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The effects of activity-based workplaces on contributors to organizational productivity: A systematic review

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ABSTRACT

The activity-based workplace (ABW) provides a variety of spaces where work can be performed. Employees have no assigned seats but are expected to change their locations in the workplace to suit their activities. We conducted a systematic review of the literature evaluating this strategy, identifying 23 investigations between 2000 and 2020 in which there was a comparison between ABW and another workplace layout examining outcome measures that influence organizational productivity, and which met criteria for internal and external validity. We grouped the office layouts into cellular offices (1–2 occupants), small rooms (2–9 occupants), medium open plan (10–24 occupants), large open plan offices (>24 occupants), and ABWs. We categorised 78 dependent variables into nine categories: environmental satisfaction, social relations, personal space, cognitive performance, work output, job satisfaction and commitment, job characteristics, health and well-being, and physical activity, and evaluated each paper's results for the comparisons between ABW and the other layouts. Comparisons of ABWs to cellular offices favoured the cellular offices for all categories except physical activity, for which there were no data. For other office types, as the number of people in the comparison office increased, the greater the tendency for the comparison to favor ABWs. People want and need spaces to support attention and focus. Organizations looking to save real estate costs should weigh these savings against the overall effect of their design choices on organizational productivity.

1. Introduction

Workplaces have been a focus of environmental psychology research and application for over 50 years (Brookes & Kaplan, 1972; Sundstrom, 1986). Office layout has been a particular focus, particularly with the increasing adoption of open-plan offices (Brill et al., 1984; Zalesny & Farace, 1987). Recognizing that organizational productivity is found in the balance between input costs (e.g., lowering recruitment costs, reducing absenteeism) and output value (i.e., increasing the quality or quantity of outputs; Pritchard, 1992), researchers have developed multivariable models for understanding how individuals respond to their work environments, encompassing environmental satisfaction, perceived privacy, and job performance (Becker, 1985-1986; Vischer, 1989, 2007). Despite this long history, media coverage of office environments in the years immediately prior to the pandemic makes clear that the evidence and its application have not resulted in satisfactory or healthful work environments (Hopland & Kvamsdal, 2020; Kalish, 2018; Megahed & Ghoneim, 2020; Pochepan, 2018; Sarkis, 2019).

The potential benefits to organizations that provide suitable office environments has, similarly, been clear for decades. Employees provide the products that generate value for organizations, whether they are software, designs, or documents. The salaries and benefits of the people who make those products dominate the expenses of organizations. Two common estimates are the rule-of-thumb that people cost $300 per square foot, operating costs are $30 per square foot, and capital costs are $3 per square foot (Jones Lang Lasalle (JLL), 2014), or the BOSTI breakdown in which staff costs are 82%, IT equipment and training cost 10%, building maintenance and operations cost 3%, and the capital costs of building and furnishings cost 5% (Brill et al., 2001). Both estimates should lead one to conclude that changes to work environments ought to focus on providing conditions that support employees in their work and that reduce or remove costs related to employees (Haynes, 2007).

Newsham et al. (2022) conducted a systematic review comparing the effects of several corporate strategies on organizational productivity outcomes including absenteeism, job satisfaction, environmental satisfaction, overall well-being, and self-rated job performance. They compared improvements made for the purpose of improving

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sustainability to other corporate strategies that might be adopted with the intent of improving organizational outcomes; one of these strategies was the change from a traditional, individual cellular office layout to an open-plan layout. The review found that the open-plan design (either with or without partially enclosed cubicles) had adverse effects on all of the organizational productivity outcomes. Despite these increased personnel-related costs to employers, open-plan offices (OPOs) are the dominant form of office space and have been for decades.

With the advent of wireless connectivity and lightweight portable computing, the potential for making offices paperless and mobile has led to a further step in open office design. It is now possible for many employees to carry their work with them on mobile electronic devices as they move from one space to another. This led to the design concept that by providing spaces of varying functionality, to which individuals move as their tasks require, it might be possible to improve the instantaneous fit between the individual and their task needs. Such spaces feature unassigned seating and are mostly known as activity-based workplaces (ABWs), although they also have been called flexible workplaces and 'hot-desking'. The design premise brings with it assumptions about the effects of such workplaces on the potential for collaboration and communication (both thought to improve with the removal of more barriers), but some writers observe that the driving forces are often more clearly seen in expectations about the potential for reduced real estate costs and increased space utilization metrics (Parker, 2016).

Mobile and flexible work practices have been traced to the late 1960s (Meel, 2011), but it appears that the first installation of an activity-based workplace as understood today was in the late 1990s (Parker, 2016). Large organizations (e.g., the Government of Canada; Government of Australia) had adopted ABW as the basis for their office design standards even before the SARS-CoV-2 pandemic. As we approach the end of the first quarter-century for this office design strategy, it seems fitting to ask whether individuals or the organizations who employ them have obtained benefits from this approach. This paper reports a systematic literature review of studies comparing the ABW workplace layout to the layouts that existed before its invention, integrating results over a broad range of dependent variables all relating to organizational productivity. The individual dependent variables are amenable to research investigation, whereas the overall effects on organizations are generally not. Commercial organizations will often retain proprietary data that contributes (e.g., sales data; salaries and benefits), and the output values for governmental and institutional organizations may be qualitative. Moreover, the effects of office layouts on the overall balance can be obscured by other variables such as market conditions.

The research question we sought to answer was: What are the effects of the ABW layout, compared to other office designs, on the measurable indicators that contribute to organizational productivity? Although this project began prior to the March 2020 cataclysm of the SARS-CoV-2 global pandemic, it has gained new relevance because of the possibility that ways of working will change when the emergency conditions resolve.

