerke R^2) of the variance in satisfaction and correctly classified over 60 per cent of the cases. The data were fit for the logistic regression analysis, showing over 0.05 of p-value tested by the Hosmer–Lemeshow analysis. In Table IV, the factor contributing most to the user satisfaction was "layout" followed by "orientation". In Table V, significant relationships contributing to satisfaction were found for "layout", "desk location" and "orientation". On the contrary to the result of CATREG, the variable "orientation" was not statistically significant for psychological satisfaction, except for "concentration". In detail, occupants in cellular offices were 3.4 times (OR 0.29, 95 per cent CI: 0.17-0.49) more likely to be satisfied with privacy, 2.7 times (OR 0.37, 95 per cent CI: 0.21-0.63) more with concentration and 1.8 times (OR 0.55, 95 per cent CI: 0.33-0.90) more with territoriality than those who work in open-plan offices. The cellular office users also tended to be 3.7 times (OR 0.27, 95 per cent CI: 0.15-0.5) more satisfied with privacy, 3.0 times (OR 0.33, 95 per cent CI: 0.17-0.61) more with concentration and 2.2 times (OR 0.45, 95 per cent CI: 0.25-0.81) more with territoriality than those who work in flex-offices. "Desk location" was an important predictor for psychological satisfaction variables except for "concentration". Remarkably, occupants sitting over "4 m away from windows" were 2-2.5 times more satisfied than those sitting "2-4 m away from windows" and 2-2.2 times more than the group of occupants sitting "0-2 m away from window". Although "orientation" was the second significant factor for the

Variable	Privacy		Concentration		Communication		Social contact		Territoriality	
	OR(CI 95%)	*p*- value	OR(CI 95%)	*p*- value	OR(CI 95%)	*p*- value	OR(CI 95%)	*p*- value	OR(CI 95%)	*p*- value
Desk location		*0.010*		0.066		*0.027*		0.141		*0.006*
0-2 m	*0.49 (0.28-0.85)*	*0.011*	0.72 (0.41-1.26)	0.250	*0.47 (0.26-0.82)*	*0.009*	0.56 (0.27-1.15)	0.119	*0.44 (0.26-0.75)*	*0.003*
2-4 m	*0.40 (0.22-0.73)*	*0.003*	0.49 (0.27-0.91)	0.024	*0.48 (0.26-0.87)*	*0.017*	0.47 (0.22-0.99)	0.048	*0.43 (0.24-0.76)*	*0.004*
Orientation		*0.001*		*p < 0.001*		*0.034*		0.213		*0.007*
S.E	1.77 (0.92-3.43)	0.087	1.59 (0.82-3.05)	0.164	0.97 (0.50-1.85)	0.929	1.48 (0.65-3.40)	0.346	1.80 (0.95-3.41)	0.068
S.W	0.75 (0.42-1.31)	0.317	*0.52 (0.30-0.91)*	*0.024*	0.63 (0.37-1.06)	0.088	0.71 (0.39-1.30)	0.273	0.70 (0.41-1.2)	0.205
N.E	1.75 (0.99-3.10)	0.053	1.32 (0.76-2.31)	0.320	1.16 (0.66-2.02)	0.593	0.86 (0.45-1.62)	0.646	1.15 (0.66-2.00)	0.604
Layout		*p < 0.001*	*0.001*		0.463	–	–		*0.018*	
Open	*0.29 (0.17-0.49)*	*p < 0.001*	*0.37 (0.21-0.63)*	*p < 0.001*	0.70 (0.42-1.16)	0.169	–	–	*0.55 (0.33-0.90)*	*0.019*
Combi	0.52 (0.25-1.08)	0.080	*0.46 (0.22-0.99)*	*0.047*	0.96 (0.46-1.97)	0.913	–	–	0.97 (0.48-1.98)	0.951
Flex	*0.27 (0.15-0.50)*	*p < 0.001*	*0.33 (0.17-0.61)*	*p < 0.001*	0.86 (0.48-1.54)	0.626	–	–	*0.45 (0.25-0.81)*	*0.008*
WWR	–	–		0.314	–	–		0.295	–	–
30%	–	–	0.89 (0.44-1.79)	0.748	–	–	0.67 (0.34-1.33)	0.257	–	–
50%	–	–	0.70 (0.44-1.10)	0.130	–	–	0.73 (0.47-1.14)	0.174	–	–
	R^2		R^2	0.120	R^2	0.050	R^2	0.040	R^2	0.081
	HL test	0.129	HL test	0.364	HL test	0.435	HL test	0.337	HL test	0.414
	Classification (%)	0.529	Classification (%)	68.0	Classification (%)	60.6	Classification (%)	75.4	Classification (%)	65.9
	69.8									

