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Self-rated productivity and employee well-being in activity-based offices: The role of environmental perceptions and workspace use

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ABSTRACT

Activity-based offices are increasingly popular. However, productivity and well-being in these work environments have been little researched. The aims of this study were to quantitatively determine perception and use of the activity-based office environment in relation to self-rated productivity and well-being at work, and to identify important predictors of these outcomes. Four activity-based offices in a large Swedish government agency were surveyed 12 months after implementation. Two hundred and thirty-nine respondents were included in the analyses. Linear regression models, adjusted for relevant covariates, were constructed separately for predictors measuring satisfaction with different aspect of the environment (physical environment, privacy, communication, personalization, personal storage, IT functions and cleaning) and office use (the number of daily workspace switches, different workspaces used and the time spent looking for a workspace). Satisfaction with the physical environment, privacy and communication had the strongest positive associations with self-rated productivity and well-being at work. Increased workspace switching was associated with higher productivity, while an increase in self-reported time spent searching for a workspace was associated with lower productivity and well-being. However, predictors related to office use generally explained only a small proportion of variance in the two outcomes. The results suggest that office developers should focus particularly on privacy needs but also on communication, personalization, smooth workspace switching and minimization of work time spent looking for available workspaces.

1. Introduction

An activity-based workplace (ABW) refers to an office where workers do not have dedicated desks but are supposed to switch between workspaces designed for specific activities, such as collaboration, concentration and speech privacy [1]. The popularity of this office design is enhanced by several trends in society, particularly the rapid technological development and the increase in knowledge work [2]. As office work gets increasingly mobile and multi-locational, the ABW enables organizations to use office space more efficiently, while at the same time allowing for different tasks contained in modern office work [3,4]. Facilitating interaction is a common goal in office re-design [5,6] as collaboration is assumed to contribute to organizational performance in knowledge work [7]. ABWs are claimed to enable organizations to reduce facility costs, accommodate changes in personnel and team structure easily, and even promote sustainability through a paperless office and decreased commuting to work [4]. Improved productivity is also a common goal when implementing an ABW [4,8].

However, there is still limited scientific knowledge on the effects of ABWs on employee productivity and well-being. The perception of the office environment has been investigated more, showing generally positive results for ABWs, particularly in comparison with open-plan offices, e.g. Refs. [8–11]. Yet, productivity and well-being have clearer financial implications for organizations than satisfaction with different aspects of the environment. Any negative effects of the office design on productivity or well-being could easily exceed the intended savings in facility costs which are normally only a fraction of personnel costs [12].

Productivity is generally defined as the ratio between the input (i.e., resources, labor) and output (i.e., what is actually produced) [4]. In office work, an objective measurement of workers' performance is often not feasible, and researchers have to rely on self-ratings of perceived productivity. An advantage of subjective ratings is, however, that they

Abbreviations: ABW, an activity-based workplace

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may capture certain aspects of the input, such as motivation, effort and perceived hindrances to efficient working, which would be difficult to quantify objectively. Well-being at work, on the other hand, is by definition a subjective state, characterized by positive emotions and perceptions related to the context of work [13,14].

Several studies have compared ABWs to other office designs in terms of productivity, e.g. Refs. [4,10,11,15–18], and well-being, e.g. Refs. [10,11,17–19]. However, factors that may influence perceived productivity and well-being in ABWs have received little attention. To our knowledge, only Kim et al. [11] have examined the perception of different environmental factors in ABWs in relation to perceived productivity and health, using quantitative methods. The use of ABWs (e.g., the frequency of workspace switching) has not been examined in relation to productivity and well-being at work by any study. Identifying environmental factors associated with productivity and well-being is, however, important because it may help designers and workplace managers address the most relevant determinants of these outcomes, even before an ABW is implemented.

In many previous studies, the relation between the ABW and productivity or well-being has been assessed subjectively, i.e., researchers have examined how these outcomes are *perceived* to be affected by the environment, e.g. Refs. [4,10,11,16]. Such measures are likely biased by the respondent's general attitude towards the ABW. The relation between ABW features, productivity and well-being should be evaluated more objectively, by examining the perceived level of productivity or well-being at work *in general* and relating that to the perception of the ABW environment.

Several features of ABWs may, in theory, be relevant to productivity and well-being. Open office spaces, which are also characteristic for ABWs, decrease perceived privacy [20,21] and expose workers to different distractions, particularly coworkers' speech [22–24]. Lack of privacy is associated with lower environmental satisfaction [25,26] and stress symptoms [21,22,27], whereas irrelevant background speech has been shown to impair cognitive performance [28–31]. Thus, distractions can even be considered as an indirect indicator of decreased productivity [4]. As insufficient privacy and distractions are well-documented disadvantages of the ABW [10,16,18,32], their relation to perceived productivity and well-being in ABWs should be investigated.

The lack of dedicated desks is also associated with certain complaints. Limited possibilities for workspace personalization are associated with decreased satisfaction with the work environment [33], perceived identity threat [34] and lower team identification [35]. The effects of low privacy on emotional exhaustion could also be mitigated by workspace personalization [21] – a way of coping that is prevented by the clean-desk policy. The time spent looking for a workspace, setting up and, eventually, clearing the desk is often perceived as non-productive [4,9,11]. Other complaints in ABWs include dissatisfaction with limited storage and insufficient hygiene related to desk-sharing [11], as well as problems with ICT which may hinder workspace switching [4]. It would be important to investigate whether the complaints related to the ABW concept are also associated with productivity and well-being at work.