2. Method

2.1. Search strategy

We used a combination of snowball searches and database searches, summarized in Table 1. An in-house database compiled since 1995 served as the starting point. Articles chosen from this database are shown in the supplementary material. Snowball searches started from papers from this database that we believed would be likely to have been cited by authors studying ABW, regardless of the year published (see Table 1 for the starter citations). For the commercial database searches, we started with a date range of 1995–2020, but this was reduced to the period 2010–2020 because the earlier years returned hundreds of records with no new ABW-related hits in addition to those previously identified in the snowball searches. Other inclusion criteria were: published in English; field investigation in a functioning organization (not a laboratory or simulated office); original empirical data (not a review paper). We added a targeted search within the *Journal of Corporate Real Estate* for years after 2009 when it appeared that our other strategies might be missing some papers.

Table 1
Summary of search strategy.

Search Strategy	Unique Results
1. Search of existing in-house database (Citations listed in supplementary material)	28
2. Snowball search (Scopus); Papers that had cited Haapakangas et al. (2019); Marquardt et al. (2002); Wells (2000); Wells et al. (2007); Wells and Thelen (2002); Soriano et al. (2021); Duval et al. (2002); Brunnberg (2000)	52
3. Scopus	42
• (TITLE-ABS-KEY (activity-based) AND TITLE-ABS-KEY ((workspace OR workplace OR office))) AND DOCTYPE (ar) AND PUBYEAR >2009 AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "ECON") OR LIMIT-TO (SUBJAREA, "HEAL") OR LIMIT-TO (SUBJAREA, "PSYC") OR LIMIT-TO (SUBJAREA, "MULT") OR LIMIT-TO (SUBJAREA, "DECI")) AND (EXCLUDE (EXACTSRCTITLE, "Journal Of Corporate Real Estate")) AND (LIMIT-TO (LANGUAGE, "English"))	
• (TITLE-ABS-KEY (workspace OR workplace OR office) AND TITLE-ABS-KEY ("office type" OR "open-plan" OR "layout" OR "social density" OR "spatial density" OR "flexible" OR "hot-desking") AND TITLE-ABS-KEY (territorial* OR privacy OR personalize OR personalization OR "personal space" OR proximi* OR "place attachment")) AND DOCTYPE (ar) AND PUBYEAR >2009 AND (LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "ENVI") OR LIMIT-TO (SUBJAREA, "PSYC") OR LIMIT-TO (SUBJAREA, "ECON") OR LIMIT-TO (SUBJAREA, "HEAL") OR LIMIT-TO (SUBJAREA, "DECI") OR LIMIT-TO (SUBJAREA, "MULT")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")) AND (EXCLUDE (EXACTSRCTITLE, "Journal Of Corporate Real Estate")	
4. PsycNET	10
• workspace* OR workplace* OR office* [AND] "office type" OR "open-plan" OR "layout" OR "social density" OR "spatial density" OR "flexible" OR "hot-desking" [AND] territorial* OR privacy OR personalize OR personalization OR "personal space" OR proximi* OR "place attachment"	
• Filters: 2010+, adult, human	
5. Journal of Corporate Real Estate (in SCOPUS)	12
• (SRCTITLE ("Journal of Corporate Real Estate") AND TITLE-ABS-KEY (activity-based OR (office W/2 type) OR layout OR density OR crowd* OR territorialism OR privacy OR personalize* OR "personal space" OR proximi* OR hot-desking OR "place attachment") AND TITLE-ABS-KEY (work OR workplace* OR office*)) AND PUBYEAR >2009	
6. Snowball from Engelen et al., 2019	2
Empirical papers - all	**146**
Empirical studies comparing ABW to other office types	**30**

A salient feature of the ABW layout is the use of unassigned seating. Conventional offices, whether cellular or open-plan, provide spaces for different functions (e.g., meeting rooms, break rooms) and there is a general expectation that one might from time to time need to leave one's assigned location to perform some task. Only an ABW lacks an assigned place to which one would return as a "home base". In order to identify papers related to ABW specifically and to exclude those without ABW, the search strategy included terms related to personal space, territoriality, and place attachment in addition to terms related to workplace design. There were no search limits for outcome measures (see below).

After removing duplicates, this combination of searches resulted in 146 papers, the earliest of which was published in 2000. All of these papers were read, summarized, and evaluated.

This manuscript focuses on investigations that were designed to support causal inferences about the effects of workplace layout on organizational productivity outcomes. From the 146 papers we identified those that reported a quantitative comparison between ABW and

another office configuration. The latter criterion excluded papers in which there was only post-move data collected after a transition to an ABW setting (including those that asked participants to recall their pre-move offices) and studies that reported comparisons between settings or employee groups within an ABW-only setting. This filtering resulted in a list of 30 papers, the summaries for which are shown in the supplemental material.

2.2. Bias assessment

Our principal concern was the strength of causal inferences that the study would support, following the criteria of Cook and Campbell (1979) for quasi-experimentation. We sought to understand the causal effects of office layout on outcomes related to organizational productivity (defined in section 2.4). To demonstrate that one variable causes another requires a high degree of internal validity, particularly with respect to the exclusion of potentially confounding variables. In a laboratory setting, many variables are within the researchers' control, but field investigations challenge researchers to eliminate alternate explanations.

Among these challenges are *selection* biases, because researchers rarely can assign participants to experience a specific office layout. When field investigations combine participants from multiple organizations, for example, there may be differences between those organizations in management style, work tasks, or the demographic makeup of each group. If groups differ on more than one variable it is impossible to know which variable has caused the observed differences between them (Cook & Campbell). A stronger research design will have comparison groups from within a single organization, and will collect extensive demographic and job data to understand similarities and differences within the groups.

Extraneous events known as *history* can threaten the internal validity of longitudinal field studies (Cook & Campbell, 1979). Unless there is a no-intervention comparison group to serve as a control (e.g., a non-moving group as well as one moving from conventional to ABW offices), one cannot attribute a change in the outcomes to the intervention and not to the other event. For example, if there is a change in managers between the pre-test and the post-test, this could affect measures of job satisfaction independently of any changes in office layout. History effects can also interact with selection effects (when the event affects one group but not the other). [See Cook and Campbell (1979), chapter 2, for further information.]