Notes: B coefficients and odd ratios (95% CI) in bold highlighted are statistically significant ($p < 0.05$); the results of Omnibus test are statistically significant ($p < 0.05$); HL test refers Hosmer-Lemeshow test

Table V.
Results of binary logistic regression to predict Indoor Environmental Quality user satisfaction based on design factors: Hosmer–Lemeshow test, odds ratios are reported with confidence intervals, parentheses and *p*-value ($N = 579$)

satisfaction in the results of the categorical analysis, this design factor was only significantly predicting the satisfaction with concentration. People in the workstations oriented to N.W tended to be more satisfied with concentration than those working in S.W-oriented workstations, and no statistical significance was found for WWR.

Figure 8 shows the most significant parameters of users' psychological satisfaction based on occupants' vote. In the questionnaire, 47.5 per cent occupants responded "having individual spaces for concentration" which was to be the most important aspect for their work environment followed by "privacy". On the contrary, "social contact" was the least important aspect with 9.7 per cent responses.

4. Discussion

4.1 Psychological satisfaction studies

This paper investigated psychological satisfaction in offices in accordance with different design parameters through user-based surveys and statistical analyses. As the categorical regression results have shown, office layout is absolutely important for user satisfaction. This study included four different layout groups, and the results were in line with the precedent research findings. In our study, open office was predicted to give higher satisfaction with territoriality than flex office, while flex office was predicted to give higher satisfaction in terms of communication than open-plan office. This outcome supports the findings of Rolfö *et al.* (2018) and Gorgievski *et al.* (2010).

Rolfö *et al.* (2018) compared user satisfaction between open-plan offices and activity-based work places with flexi-desks, and observed different satisfaction rate according to the office types. Open-plan offices decreases user satisfaction in terms of privacy (De Croon *et al.*, 2005; Kim and De Dear, 2013), and communication (Brennan *et al.*, 2002). On the other hand, cellular offices showed good overall psychological satisfaction results. Aries *et al.* (2010) also reported that the best satisfaction results were found in cellular offices.

In this study, combi- and flex-office types were included additionally. The probability of higher satisfaction was observed in combi-offices and cellular offices as opposed to open and flex offices. It is assumed that combi-office has personal workstations, which can be shared with others, and meeting spaces for group/team work. Although the probability of user satisfaction in combi offices was not higher compared with that in cellular offices, it was relatively higher compared with that in open- and flex-offices. De Been and Beijer (2014) revealed that occupants in combi-offices were more satisfied with communication than those in flex-offices. They argued that creating more chance to meet colleagues through the layout design does not lead to better communication. De Been and Beijer (2014) also reported that occupants in combi- and flex-offices were less satisfied with privacy and concentration than occupants in cellular and shared offices. In the result of the categorical regression analysis, users in combi-offices were more satisfied with communication than users in open and flex-