Interaction and collaboration are, in turn, perceived positively in the ABW according to several studies [8,32,36,37]. The only earlier study on the relation between ABW features, productivity and well-being [11] found that interaction with colleagues had the strongest relation with perceived productivity. Another factor, which could be expected to show a positive association with productivity and well-being, is workspace switching behavior. An active use of workspaces might facilitate productivity by ensuring appropriate conditions for different work tasks. Furthermore, it might enhance the sense of autonomy and control which could positively affect motivation, performance and well-being, cf. [1].

The aim of this study is to examine the extent to which workers' perception of different environmental factors and the reported use of workspaces at an ABW are associated with self-rated productivity and well-being at work. We expect that the perception of environmental factors identified in the literature (i.e., environmental satisfaction, privacy, personalization, storage space, IT functions, and cleaning), satisfaction with communication, and use of office (i.e., workspace switching, the variety of workspaces used, the time spent searching for a workspace) will be associated with both productivity and well-being at work.

2. Methods

2.1. ABWs

Employees working for a large Swedish government agency (the Swedish Transport Administration), were recruited at four office sites at different geographical locations where a relocation to ABWs had been implemented 12 months earlier. The data were originally collected for a longitudinal study with three measurement points: (I) prior to relocating to the ABW, (II) three months after relocation, and (III) 12 months after relocation (for more details, see Ref. [38]). Due to the nature of the research questions, only cross-sectional data from the 12-months follow-up in the ABW is used in this study.

The four ABWs generally contained web-meeting rooms, project rooms, single rooms for telephone calls, conversation rooms, meeting rooms, large open-plan room(s) accommodating 24 workers or more, quiet rooms/zones, and conference rooms. The four ABWs differed, however, in size and spatial design. The total area of the office ranged from 775 m^2 to 14,714 m^2, and the area per employee ranged from 12 m^2 to 22 m^2. Prioritized workstations (i.e., workstations giving priority to employees with special needs), a lounge area, and single rooms for phone calls were available in some, but not all, ABWs. Photographs of the ABWs are provided in Supplementary material.

The relocation to ABWs was planned, initiated and implemented by the agency without interference from the researchers. The study was approved by the Regional Ethical Review Board in Uppsala, Sweden (Dnr.2015/118) and all respondents provided their written informed consent prior to participation.

2.2. Respondents

We approached 514 employees at the four ABWs with a questionnaire 12 months after the relocation, achieving response rates of 60% (Office A), 64% (Office B), 76% (Office C) and 66% (Office D). Respondents who did not work in an ABW and who were not present at their primary office for at least 30% of time were excluded. Data from, in total, 239 respondents (49, 57, 33 and 100 in Offices A-D, respectively) were included in further analyses. Descriptive statistics of the sample are given in Table 1.

2.3. Measures

The questionnaire addressed several issues. The following items were analyzed in this study.

Age and *gender* were included as basic demographic covariates. *Managerial position* (yes, no) was also used as a covariate because initial analyses showed that managers gave higher ratings for productivity and well-being than employees in non-managerial positions. In addition, *perceived general health* was included as another covariate because it is associated with self-ratings of performance [39] and can be viewed as a sub-component of well-being [13]. It was measured with one item from the SF-36 Health Survey ("Overall, would you say your health is …? Excellent, very good, good, fair, poor" [40]). The highest two and the lowest two categories were combined to arrive at a 3-category variable.

Satisfaction with the physical environment was measured on a 5-point scale. The responses were merged into three categories: satisfied (comprising satisfied and very satisfied), neutral (neither satisfied nor dissatisfied) and dissatisfied (comprising dissatisfied and very dissatisfied).

Table 1
Descriptive statistics for variables included in the study. N = 239.

Variable	Category	%	Mean	SD
Population statistics				
Gender	Women	46		
	Men	54		
Age			48.9	9.6
Managerial position	No	79.9		
	Yes	20.1		
Perceived general health	Poor	15.1		
	Good	30.5		
	Very good	54.4		
Predictors				
Satisfaction with the physical environment	Dissatisfied	38.1		
	Neutral	25.5		
	Satisfied	36.4		
Satisfaction with privacy[a]			2.99	1.54
Satisfaction with communication[a]			4.63	1.47
Satisfaction with possibilities to personalize workspaces[a]			2.58	1.94
Satisfaction with personal storage[a]			3.50	1.88
Satisfaction with IT functions[a]			4.75	1.52
Satisfaction with cleaning[a]			4.12	1.63
Number of workspace switches per day	No changes	28.5		
	1-3	55.2		
	4 more	16.3		
Number of different workspaces used	1–3	35.6		
	4–6	33.1		
	7–15	31.4		
Time spent looking for a workspace per day	0 min	38.2		
	1–5 min	15.1		
	6–15 min	31.5		
	16–60 min	15.1		
Outcome variables				
Productivity[b]			6.27	2.20
Well-being at work[c]			4.90	1.37

[a] Scale: 1 'Very dissatisfied' – 7 'Very satisfied'.
[b] Scale: 0 'Not at all productive' – 10 'Maximally productive'
[c] 7-point scale, see Section 2.3.

Satisfaction with privacy included six items concerning perceived noise, acoustic privacy and visual shields (Cronbach's $\alpha = 0.94$) of which four were adopted from Ref. [26]. *Satisfaction with communication* was measured using three items concerning information exchange and overall communication with the closest colleagues and the possibility to engage colleagues quickly for short matters ($\alpha = 0.86$). Single questions were used to measure *satisfaction with possibilities to personalize workspaces, personal storage, IT functions* and *cleaning*. All these questions were measured on a 7-point scale (1: Very dissatisfied – 7: Very satisfied).