One researcher classified each of the 30 papers that remained after the screening according to seven research design strategies varying in the possible strength of causal inference (Table 2). A second researcher randomly checked the classifications and also examined papers for which there was any ambiguity. Table 2 shows the distribution of papers across the categories before and after the bias assessment. Longitudinal studies followed the same individuals before and after a move; cross-sectional studies involving a move had different participants at each time point, or had only one measurement occasion. Type 1 is the strongest design for a longitudinal study, and type 4 is the strongest type for a cross-sectional study. In addition to the overall research design, this step included an evaluation of other potential confounds (e.g., selection biases, construct validity) that would impair causal inferences.

At the end of this evaluation, 23 papers met the inclusion criteria, and 7 showed research design weaknesses. The 23 papers were included in the remainder of this review, and are indicated in the reference list by an asterisk *. The supplemental material shows the summary and evaluation for all 30 papers, and explains the reasons for the exclusion of the 7 papers.

2.3. Categorization: office types

Although all of the papers in the final database included an ABW condition, the comparison office types varied widely, with different labels and cut-off values being used by different researchers. In order to rectify the inconsistent ways in which various researchers have categorised office types, we simplified the 7 categories used by Bodin Danielsson and Bodin (2008) to a list of 6 office types (Table 3) and categorised each paper accordingly as best as possible given the different cut-off values used in different studies. This provided a standardized basis for comparing the results. Several studies combined many office types in one group and compared them to an ABW installation, which complicates causal inferences.

Table 2
Research design classification scheme and results following the bias assessment.

Study Type	Definition	Longitudinal	Cross-sectional	Post-search N_1	After bias assessment N_2
1	There was a non-moving comparison group beside the moving group to ABW	●		6	5
2	All groups moved to ABW, from different baseline offices	●		2	2
3	All groups moved to ABW, from the same baseline office	●		7	6
4	There was a non-moving comparison group beside the moving group to ABW		●	1	1
5	All groups moved to ABW, from different baseline offices		●	1	0
6	All groups moved to ABW, from the same baseline office		●	1	1
7	ABW was compared with other layout(s) without any movement		●	12	8
			Total =	30	23

2.4. Categorization: dependent variables

Pritchard defined productivity as "how well a system uses its resources to achieve its goals" (Pritchard, 1992, p. 455). This definition can be applied to individuals, teams, organizations, or countries; we focus on organizations. This definition requires an understanding of both the resources and the goals or outputs; it is not synonymous with work output in isolation. For a complete understanding, one must recognize the interdependence of individuals and groups. For example, when an employee departs the organization, the loss might affect other team members' ability to perform, and the costs of recruiting a replacement cannot be attributed to any individual. A complete understanding is best accomplished using a multi-indicator approach (Heerwagen, 2000; Kaplan & Norton, 1992).

Unsurprisingly, given the complexity of the concept, researchers have operationalized the multiple indicators in different ways. In screening the 146 empirical papers, we identified over 150 dependent variables, 78 of which appeared in the final set of 30 papers. One researcher analyzed all papers, grouping the dependent variables together when they used the same scale or measurement process, or when review of the individual questions showed that they clearly

Table 3
Re-categorization of office layouts used in the literature.

Office layouts in studies	Category in this paper	Definition
ABW, activity-based office, activity-based flexible office (AFO), flex office, flexible and shared workstations, task facilitating working environment, hot-desking, open plan office (OPO) with hot-desking, OPO with desk-sharing, open bench seating, more open group-centered and non-territorial environment, non-territorial workplace, flexi-desks, flexible-locations, and flexible workspace.	ABW	Unassigned seating, mix of space types, intended for individuals to move from one space type to another as required
Cellular office, single office room, own office, private office, cellular (1 p), individual and shared-room (1–3 p).	Cellular office	Fully enclosed, with door, 1–2 people, assigned seating, might or might not have a window
Small OPO (4–9 p), shared-room office (2–3 p), shared-room office (3–4 p), single cellular or shared-room (2–4 p), team office (4–6 p).	Small room office	Fully enclosed space, 2–9 people, assigned seating, individual desks might or might not have surrounding panels
Medium OPO (10–24 p), cubicle shared-room (12 allocated desks), zoned OPO (<40 p), landscape office (4–25^{+} p).	Medium OPO	Open space with 10–24 people, assigned seating, might or might not have panels between desks
OPO, Large OPO (>24 p), OPO with assigned desks, territorial workplace, OPO with allocated desks, OPO with owned desks, cubicle, assigned cubicles, zoned OPO (>40 p), shared offices with dedicated workstations.	Large OPO	Open space with >24 people, assigned seating, might or might not have panels between desks
Combi office, fixed desks (in OPO, private, and shared offices), traditional office, traditional office (cellular, shared-room and OPO), multiple offices (cellular, shared-room, and small landscape), OPO and shared-room (2–3 p), fixed-locations, old offices (own room, small OPO, medium shared office (2–3 p)), private and share-room (2–3 p) and OPO (4–24 p).	Mixed assigned location	Traditional multiple and mixed offices with assigned workstations

measured the same concept. If the authors identified an underlying concept, that contributed to content group labels. We also were guided by concept linkages in standard textbooks (e.g., Gifford, 2014). A second researcher reviewed the classifications on a random basis, and resolved uncertainties in discussion with the first researcher. This resulted in nine logical categories of conceptually related variables (Fig. 1), which formed the basis for comparisons between the investigations. This structure is consistent with the workplace literature (Becker, 1985-1986; Carlopio, 1996) and with organizational guidance aimed at supporting organizational investments in better buildings (World Green Building Council, 2013). The supplemental material shows the mapping of each study's dependent variables into the categories, permitting the reader to determine the frequency of occurrence of each variable across studies.