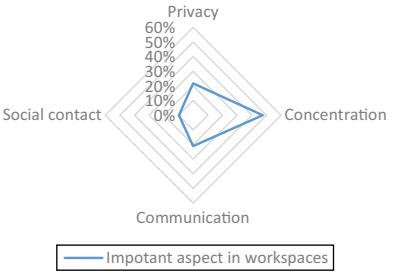

Figure 8.
Important aspects in workspaces

offices, which can partly support the results of De Been and Beijer (2014). Even though open-plan offices have been known as causing lower concentration, and more interruptions (Samani *et al.*, 2017), occupants from open offices were more tended to be satisfied with privacy, concentration and territoriality than those working in flex-offices. It is assumed that open offices allow occupants to have their own desks so that they were guaranteed territoriality. According to the regression analysis, "office layout" did not significantly predict user satisfaction with communication. Nonetheless, the office users were found to be the most satisfied with the cellular office layout, followed by combi-offices, the open-plan office and, lastly, flex-offices. "Orientation" was the second largest contribution factor to psychological satisfaction in this study. Nonetheless, there are few studies dealing with the association between façade/workstation orientation and psychological satisfaction. Instead, there are many studies about orientation and visual comfort (Araji, 2008). Aries *et al.* (2010) tried to identify the impact of façade orientation on physical psychological discomfort, but orientation was ignored and combined in one group for their further research. One of the questionnaires in their research was to examine the view quality. Users were supposed to answer whether they had good or bad outside view. They found that view quality influences employees' visual or psychological comfort, which was also confirmed by Tuaycharoen and Tregenza (2007). Even though the impact of orientation on psychological satisfaction has not been investigated yet, it can be explained that view/orientation may affect psychological satisfaction. Fabi *et al.* (2011) reported that users located towards the south façade would interact more with windows by opening and closing windows and blinds. However, it does not mean that people were highly satisfied with the interaction. In this paper, orientation greatly contributed to users' concentration on work. Occupants having an N.E orientation tended to be more satisfied than those working at the S.W. People working at the S.W showed least satisfaction with other psychological variables. Together with the findings of Fabi *et al.* (2011), the phenomenon can be explained by an assumption that having more interaction with the façade causes low concentration of occupants on work.

How far people sit away from the window was not a significant predictor for territoriality but it was a significant factor for the rest of the satisfaction parameters. Remarkably, "desk location" gave the biggest effect on satisfaction with social contact. Although this study found that there was a relationship between desk location and psychological satisfaction, hardly any research has studied this association. Aries *et al.* (2010) used the same scale of parameters for desk location categories: 0-2, 2-4 and over 4 m. The most frequent subject related to vicinity of the window is illuminance. For this reason, desk location was an important factor for the exposure of occupants to natural daylight. Escuyer and Fontoynont (2001) and Wang and Boubekri (2011) revealed that the desk location influences satisfaction with illuminance and shows negative impact of desks close to windows on concentration. It is obvious that glare from direct sunlight causes occupants' visual discomfort (Inkarojrit, 2005). In line with the previous research, this paper showed that the glare may not only decrease visual comfort but also disturb concentration on work. Although WWR was analysed to examine the impact of the natural daylight on psychological satisfaction, the "WWR" was not a significant factor to predict any of the psychological satisfaction factors.

4.2 Low level of R^2 value

In this study, the low R^2-square was observed in the outcomes of the regression analyses. R^2 indicates the percentage of variation in the independent variables; therefore, the higher the R^2-square value is, the better the explanation of the model. In general, an R^2 of 0.75 is strong, 0.5 is moderate and 0.25 is weak (Wong, 2013). For that reason, some researchers interpret that the model is incomplete when the R^2 is lower than 0.25, although the relation is

statistically significant. However, the low R^2, indicating the large spread of data explained by independent variables, is often presented in social science, as human behaviour or satisfaction is difficult to predict (Frost, 2017).

Glenn and Shelton (1983) stated that eliminating the regression results with low R^2 is not appropriate in social research, instead, it is recommended to compare to other research. Moksony (1990) demonstrated that R^2 is not useful to compare either contribution of the independent variable or the goodness of the model fit and suggested to use the unstandardised regression coefficient for the explanatory power and the standard error for the goodness of fit.