The *number of workspace switches* was assessed with a question "How many times during a work day do you normally switch between different workspaces" (0: Work in the same place the whole day – 10: 10 or more times). The responses were merged into three categories: no switches, 1–3 switches and 4 or more switches per day.

The use of different workspaces during an average week was rated using a 5-point scale (all the time, often, sometimes, rarely, never). Seventeen different workspaces were rated (for examples, see Section 2.1). A score for the *number of different workspaces used* was created by calculating the number of workspaces reported to be used at least sometimes by the respondent. This variable was then merged into three categories: 1–3, 4–6 and 7–15 workspaces used.

The time spent looking for workspace was based on two questions from Ref. [6]: "Do you need to spend time to look for a suitable workspace?" (yes/no), and "How many minutes per day do you spend looking for a suitable workspace?" Respondents reporting 'no' to the first question, were assigned a value of 0 min. Four categories were formed: 0, 1–5, 6–15 and 16–60 min (60 min was the highest response given). Perceived *productivity* was assessed on an 11-point scale: "What score would you give to your overall productivity over the past month?" (0: Not at all productive, 10: Maximally productive).

Well-being at work was assessed on a 7-point scale using seven faces with expressions ranging from very happy/satisfied to very sad/dissatisfied ("Here are some faces that express different degrees of well-being. Which of the faces expresses best how you have experienced your well-being at work over the past four weeks?" [41]). The scale was reversed so that higher values indicate more well-being.

2.4. Statistical analyses

Statistical analyses were conducted using IBM SPSS Statistics 24 (Armonk, NY: IBM Corp). Prior to the analyses, categories of some variables were merged (see Section 2.3) to avoid loss of statistical power due to categories with too few responses. The items measuring office use (i.e., the number of workspace switches and different workspaces used, and the time spent looking for workspace) were categorized due to strong skewness to the right. Thus, the highest categories include a wider range of responses to avoid too small categories. Different ways of categorization were examined and categories that produced similar estimates were merged.

Effects of each predictor on both outcomes (i.e., productivity and well-being at work) were determined using two-step linear regression. The models were adjusted for age, gender and managerial position (Model 1). Additional models were constructed with further adjustment for general health (Model 2). Perceived general health was included in the model separately because of the possibility that it could abolish associations between predictors and well-being at work, due to the conceptual overlap between this outcome and general health. Adjusted R^2 is reported as a measure of model fit. In both models, covariates were first entered alone in the model followed by the predictor variable at the second step. This was done to determine the proportion of variance explained by the predictor which is indicated by the change in adjusted R^2 between the first and second step. Assumptions of normality, linearity, homoscedasticity, and absence of multicollinearity were checked. For each model, effect estimates (B) were determined with 95% confidence intervals (CI). Unstandardized estimates are reported below, unless otherwise stated. Standardized coefficients (β) were calculated and used in comparisons of models.

3. Results

Descriptive data for all variables are shown in Table 1. Respondents were most satisfied with communication and IT functions, and least satisfied with privacy and possibilities to personalize workspace. Initial analyses showed that one of the four offices (Office C) had higher ratings of productivity and most predictor variables, particularly among managers. However, excluding this workplace did not affect the essential findings reported below, and results are, therefore, reported with all four offices included. Correlations between variables are shown in Table 2. Unadjusted associations are shown in diagrams for satisfaction with privacy (Fig. 1) and the time spent looking for workspace (Fig. 2), in relation to both outcomes. Diagrams for all other unadjusted associations are provided in Supplementary material.

3.1. Productivity

Estimates of the associations between each predictor and productivity, adjusted for age, gender and managerial position (Model 1) as well as for general health (Model 2), are shown in Table 3. Age, gender and managerial position explained together only 2% of variance in productivity while general health explained incremental 14% of variance.

Of the different predictors in Model 1, overall satisfaction with the physical environment was positively associated with productivity, improving the model fit substantially (18%) in comparison to only including covariates. The difference between dissatisfied and satisfied employees corresponded to 2.2-units (unstandardized estimates) improvement in productivity (measured on an 11-point scale). Among

Table 2
Correlations between predictors and outcome variables. Pearson's correlation coefficient is reported for associations between continuous variables and Spearman's correlation coefficient for associations involving categorical variables (see Table 1).

		1	2	3	4	5	6	7	8	9	10	11	12
1	Satisfaction with the physical environment	–											
2	Satisfaction with privacy	0.651***	–										
3	Satisfaction with communication	0.498***	0.661***	–									
4	Satisfaction with possibilities to personalize	0.499***	0.693***	0.444***	–								
5	Satisfaction with personal storage	0.325***	0.439***	0.381***	0.409***	–							
6	Satisfaction with IT functions	0.218**	0.268***	0.359***	0.246***	0.397***	–						
7	Satisfaction with cleaning	0.378***	0.438***	0.367***	0.397***	0.340***	0.272***	–					
8	Number of workspace switches per day	0.280***	0.288***	0.177**	0.244***	0.075	−0.026	0.210**	–				
9	Number of different workspaces used	0.360***	0.376***	0.267***	0.349***	0.239***	0.052	0.206**	0.420***	–			
10	Time spent looking for a workspace per day	−0.333***	−0.366***	−0.424***	−0.256***	−0.216**	−0.130*	−0.186**	0.110	−0.081	–		
11	Productivity	0.456**	0.520***	0.478***	0.365***	0.282***	0.255***	0.263***	0.192**	0.233***	−0.257***	–	
12	Well-being at work	0.433**	0.386***	0.438***	0.306***	0.203**	0.276***	0.236***	0.131*	0.267***	0.195**	0.485***	–

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

other items, satisfaction with privacy ($B = 0.73$) and communication ($B = 0.71$) had the strongest positive associations with productivity. Satisfaction with privacy explained the largest proportion of variance (25%) among all predictors, followed by satisfaction with communication (22%). Including general health as a covariate (Model 2) decreased all three estimates and the proportion of variance explained slightly without changing the observed pattern of associations.