2.5. Categorization: results

For each dependent variable category, we scrutinized all of the individual comparisons between ABW and each office type and summarized the results in a table with color-coding and naming the dependent variable as described by the authors (Tables 4–12 in the next section). Some studies had not used ABW as the reference case; in those instances we parsed the statistical results to make all results comparable. With respect to each office type, each table shows the direction of the results with comparisons between that office type and ABW, identifying which results were negative, neutral, or positive. Most studies have only one row per comparison, but if there were mixed results for different variables in one study then that study appears more than once in the table. The strength of the evidence is coded using bold text for the reference number if the study meets the criteria for a strong research design described above.

3. Results

3.1. Environmental satisfaction

Thirteen studies provided evidence about the environmental satisfaction in ABW compared to other office layouts (Table 4). Overall, we see a gradient in which office types (cellular, small room, and medium OPOs) that offer more privacy, focus, and individual control tend to provide better environmental satisfaction than ABW. However, ABW compares more favorably with large OPOs and mixed assigned locations.

Studies with a strong research design tended to be those reporting comparisons with identifiable alternatives (not mixed assigned locations). Pitchforth et al. (2020) conducted a field experiment in a

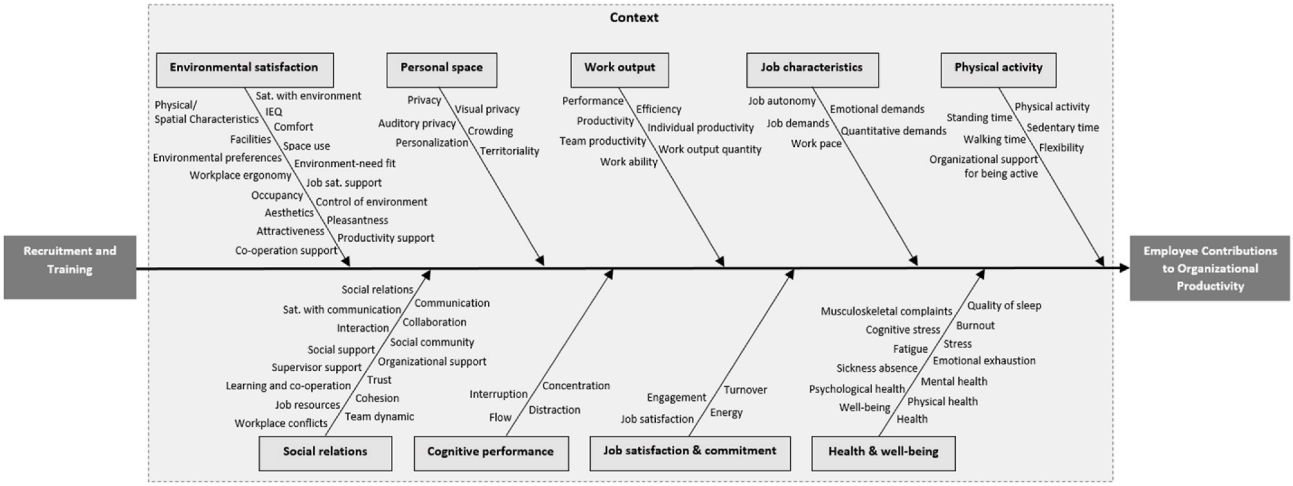

Fig. 1. Dependent variables and the categories to which each was assigned.

Table 4
Summary for environmental satisfaction in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	Productivity support; Satisfaction with indoor climate; Satisfaction with facilities	-	De Been & Beijer, 2014
	Access to supportive facilities (Individual room for concentrated work; space for special meeting; Space for booked meeting); Satisfaction with workplace contribution to Job satisfaction, Performance, and Pleasantness	-	Bodin Danielsson & Theorell, 2019
	Physical environment		Berthelsen et al., 2018
	Satisfaction with architecture and lay-out	+	De Been & Beijer, 2014
Small room office	Environmental satisfaction; Enjoyment of place; Productivity support	-	**Pitchforth et al., 2020**
	Access to supportive facilities (Individual room for concentrated work; space for special meeting)- for women only; Satisfaction with workplace contribution to Job satisfaction, Performance, and Pleasantness	-	Bodin Danielsson & Theorell, 2019
	Access to supportive facilities (Space for booked meeting)		Bodin Danielsson & Theorell, 2019
	Environmental satisfaction; Need-supply fit	+	Gerdenitsch et al., 2018
Medium OPO	Environmental satisfaction; Enjoyment of place; Productivity support	-	**Pitchforth et al., 2020**
	Access to supportive facilities (space for special meeting)- for women only; Satisfaction with workplace contribution to Pleasantness- for women only	-	Bodin Danielsson & Theorell, 2019
	Fit for function	-	**Lansdale et al., 2011**
	Access to supportive facilities (Individual room for concentrated work; Space for booked meeting); Satisfaction with workplace contribution to Job satisfaction; and Performance		Bodin Danielsson & Theorell, 2019
	Space use *		**Lansdale et al., 2011**
	Environmental preferences: favorable, pleasant environment	+	**Lansdale et al., 2011**
Large OPO	Environmental satisfaction; Enjoyment of place; Productivity support	-	**Pitchforth et al., 2020**
	Access to supportive facilities (Individual room for concentrated work; space for special meeting; Space for booked meeting)- for women only	-	Bodin Danielsson & Theorell, 2019
	Satisfaction with workplace contribution to Job satisfaction, Performance, and Pleasantness		Bodin Danielsson & Theorell, 2019
	Space use *		Blok et al., 2009
	Space use; Staying and movement patterns *		**Zhang et al., 2011**
	Space use *		Rolfö et al., 2018
	Lower Perceived and Actual Noise; Support for cooperation with colleagues	+	Blok et al., 2009
	Overall satisfaction with Physical Environment; Satisfaction with Air quality, Outdoor view, Aesthetics and freshness and brightness, Background noise	+	Rolfö et al., 2018
	Satisfaction with overall office	+	Gonsalves, 2020
Mixed assigned locations	Overall satisfaction	-	Wijk et al., 2020
	Satisfaction with workplace contribution to Job satisfaction- for men only	-	Bodin Danielsson & Theorell, 2019
	Productivity support; Satisfaction with indoor climate; Satisfaction with Facilities	-	De Been & Beijer, 2014
	Satisfaction with architecture and lay-out		De Been & Beijer, 2014
	Auditory work environment		Rolfö, 2018
	Access to supportive facilities (Individual room for concentrated work; space for special meeting; Space for booked meeting); Satisfaction with workplace contribution to Performance and Pleasantness		Bodin Danielsson & Theorell, 2019
	Environmental satisfaction	+	**Arundell et al., 2018**
	Satisfaction with Physical Environment; Satisfaction with Aesthetics	+	Rolfö, 2018