This study presented the percentage of cases correctly classified, which is one of the methods to examine the predictive accuracy (Hosmer *et al.*, 2013), and the Hosmer–Lemeshow analysis was used for the goodness of fit. The regression models had statistically significant explanatory power with between 60 and 70 per cent of cases correctly classified, and the Hosmer–Lemeshow test showed higher than 0.05 in overall model coefficient. The range of the R^2 was from 5.6 per cent to 14.2 per cent in the categorical analysis and from 5 to 12.9 per cent in the logistic regression. A study about employees' discomfort of Aries *et al.* (2010) shows a similar range of R^2 (2 – 22 per cent) and an outlier of 27 per cent.

4.3 Study limitations

Four renovated offices and one non-renovated office were selected as case studies. This study included all collected samples for the statistical analyses, which could be a limitation of the study. The collected answers may be influenced by whether the office was renovated or not, as renovated offices are expected to have a higher environmental quality compared with non-renovated offices. To complement the issue that office renovation might affect the user satisfaction, the mean values of satisfaction were compared in Figure 4. The result showed that there were no big differences, and the non-renovated office actually showed higher satisfaction levels for some categories. Thus, all samples were included for further analyses. The scale of independent variables was recoded (e.g. satisfied and no satisfied) for the binary logistic regression. This is a common simplification to interpret being satisfied and not being satisfied instead of being dissatisfied.

This study intended to explore the indirect connection between the size of windows and psychological satisfaction. WWR was not a statistically significant predictor for the increase of satisfaction. The limitation of this study is that the research boundary condition was limited to the office design with physical design factors and socio-psychological aspects, which means that variables such as interaction with nature or view quality were not considered. Instead of including cognitive visual impact, it focussed on the analysis of the individual and organisational level of satisfaction. Lastly, this study did not investigate the impact of psychological satisfaction on overall work/job satisfaction. However, it is obvious that lack of privacy and personal territory can cause overall dissatisfaction in workplaces (De Been and Beijer, 2014; Lansdale *et al.*, 2011).

5. Conclusions

This paper examined the psychological satisfaction based on design factors for office buildings. This study explored various design parameters affecting user satisfaction. In addition, satisfaction ratings provide the data on occupants' satisfaction and no satisfaction. It clearly shows how well physical environments support the needs of the occupants. The findings suggest the relative importance of each design factor and the probability of higher

psychological users' satisfaction according to predictable design factors. Statistical analyses revealed two main significant predictors for psychological satisfaction. The following prediction models were created through the logistic regression analysis:

- Some design factors such as layout, orientation and desk location contribute to psychological user satisfaction in workplaces.
- High levels of satisfaction corresponded to "layout" except for variables of "communication" and "social contact".
- Although the WWR was a significant predictor for satisfaction with social contact, the binary logistic regression showed that the factor was not statistically significant for predicting satisfaction.
- The probability of user satisfaction increased following the order of flex < open < combi < cellular office for privacy, concentration and territoriality.
- The probability of user satisfaction increased following the order of 2-4m < 0-2m < 4m away from windows for privacy and territoriality, and 0-2m < 2-4m < 4m for communication.
- Users sitting at the N.W-oriented workplace were more satisfied than those who sit at the S.W-oriented workplace.
- The office design for the highest probability of users' satisfaction can be estimated to be a combination of N.W-oriented workplaces, working desks located at least 4m away from the windows in a cellular office layout.

From an office organisational perspective, the conclusions in this paper may not directly give directions for the best office design to increase employee satisfaction, as the results focus only on occupants' psychological comfort. To give a complete picture, criteria contributing to physical comfort should be included. Therefore, to develop a new design approach for office renovations, these results could be enhanced by including more satisfaction parameters. Nevertheless, this exploration of design factors could play a crucial role to improve occupants' satisfaction.

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