Satisfaction with the possibility to personalize, personal storage, IT functions and cleaning showed weaker, but still positive, associations ($B = 0.33–0.40$, Model 1). Thus, a one-unit increase in any of these four items (measured on a 7-point scale) was associated with less than a half-unit increase in productivity. Based on the standardized estimates and the change in adjusted R^2, satisfaction with personalization appeared, however, to be more strongly associated with productivity than satisfaction with personal storage, IT functions and cleaning. The variance explained by personalization (12%) was roughly double that of the other three predictors. Again, the observed associations remained similar when further adjusting for general health even though the size of the estimates and the proportion of variance explained slightly decreased (Model 2).

Regarding workspace use, a higher number of workspace switches per day and a larger number of different workspaces used were associated with higher productivity (Model 1). Compared to not switching workspace during the day, productivity increased among workers switching 1–3 times per day ($B = 0.80$), and increased further with more frequent switches ($B = 1.18$). The benefits of changing workspace were less apparent when measured by the number of different workspaces used; the number of workspaces needed to exceed six for productivity ratings to increase ($B = 1.25$). These predictors explained only 3–5% of variance in Model 1. Nevertheless, they remained statistically significant in Model 2, despite a decrease in the size of estimates and in the proportion of variance explained.

More time spent looking for a workspace was associated with lower productivity, even though this association was statistically non-significant when only 1–5 min were spent looking ($B = -0.58$; 95% CI: -1.4-0.25, Model 1). Spending 6–15 min and 16–60 min were associated with decreases of 1.10 units and 1.30 units in productivity, respectively. The time spent looking for workspace explained only 5% of variance in productivity. As with other predictors, the size of the estimates and the proportion of variance explained decreased in Model 2.

3.2. Well-being at work

The results for the regression models for well-being at work are shown in Table 4. Age, gender and managerial position explained a very small proportion of variance in this outcome (2%). Including general health improved the model fit substantially, as it explained 24% of variance in well-being at work.

Of the different predictors in Model 1, overall satisfaction with the physical environment was positively associated with well-being at work ($B = 0.90–1.3$, Table 4). Satisfaction with communication ($B = 0.41$) had a stronger positive association with well-being than satisfaction with privacy ($B = 0.33$). Satisfaction with communication explained the largest proportion of variance among predictors (19%), followed by satisfaction with the environment (17%) and privacy (13%). Again, including general health as a covariate decreased the estimates and the proportion of variance explained while the pattern of associations remained otherwise similar.

Satisfaction with personalization ($B = 0.20$) and IT functions ($B = 0.25$) showed weaker associations, while still positive and statistically significant (Model 1). They explained 8% and 7% of variance, respectively. The associations for personal storage and cleaning were even weaker, but statistically significant. A one-unit increase in these variables corresponded to less than 0.2-units improvement in well-being, measured on a 7-point scale, explaining 4–5% of variance. The associations remained statistically significant in Model 2, despite the

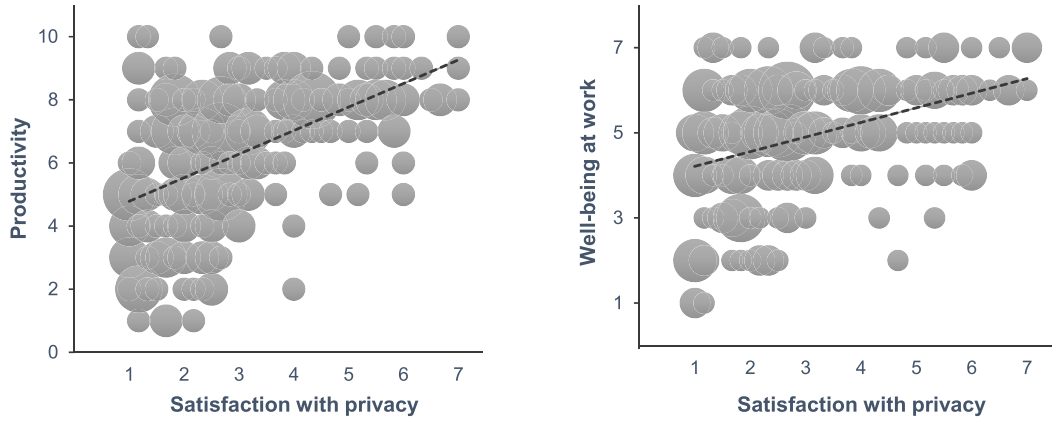

Fig. 1. Associations between satisfaction with privacy and the outcomes productivity (left) and well-being at work (right) with fitted unadjusted regression lines. Bubble areas are proportional to the number of respondents sharing a particular (x,y)-combination, ranging from one to six respondents for productivity and from one to seven for well-being. See Supplementary material for more diagrams.

decrease in estimate sizes and in the proportion of variance explained.