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

technology company, rotating intact work groups through different office conditions for two weeks in each, one of which was ABW. This is an unusual example of an experimental approach to testing office layouts, allowing a stronger causal inference than is often possible (e.g., no selection bias), although with a limitation on external validity because some of the conditions were novel and time to acclimate was short. Employees rated ABW poorly in satisfaction with environment, enjoyment of the place, and productivity support compared to the small room, medium open-plan, and large OPOs.

Lansdale et al. (2011) compared ABW with a medium OPO, revealing mixed findings. This longitudinal field study was conducted in a research environment with two groups of Ph.D. researchers: a moving group to ABW and a non-moving comparison group who stayed in their older offices. Researchers who moved from medium OPOs to ABW reported higher environmental preferences in the ABW offices. Although the new environment was judged favorably and as being more pleasant, occupants' observational data showed a less positive behavioral response. Facilities and the novel aspects of the new place (such as touch-down spaces, the kitchen table, and the break-out area) remained mostly unused over twelve months, and were described as 'not fit for function'. Occupants indicated inconvenience and inefficiency of the hot-desking policy and some were colonizing space in defiance of the hot-desking policy. These findings can be understood logically: although ABW might be more attractive because they are new and fresh in comparison to older offices, they might not meet workers' needs and task requirements better than older layouts.

ABW workplaces in many investigations seem likely to be more pleasing because they are new and in good condition, whereas existing workplaces might suffer by comparison because they are old and in need of repair. This could explain the difference in environmental satisfaction based on aesthetics and those based on functionality. This pattern occurred, for example, in the results of studies by Arundell et al. (2018), De Been and Beijer (2014), Lansdale et al. (2011), and Rolfö et al. (2018).

Gonsalves (2020) offered another explanation. He did not observe any negative outcomes regarding satisfaction with ABW offices and reported a greater satisfaction with ABW compared to large OPO. He suggested that this redesigned provided greater variation in space options than some other ABW, perhaps providing employees with better fit to job requirements and better ability to control job demands.

Studies with strong research designs that include moves to new or renovated non-ABW spaces as well as ABW spaces are lacking in the literature. Without them, the quality of the finishes can be considered a confounding variable in assessments of environmental satisfaction.

Employees' space use and work behaviors, both observed and reported in interviews, show how they respond to their physical workplace and can be considered as indirect indicators of environmental satisfaction. Berthelsen et al. (2018), for example, observed that teachers and researchers challenged the ABW solution by occupying the same place each day (86% of them) or by working from home, even nine months after relocation to ABW.

Four studies of space use in ABW compared with other office layouts showed unclear results; these are marked with a white cell and * in Table 4. Zhang et al. (2011) observed architects' and engineers' staying and movement patterns through a cross-sectional study. Considering the estimated rates of proprietary occupancy and flexible occupancy, the authors declared that ABW was used more efficiently than the large OPO, but this result differed for architects vs engineers and also was influenced by role. Blok et al. (2009) found some positive outcomes for ABW, but reported that ICT workers moving from a large OPO to ABW showed the same number of changes of workspace in the ABW office as they had in their previous layout. The authors suggested that the variety of different workspaces in the ABW office might not have been the best fit for the work tasks. Lansdale et al. (2011) found no change in facility usage but observed a drop in the daily attendance of researchers twelve months after relocation to an ABW from medium OPOs.

Need-supply fit appears to be a major area of concern in the success of the ABW concept (e.g., Bodin Danielsson & Theorell, 2019). Gerdenitsch et al. (2018) showed a positive relation between workspace satisfaction and the perceived need-supply fit and inferred that the benefits of ABW are contingent upon the abilities of workers to create a fit. Conversely, when fit is poor, so is satisfaction: Rolfö et al. (2018) interviewed employees who had moved from a large open plan office as part of a multi-method pre-post renovation study, and found that the ABW was not able to provide suitable work conditions for them. Problems including a workstation shortage, nesting, lack of auditory privacy, and difficulties in finding colleagues appeared to be related to a high people-to-workstation ratio, inappropriate workstation arrangements, and a lack of rules. However, the possibility to withdraw to private areas did not change. A preference for having fixed workplaces was indicated by the high self-reported nesting rate (28%) and that 25% preferred an OPO rather than an ABW (Rolfö et al., 2018). These results are consistent with the findings of Lansdale et al. (2011) described above.

Organizational characteristics and policies regarding space use also contribute to employees' satisfaction with the office environment. De Been and Beijer (2014) conducted a cross-sectional online survey in multiple companies and found that satisfaction with the organization explained more of the variance in environmental satisfaction than did office type. Rolfö et al. (2018) observed that workplace rules need to be consistent with the architectural intent for ABW to be perceived as fit for function. Furthermore, employees' participation and empowerment throughout the process of design and relocation to an ABW contribute to their favorable perception of it.

3.2. Social relations

Thirteen studies investigated the effects of working in ABWs on employees' social relations in comparison with other office layouts (Table 5). Surprisingly, ABWs did not have any positive influence in comparison with cellular offices and negative effects dominate the results for this category. Compared to the small room and medium OPOs, ABWs had similar effects except for one positive outcome for ABWs compared to the small room offices. The results contradict the claimed benefit of the ABW concept on social relations. ABWs, however, performed better in comparison with some large OPOs and mixed assigned locations; there are more positive and neutral effects than negative effects.

Three studies were identified as strong research designs, though they revealed mixed findings. All of them reported a pre-post field study with a control group, comparing groups of employees who moved to an ABW and those who stayed in their older office environment. Arundell et al. (2018) and Lansdale et al. (2011) did not find a change in communication and relations between workers who moved to ABWs from medium OPO and mixed assigned locations, respectively. Lansdale et al. (2011) also examined face-to-face interactions between researchers, finding that they decreased in the six and nine months after the move to the ABW. Observational data of this study showed that the predominant activity was solitary computer work, with conversation representing less than one-tenth of the activity in any observed situation. The only positive result of Arundell et al.'s (2018) study – the increased frequency of eating lunch with colleagues in ABWs – might be explained by a new workplace policy prohibiting eating at the desk. Haapakangas et al. (2019) compared the effects of ABWs with both cellular office and mixed assigned locations. They did not find a positive effect of ABWs on employees' social support, social community, and satisfaction with communication compared to before the move.

There is a fine distinction between the results of measures of "communication" and "satisfaction with communication". Although the level of communication in some investigated ABWs has been reported as higher, this is not necessarily a positive aspect of the perceived psychosocial work environment. Studies with a focus on employees' satisfaction with communication (De Been & Beijer, 2014; Haapakangas

Table 5
Summary for social relations in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	More Workplace conflicts- for women only	-	Bodin Danielsson et al., 2015
	Psychosocial environment; Social community at work; Social support from supervisor; Social support from colleagues	-	Berthelsen et al., 2018
	Satisfaction with Communication; Social Community; Social support	-	**Haapakangas et al., 2019**
	Good relationship with closest supervisor		Bodin Danielsson & Bodin, 2008
	Satisfaction with communication		De Been & Beijer, 2014
Small room office	Good relationship with closest supervisor		Bodin Danielsson & Bodin, 2008
	Workplace conflicts		Bodin Danielsson et al., 2015
	Interaction across teams	+	Gerdenitsch et al., 2018
Medium OPO	Face-to-face interaction	-	**Lansdale et al., 2011**
	Good relationship with closest supervisor		Bodin Danielsson & Bodin, 2008
	Collaboration between room members		**Lansdale et al., 2011**
	Workplace conflicts		Bodin Danielsson et al., 2015
Large OPO	More Workplace conflicts- for women only	-	Bodin Danielsson et al., 2015
	Location knowledge	-	Gonsalves, 2020
	Ease of interaction		Rolfö et al., 2018
	Good relationship with closest supervisor	+	Bodin Danielsson & Bodin, 2008
	Communication with colleagues and visitors	+	Blok et al., 2009
	Spontaneous greetings	+	Gonsalves, 2020
Mixed assigned locations	Satisfaction with communication	-	De Been & Beijer, 2014
	Social support	-	**Haapakangas et al., 2019**
	Sat with Psychosocial environment	-	Wijk et al., 2020
	Relation with coworkers and supervisor		**Arundell et al., 2018**
	Workplace conflicts		Bodin Danielsson et al., 2015
	Satisfaction with Communication; Social Community		**Haapakangas et al., 2019**
	Good relationship with closest supervisor	+	Bodin Danielsson & Bodin, 2008
	Frequency of eating lunch with colleagues	+	**Arundell et al., 2018**
	Communication and teamwork cohesion	+	Rolfö, 2018

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

et al., 2019), social and supervisory support (Berthelsen et al., 2018; Haapakangas et al., 2019), and psychosocial work environment (Berthelsen et al., 2018; Wijk et al., 2020) did not present a positive result in favor of ABWs.

Merely being in a shared environment does not facilitate social relations, and there appears to be a negative relationship between social relations and the number of workers who share an office. This could explain the results in line with private, small, and medium shared offices. There are more results favouring ABWs when the comparison is to large OPOs and mixed locations (which often included many large OPOs in the mix). This is probably because an ABW installation usually includes some spaces designed to provide concentration and focus, to which employees can move for at least some of the time. Nonetheless, the number of negative and neutral results outnumber the number of positive effects observed.

One explanatory factor is the reduction of privacy in highly shared offices, and particularly in non-territorial environments. Inadequate privacy and lacking control over the level of social contact could lead to a negative perception of social relations and in turn, withdrawal from social contact. Unlike ABWs, private and small group size offices offer more enclosure, more defined personal space, and more control over adjustments according to their social/privacy needs. Lansdale et al. (2011) and Haapakangas et al. (2019) concluded that the loss of privacy in ABWs was a reason for impairing face-to-face interaction and interpersonal relations.

Shared spaces also can bring noise distraction from both conversations and equipment. Noise distraction can lead to increased workplace conflicts, as Bodin Danielsson et al. (2015) observed for the female employees in their sample. Noise is well-known as a reason for withdrawal from face-to-face interactions, perhaps in response to the loss of privacy and increased distraction (Lansdale et al., 2011).

The technologies that support ABW can also support remote work, and when organizational policies permit this it provides another means to withdraw, which can weaken interaction and the psychosocial work environment (Berthelsen et al., 2018; Lansdale et al., 2011). Those whose work is knowledge-based appear to value concentration over communication.