Well-being was higher when switching workspace 1–3 times during the day than when not switching at all ($B = 0.51$) whereas switching more than that showed a weaker effect, which could not be confirmed statistically to differ from not switching at all ($B = 0.23$; 95% CI: −0.32-0.77, Model 1). These associations became statistically non-significant when further adjusting for general health (Model 2).

Furthermore, using 7–15 different workspaces was associated with better well-being than using 1–3 workspaces ($B = 0.66$, Model 1). The middle category of using 4–6 workspaces differed only a little from using 1–3 workspaces, and the difference was not significantly different from zero ($B = 0.27$, 95% CI: −0.15-0.68). Well-being decreased when 6–15 minutes ($B = -0.64$) or more ($B = -0.73$) were spent looking for a workspace compared with not spending any time. The number of workspaces used explained only 3% of variance in well-being while the time spent looking for workspace explained 5%. These associations remained statistically significant in Model 2 despite the decrease in estimate sizes and in the proportion of variance explained.

4. Discussion

This study examined the perceptions of the ABW in relation to self-rated productivity and well-being at work. To our knowledge, only Kim et al. [11] have quantitatively investigated this question before. We also examined the role of office use which has not been explored in relation to productivity and well-being in previous research. Yet, the assumption that activity-based use of workspaces can facilitate work performance and employee satisfaction is central to the ABW concept. We found that positive perceptions of the ABW environment and communication and more active use of workspaces were associated with higher productivity and well-being at work, whereas the time spent looking for a workspace was associated with lower productivity and well-being. Standardized estimates of the associations between the investigated predictors and productivity were generally slightly larger than the corresponding associations with well-being at work. The fact that the findings persisted even after adjusting for general health further supports the assumption that the use and perception of the ABW have their own role in productivity and well-being.

4.1. Satisfaction with the ABW environment and communication

Overall, satisfaction with the physical environment had a positive association with both productivity and well-being at work. This was expected as several environmental factors have been associated with

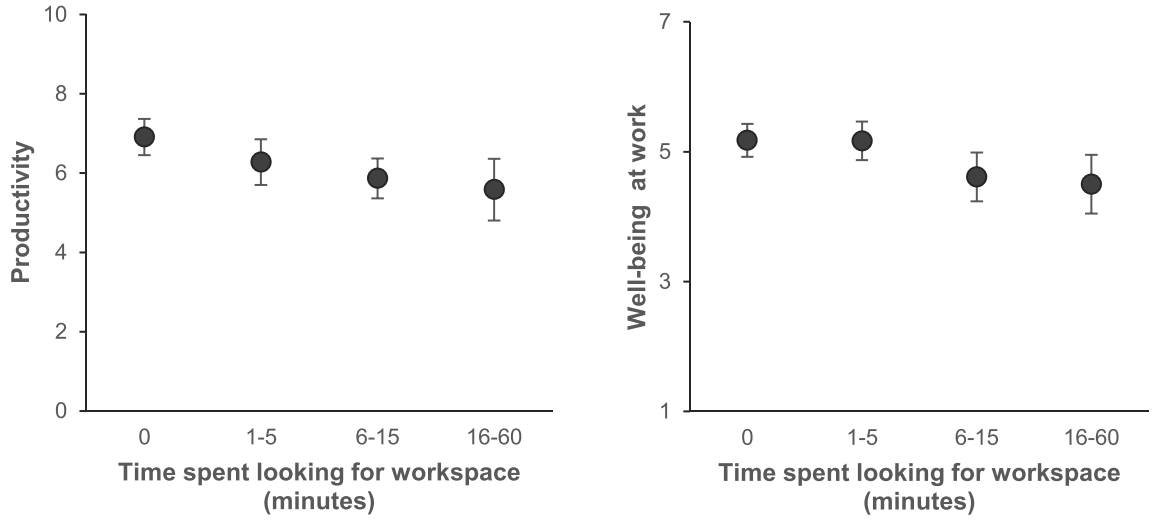

Fig. 2. Unadjusted associations between the time spent looking for workspace and the outcomes productivity (left) and well-being at work (right). Diagrams show the means for each answer category with 95% confidence intervals. See Supplementary material for more diagrams.

Table 3
Results from the regression models for self-rated productivity. The table shows unstandardized estimates (*B*) with lower and upper 95% confidence limits, standardized estimates (β), *p*-values indicating the probability of the "true" *B* being, in fact, zero, and adjusted R^2 as a measure of model fit. The change in adjusted R^2 indicates the percentage of variance explained by the predictor. Model 1 is adjusted for age, gender and managerial position; Model 2 includes also perceived general health.