Some designers of ABW installations intentionally scatter workers throughout the workplace with the intent of improving random intersections and collaboration. This might promote inter-team collaborations by increasing the visibility and proximity among colleagues of different teams (Gerdenitsch et al., 2018). However, the intra-team collaboration might suffer because of poorer visibility and proximity to team members, less occurrence of unplanned encounters, and difficulty in exchanging information in the desk-sharing strategy (Arundell et al., 2018; De Been & Beijer, 2014; Haapakangas et al., 2019; Rolfö

et al., 2018). This problem might foster nesting tendencies in ABW occupants when intra-team collaboration is needed (Rolfö et al., 2018).

3.3. Personal space

Four studies compared ABWs with other office layouts concerning personal space (see Table 6). As expected, ABWs did not perform better than any of investigated cellular and medium OPOs. The results for mixed assigned locations showed inconsistent results in comparison to ABWs (some better for ABWs, and some not). In contrast, ABWs never performed worse than large OPOs. The results can be explained by the fundamental difference between the nature of offices shared with many people and those shared with few or no people. ABWs intend to provide, at best, a combination of unassigned shared offices beside some private and quiet rooms so that employees can choose the most fitting workspace for their work task. This temporary option in an ABW is unlikely to satisfy employees more than the permanent privacy in cellular and less-shared offices, whereas it can be perceived as equal to or perhaps better than large OPOs because these offer few or no private space options.

Only one study was identified as a strong research design. Lansdale et al. (2011)'s pre-post field study reported a reduction in the personal privacy of researchers moving to an ABW comparing with their counterparts in medium OPOs. The respondents complained about the ABW layout providing inadequate privacy, distracting conversations, and the inability to have a conversation without disturbing others. This condition decreased their own concentration and reduced their face-to-face interactions.

As an office becomes more shared, the visual and auditory privacy decreases. Highly shared offices, and particularly non-territorial workplaces like ABWs, cannot outperform private or smaller offices regarding privacy and satisfaction with territory. People regulate their boundaries to meet their needs for social separation or connection and to control both their disclosure of information of about themselves and their acquisition of information about others through what has been called "selective conspicuousness" (Appel-Meulenbroek et al., 2020). The amount of enclosure is a way to define the boundaries.

Moreover, personalization is a territorial behavior through which people mark their own space and attach their personal identity to the place. Desk ownership and personalization of workstations are totally ruled out as possibilities in ABWs. Therefore, it can be a threat to the personal identity of employees (Elsbach, 2003). This might explain why ABWs did not satisfy employees in terms of territory and personalization even in comparison to OPOs.

Challenging the lack of assigned desks and territory in the ABW, some employees used colonizing and nesting strategies (Rolfö et al., 2018). Besides employees' tendency to use favorable locations like workstations next to a window, being close to friends or team members, studies also explained this behavior as demonstrating employees' desire to own territory. Desk ownership also brought cognitive benefits of spreading out the work materials such as papers and notes over the day (Lansdale et al., 2011; Rolfö et al., 2018). Moreover, the need for adjustment of a new workstation, tidying up items, cleaning the desk, and carrying and installing ergonomic aids in ABW offices were found as excessive, time-consuming operations that were used as a justification for nesting (Rolfö et al., 2018).

3.4. Cognitive performance

Nine studies provided evidence about the effects of working at ABWs on employees' cognitive abilities in comparison with other office layouts (see Table 7). Compared to cellular offices, ABWs did not show any benefit. This can be simply explained by the lower level of auditory and visual distraction in private and enclosed offices providing more suitable conditions for concentrated work. Compared to the small room and medium OPOs, the negative and neutral effects of ABWs are more numerous than positive influences. In contrast, ABWs did not cause any negative effects compared to large OPOs, with an equal number of studies showing neutral and positive results. This may be attributed to the high level of distraction and noise disturbance in large OPOs whilst ABWs combine OPOs with some enclosed spaces that enable occupants to create a better fit between their needs and the workspace they choose. Thus, ABWs seem more likely to provide an opportunity for distraction-free working than large OPOs. Mixed assigned locations was a research design category in which large OPOs predominated, but some studies included cellular or small enclosed offices, which could explain the mixture of positive, negative, and neutral comparisons in this category.

Only two studies applied a strong research design. Pitchforth et al. (2020) found that small room and medium open-plan conditions were rated more positively regarding flow states compared to an ABW design. However, the large OPO condition in that study did not cause a significant change in flow. There was a high level of noise in the large OPO design that was the most likely explanation as a reason for the latter result. Lansdale et al. (2011) found that people who moved to an ABW reported a higher level of distraction and as a result, lower concentration than the comparison group, who did not move from their assigned medium OPOs. In addition to distraction, they made complaints about the inefficiency of the hot-desking policy that caused the loss of cognitive benefits of spreading papers and notes out and using them over days. This inconvenience might have led people to colonize space, a result noted above (section 3.1).

There is a clear gradient in which the higher the number of employees sharing an office, the higher level of distraction and then, the more diversion of attention. The only positive result for ABWs compared to small room offices was of the study by Gerdenitsch et al. (2018). They

Table 6
Summary for personal space in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	Privacy	-	De Been & Beijer, 2014
Medium OPO	Privacy	-	**Lansdale et al., 2011**
Large OPO	Satisfaction with Visual privacy; Territoriality		Rolfö et al., 2018
	Privacy	+	Blok et al., 2009
	Satisfaction with Auditory privacy	+	Rolfö et al., 2018
Mixed assigned locations	Privacy	-	De Been & Beijer, 2014