	Model 1						Model 2					
	B	*95% CI*	β	*p*	Adjusted R^2	Adjusted R^2 change	*B*	*95% CI*	β	*p*	Adjusted R^2	Adjusted R^2 change
Covariates (Step 1)					0.02						0.16	
Gender												
Men	−0.47	−1.04; 0.09	−0.11	0.101			−0.53	−1.05; 0.00	−0.12	0.049		
Women (ref.)												
Age	0.01	−0.02; 0.04	0.02	0.712			0.01	−0.02; 0.04	0.04	0.526		
Managerial position												
Yes	0.84	0.15; 1.54	0.15	0.017			0.60	−0.05; 1.24	0.11	0.071		
No (ref.)												
General health												
Poor							−2.30	−3.05; −1.55	−0.37	0.000		
Good							−1.18	−1.77; −0.60	−0.25	0.000		
Very good (ref.)												
Predictors (Step 2)												
Satisfaction with the physical environment					0.21	0.18					0.29	0.12
Satisfied	2.23	1.65; 2.82	0.49	< 0.001			1.89	1.31; 2.46	0.41	< 0.001		
Neutral	1.02	0.38; 1.66	0.20	0.002			0.91	0.30; 1.52	0.18	0.003		
Dissatisfied (ref.)												
Satisfaction with privacy	0.73	0.57; 0.89	0.51	< 0.001	0.27	0.25	0.65	0.50; 0.81	0.45	< 0.001	0.35	0.19
Satisfaction with communication	0.71	0.54; 0.88	0.47	< 0.001	0.24	0.22	0.63	0.46; 0.79	0.42	< 0.001	0.33	0.16
Satisfaction with possibility to personalize	0.40	0.26; 0.53	0.35	< 0.001	0.14	0.12	0.35	0.22; 0.48	0.31	< 0.001	0.25	0.09
Satisfaction with personal storage	0.33	0.19; 0.48	0.29	< 0.001	0.10	0.07	0.29	0.15; 0.43	0.25	< 0.001	0.22	0.05
Satisfaction with IT functions	0.37	0.19; 0.54	0.25	< 0.001	0.08	0.06	0.31	0.15; 0.48	0.22	0.001	0.21	0.04
Satisfaction with cleaning	0.37	0.21; 0.54	0.28	< 0.001	0.09	0.07	0.32	0.16; 0.47	0.23	< 0.001	0.22	0.05
Number of workspace switches per day					0.05	0.03					0.18	0.02
4 or more	1.18	0.30; 2.05	0.20	0.009			1.06	0.25; 1.88	0.32	0.005		
1–3	0.80	0.17; 1.44	0.18	0.013			0.58	−0.02; 1.18	0.17	0.064		
None (ref.)												
Number of workspaces used					0.07	0.05					0.19	0.03
7–15	1.25	0.55; 1.96	0.26	0.001			0.98	0.32; 1.64	0.21	0.004		
4–6	0.24	−0.42; 0.91	0.05	0.471			0.06	−0.57; 0.68	0.01	0.857		
1-3 (ref.)												
Time spent looking for workspace					0.07	0.05					0.19	0.03
16–60 min.	−1.32	−2.15; −0.49	−0.21	0.002			−1.17	−1.95; −0.40	−0.19	0.003		
6–15 min.	−1.06	−1.72; −0.40	−0.22	0.002			−0.78	−1.40; −0.16	−0.16	0.014		
1–5 min.	−0.58	−1.42; 0.25	−0.09	0.172			−0.57	−1.35; 0.20	−0.09	0.146		
0 min. (ref.)												

ref. = reference category.

Table 4
Results from the regression models for well-being at work. The table shows unstandardized estimates (*B*) with lower and upper 95% confidence limits, standardized estimates (β), *p*-values indicating the probability of the "true" *B* being, in fact, zero, and adjusted R^2 as a measure of model fit. The change in adjusted R^2 indicates the percentage of variance explained by the predictor. Model 1 is adjusted for age, gender and managerial position; Model 2 includes also perceived general health.

	Model 1						Model 2					
	B	*95% CI*	β	*p*	Adjusted R^2	Adjusted R^2 change	*B*	*95% CI*	β	*p*	Adjusted R^2	Adjusted R^2 change
Covariates (Step 1)					0.02						0.26	
Gender												
Men	0.06	−0.28; 0.41	0.02	0.728			0.03	−0.28; 0.33	0.01	0.866		
Women (ref.)												
Age	0.00	−0.02; 0.01	−0.03	0.654			0.00	−0.02; 0.01	−0.01	0.881		
Managerial position												
Yes	0.60	0.17; 1.03	0.18	0.007			0.42	0.04; 0.80	0.12	0.031		
No (ref.)												
General health												
Poor							−1.89	−2.33; −1.45	−0.50	0.000		
Good							−0.82	−1.17; −0.48	−0.28	0.000		
Very good (ref.)												
Predictors (Step 2)												
Satisfaction with the physical environment					0.19	0.17					0.36	0.10
Satisfied	1.31	0.95; 1.68	0.46	< 0.001			1.02	0.68; 1.36	0.36	< 0.001		
Neutral	0.90	0.50; 1.30	0.29	< 0.001			0.81	0.45; 1.16	0.26	< 0.001		
Dissatisfied (ref.)												
Satisfaction with privacy	0.33	0.22; 0.44	0.37	< 0.001	0.15	0.13	0.26	0.16; 0.36	0.29	< 0.001	0.35	0.09
Satisfaction with communication	0.41	0.30; 0.52	0.44	< 0.001	0.21	0.19	0.34	0.24; 0.43	0.36	< 0.001	0.38	0.12
Satisfaction with possibility to personalize	0.20	0.12; 0.29	0.29	< 0.001	0.10	0.08	0.17	0.09; 0.24	0.24	< 0.001	0.31	0.05
Satisfaction with personal storage	0.15	0.06; 0.25	0.21	0.001	0.06	0.04	0.12	0.04; 0.20	0.16	0.004	0.28	0.02
Satisfaction with IT functions	0.25	0.14; 0.35	0.27	< 0.001	0.09	0.07	0.20	0.11; 0.30	0.23	< 0.001	0.31	0.05
Satisfaction with cleaning	0.20	0.09; 0.30	0.24	< 0.001	0.07	0.05	0.15	0.06; 0.24	0.18	0.001	0.29	0.03
Number of workspace switches per day					0.04	0.02					0.26	0.00
4 or more	0.23	−0.32; 0.77	0.06	0.413			0.15	−0.33; 0.63	0.04	0.543		
1–3	0.51	0.12; 0.91	0.19	0.011			0.33	−0.03; 0.68	0.12	0.069		
None (ref.)												
Number of workspaces used					0.05	0.03					0.27	0.01
7–15	0.66	0.22; 1.10	0.23	0.003			0.43	0.04; 0.82	0.15	0.029		
4–6	0.27	−0.15; 0.68	0.09	0.209			0.11	−0.25; 0.48	0.04	0.542		
1-3 (ref.)												
Time spent looking for workspace					0.07	0.05					0.28	0.02
16 min. or more	−0.73	−1.25; −0.21	−0.19	0.006			−0.62	−1.08; −0.17	−0.16	0.007		
6–15 min.	−0.64	−1.05; −0.23	−0.22	0.002			−0.42	−0.78; −0.05	−0.14	0.025		
1–5 min.	−0.05	−0.57; 0.46	−0.01	0.836			−0.05	−0.50; 0.41	−0.01	0.829		
0 min. (ref.)												

ref. = reference category.

perceived productivity effects before [11] and the overall satisfaction with the physical environment likely captures their combined effect. Other studies have observed that the perceived physical environment influences where employees prefer to work within an ABW [11,42], demonstrating its importance to workers.

Satisfaction with privacy and communication had the largest effect sizes among predictors measuring satisfaction with specific aspects of the ABW. They also outweighed satisfaction with personalization, storage, IT functions and cleaning, as well as the variables related to office use, in the proportion of variance explained (Tables 3 and 4). Both privacy and communication have been highlighted in previous literature portraying lack of privacy as a disadvantage of the ABW [10,16,32] and ease of communication as an advantage [43]. Our results are consistent with previous observations that possibilities to both concentrate and collaborate have high priority among office workers [36,44]. Lack of privacy may impair productivity directly through the effects of noise on cognitive performance [31] but it is also a source of stress affecting well-being [21,27]. The association between communication and productivity is, in turn, compatible with the emphasis of collaboration in knowledge work [7]. The positive association between communication and well-being likely stems from the quality of interpersonal relationships at the workplace in general which is associated with worker satisfaction and stress through several mechanisms [27,45,46]. From this perspective, it is not surprising that satisfaction with communication appears more important for well-being than any aspect of the physical environment (Table 4).

Even though limited possibilities for personalization are discussed as a concern in the ABW, e.g., Refs. [1,11,47], the present results suggest that they are less important than privacy and communication. This appeared particularly in the proportion of variance explained, but also in the standardized estimates (Tables 3 and 4). Consistent with our findings, personalization did not have particularly large effect size in the study by Kim et al. [11], while still being a statistically significant predictor. Interestingly, personalization appeared more important for productivity than for well-being at work even though it is suggested to be related to important psychological needs in the literature, e.g. Refs. [47,48]. Satisfaction with personal storage, IT functions and cleaning had weaker and similar effect sizes, as indicated by overlapping confidence intervals on *B* (Tables 3 and 4). Thus, while personalization, storage, IT functions and cleaning may be sources of dissatisfaction (Table 1, [4,11,36]), they appear to have limited relevance to productivity and well-being at work. However, these factors likely contribute to general satisfaction with the environment, which did show a clear relation to productivity and well-being in our study.

4.2. The use of the ABW

Confirming the core premises of the ABW, we found that more active use of workspaces was associated with improved productivity and well-being at work. The observed frequency of workspace switches differed, however, remarkably from that reported in earlier studies. In our population, only 29% did not switch workspace at all during the day, compared to 68% reported by Appel-Meulenbroek, Groenen and Janssen [42] and 95% by Hoendervanger, De Been, Van Yperen and Albers [49]. Our results agree, however, with these two studies in showing that very active switching is rare. While the differences in switching behavior may partly stem from the different metrics used, the results suggest that our population may have matched the concept of the ABW better and, thus, provided a valid context for the present research questions related to productivity and well-being in ABWs if they are used as intended.

Workspace switching had slightly differing relations to productivity and well-being at work. Productivity increased with more daily switches whereas, for well-being, switching workspace more than 3 times had no advantage over working in the same place all day. On the other hand, using a larger number of different workspaces was positively associated with well-being at work. This contradiction may be explained by the timeframe of these questions: workspace switches were assessed on a daily level while the use of different workspaces concerned a normal work week. The finding that a few switches have a more favorable association with well-being than no or more switches may suggest that switching entails some negative consequences, which, above a certain threshold, exceed the initial benefits. Frequent switching increases the time and effort spent on practical arrangements, and workers may perceive that as additional work. This may also explain why switching during the work day is avoided according to other studies [42,49]. In theory, such difficulties should also decrease perceived productivity, and so it is surprising why we found this pattern only for well-being.

The benefits of actively using different workspaces within ABWs can be explained by several mechanisms. The most obvious explanation is that by actively choosing different workspaces, employees more likely work in conditions that help them to effectively perform their work. The possibility to withdraw to quiet workspaces appears to be particularly important in this respect [22]. Having several workspaces to choose from may also enhance the perception of environmental control which is positively associated with satisfaction with the environment and the job [25], as well as perceived job performance [50]. In addition, workspace switching has the potential to improve well-being through increased physical activity and breaks from sedentary work. However, studies including objective activity measurements suggest that moving into an ABW has no or only modest effects on physical activity and sedentary behavior [9,51] although differences between workplaces can be substantial [38]. No studies have so far specifically focused on the effects of workspace switching on metabolic outcomes and musculoskeletal health, which is an interesting issue considering the current debate on negative health effects of sedentariness [52–55].

However, the work time lost while looking for a suitable workspace may reduce the benefits of workspace switching. Notably, productivity was reduced already with as few as 1–5 min of search time, although the decrease was not pronounced until even more time was spent. For well-being at work, losing only 1–5 min was not an issue, while more time use was negative. As nearly 50% of the respondents reported to spend at least 6 minutes looking for workspace daily (Table 1), the related decrease in productivity and well-being at work probably have notable implications for organizational productivity. Our results suggest that measuring lost work time with a good resolution may be very informative in studies of ABWs.

The comparison of different models shows that the estimates related to office use were more uncertain than those concerning satisfaction, as shown by wider confidence intervals (Tables 3 and 4). This is partly a result of merging these items into categories, resulting in some loss of measurement accuracy. The office use predictors explained only a few percent of variance in the outcomes. The results suggest that satisfaction with the physical environment, privacy, communication and personalization are more strongly related to productivity and well-being in the ABW than the use of activity-based workspaces. Our findings also suggest that the perception and use of the ABW has a stronger association with productivity than it does with well-being at work. This is logical given that work performance may be affected immediately by adverse work conditions, whereas well-being may change in a longer and more complex process that is also moderated by the adaptive capacity of the individual.

4.3. Strengths and limitations

Our study offers novel results on the perception and use of ABWs. It is the first to quantitatively associate specific aspects of the ABW to

general measures of perceived productivity and well-being at work. Several earlier studies have measured the *perceived impact* of the environment on productivity and well-being, e.g. Refs. [4,10,11,16], not the *perceived actual level* of productivity and well-being. While such an approach adds to knowledge on ABWs, the methodology used in our study is more objective in relating specific environmental variables to self-rated productivity and well-being at work. Another strength of our study is that the effects of relevant covariates were controlled for in the statistical models; this does not appear to have been addressed in the study of Kim et al. [11]. Controlling for covariates was particularly important due to the cross-sectional design of our study.

Owing to the cross-sectional nature of our study, causal relationships should not be inferred from the findings. In terms of practical implications, it is unclear whether improvements in, for example, privacy and number of workspace switches would lead to higher productivity and well-being at a specific ABW. The factors identified in the present study could be addressed in intervention studies to gain stronger evidence on effects of actually changing them.

In addition, the self-reports of the time spent looking for workspace are likely inaccurate due to perceptual and psychological sources of bias involved in time estimation [56]. In an ABW, the inaccuracy of reported time is probably amplified by the fact that attention is not focused on estimating time but on finding a workspace, and that estimation is retrospective and represents a perceived average. As time perception is influenced by arousal and emotions [57], frustrations experienced when searching for workspaces might lead to an overestimate of the lost work time. However, in that case, the negative effect could be present already at shorter time losses than those suggested by our results. Future studies could combine objective measures (e.g., on-site tracking or observation) with surveys or diary methods to investigate the actual time lost navigating in the office, and then relate it to productivity and well-being at work.

The generalizability of the findings is restricted by the fact that data were only gathered in one Swedish organization. The possibility of confounding due to differences between the four ABWs (see Section 2.1) cannot be ruled out although the findings remained similar when the analyses were re-run excluding the office where some results deviated from the other three. The current population exhibited a low-to-neutral level of satisfaction (Table 1), and ABWs with higher satisfaction levels have been described in the literature [4,36]. The use of workspaces, however, matched the concept of the ABW better than what has been reported in some other studies [42,49].

Our statistical models tested only one predictor at a time; we did not construct multivariate models due to multicollinearity issues. Thus, strong conclusions should not be drawn on the relative importance of variables, including whether the factors with the lowest effect sizes are, indeed, important or not. As the distributions of ABW use appear highly skewed, larger populations are needed to gain a more detailed view of the relation between activity-based working and outcomes related to performance and well-being.

4.4. Practical implications

Our findings suggest that the perception of the ABW and the way it is used influence organizational performance, through effects on employee productivity and well-being at work. As satisfaction with communication tends to be high already in ABWs [43], workplace design and management should particularly focus on improving privacy. This is also important for maintaining good communication, as annoyance with office distractions may spill over on the perception of interpersonal relations [22]. Privacy can be increased by providing sufficient, easy accessible quiet workspaces or zones, by adopting behavioral codes that diminish distractions, and by improving room acoustic design. In terms of office use, attention should be paid to smooth workspace switching and reducing time spent navigating in the office. This can be achieved, for example, by information systems providing a real-time overview of vacant workspaces.

4.5. Conclusions

This study showed that the perception of activity-based offices as well as the way these offices are used are associated with self-rated productivity and well-being at work. Our results showed that both of these outcomes were most strongly associated with satisfaction with privacy, communication and the physical environment in general. Satisfaction with personalization was less important and even weaker associations were observed for satisfaction with storage, IT functions and cleaning. An active use of different workspaces was associated with higher productivity and well-being but the work time lost while looking for workspace was detrimental to both outcomes. Overall, our results suggest that initiatives focusing on improving privacy, communication and smooth workspace switching should be particularly prioritized when striving for good productivity and well-being in activity-based offices.

Author contributions

AH contributed to the research questions and data processing, conducted the statistical analyses, and drafted and revised the manuscript. DM contributed to planning and designing the study, gave advice on the statistical analyses, and critically revised the manuscript. SEM contributed to planning and designing the study and critically revised the manuscript. HJ initiated the project and received funding, designed and planned the study, coordinated data collection, took part in decisions concerning statistical analyses and critically revised the manuscript.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.buildenv.2018.09.017.

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