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

Table 7
Summary for cognitive performance in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	Satisfaction with Concentration	-	De Been & Beijer, 2014
	More Distraction	-	Seddigh et al., 2014
	Higher Perception of Noise Disturbances	-	Bodin Danielsson et al., 2015
Small room office	Higher Perception of Noise Disturbances	-	Bodin Danielsson et al., 2015
	Flow	-	**Pitchforth et al., 2020**
	Distraction		Seddigh et al., 2014
	Lower Distraction	+	Gerdenitsch et al., 2018
Medium OPO	Higher Distraction; Lower Concentration	-	**Lansdale et al., 2011**
	Flow	-	**Pitchforth et al., 2020**
	Perception of Noise Disturbances		Bodin Danielsson et al., 2015
	Lower Distraction	+	Seddigh et al., 2014
Large OPO	Perception of Noise Disturbances		Bodin Danielsson et al., 2015
	Flow		**Pitchforth et al., 2020**
	Lower Visual and Auditory Distraction; Higher Concentration	+	Blok et al., 2009
	Lower Distraction	+	Seddigh et al., 2014
Mixed assigned locations	Satisfaction with Concentration	-	De Been & Beijer, 2014
	Higher Distraction	-	Hodzic et al., 2020
	Perception of Noise Disturbances		Bodin Danielsson et al., 2015
	Auditory work environment		Rolfö, 2018
	Lower Distraction	+	Rolfö, 2018

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

explained the higher distraction in the small room office by the limited reliability and validity of the distraction scale used. Interestingly, some studies indicated that the outcomes might not differ significantly among different types of OPOs although the number of occupants increased (Bodin Danielsson et al., 2015; Seddigh et al., 2014). Indeed, the main differentiation was related to whether or not the office environment was enclosed or open.

The degree to which the job requires concentration influences these effects. Seddigh et al. (2014) observed both a main effect of concentration and an interaction of office type of need for concentration as influences on perceived distraction. The level of distraction was higher for employees with higher concentration need in all office types, except for cellular offices. Employees whose jobs demanded more concentration reported higher satisfaction in cellular offices. Furthermore, sex might influence the outcomes due to differences in perception of noise between the sexes. Bodin Danielsson et al. (2015) found that female workers had a greater sensitivity to environmental stimuli and as a result were more affected by the perceived noise disturbances.

3.5. Work output

Eight studies focused on work output in ABWs compared to other office layouts (see Table 8). The results were neutral for the comparisons of ABWs to cellular, small room, and medium OPOs. A few positive results were found for ABWs when compared with large OPOs and mixed offices.

Only two studies were identified as strong research designs. Pitchforth et al. (2020)'s field experiment of programmers found no significant association between the office type and work output quantity measured as the number of created 'Git Commits'. Arundell et al. (2018) reported no change in employees' self-rated productivity between pre and post measurements. However, qualitative findings revealed that some ABW occupants experienced a decline in their productivity because of a high level of noise at the office, lost time for finding desks and colleagues, and adjusting to new ways of working. Although they were satisfied with increased opportunities for collaboration or interaction with all management levels in the ABW, the reduced contact between team members and the decreased intra-team-related work adversely influenced work productivity.

The work output-related results in each study are mostly consistent with the results of that study in other outcome categories. Whenever an ABW could improve employees' work output, the results also showed an improvement in the workplace support for productivity and intra-team collaboration, a lower level of distraction and more privacy, and more possibility for teamwork and cohesion in ABWs compared to other office types (Blok et al., 2009; Rolfö, 2018). There was the same pattern in studies with neutral results (Arundell et al., 2018; Rolfö et al., 2018).

Two studies in IT companies are exceptions to this consistency between outcome categories. For instance, Seddigh et al. (2014) found no significant difference in personal efficiency despite different levels of distraction among office types (distraction in ABWs was higher than the cellular offices and lower than medium and large OPOs). The authors explained this result with effective coping strategies that occupants of highly shared offices tend to use to reduce the impact of distraction on their performance. Furthermore, not every office worker required a high level of concentration so that the high level of distraction in the workplace did not influence all workers' efficiency. Although it is known that quieter workplaces facilitate workers' productivity, some studies emphasized the critical role of office design in managing noise and distractions (e.g., Pitchforth et al., 2020) and showed that the main differentiation is related to whether or not the office environment is open or enclosed (e.g., Seddigh et al., 2014).

Organizational variables can contribute to work output irrespective of the office layout. For example, Rolfö (2018) revealed a significant

Table 8
Summary for work output in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	Personal efficiency		Seddigh et al., 2014
Small room office	Personal efficiency		Seddigh et al., 2014
	Performance		Bäcklander et al., 2019
	Work output quantity [Git Commits]		**Pitchforth et al., 2020**
Medium OPO	Personal efficiency		Seddigh et al., 2014
	Performance		Bäcklander et al., 2019
	Work output quantity [Git Commits]		**Pitchforth et al., 2020**
Large OPO	Personal efficiency		Seddigh et al., 2014
	Work ability		Foley et al., 2016
	Performance; Individual and Group Efficiency		Rolfö et al., 2018
	Work output quantity (Git Commits)		**Pitchforth et al., 2020**
	Self-rated Productivity	+	Blok et al., 2009
Mixed assigned locations	Productivity		**Arundell et al., 2018**
	Perceived Individual and Group Performance	+	Rolfö, 2018

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

correlation between satisfaction with participation in decision-making regarding the design of the new premises and individual productivity at the workplace ($r_s = 0.69, p < 0.001$). Bäcklander et al.'s (2019) online survey in four organizations did not find any significant relationship between employee performance and office type, but did report a positive relationship between employee performance and personal and job resources (i.e. goal-setting and information richness).

3.6. Job satisfaction and commitment

Among studies comparing ABWs with other office layouts, five studies focused on job satisfaction and one study focused on commitment (see Table 9). The studies did not find any positive effect in favor of ABWs compared to all office types and resulted mostly in neutral effects.

Two studies implemented a strong research design, one being a quasi-experiment (Arundell et al., 2018) and one a field experiment (Pitchforth et al., 2020). The quasi-experiment found no change 6–9 months post-move in job satisfaction for those who moved compared to those who did not (Arundell et al., 2018). The field experiment assessed employees' energy or level of motivation over a two-week exposure to each office type. Results were neutral, except for the comparison between small rooms and ABW (Pitchforth et al., 2020). The level of collaboration required for the job had a larger effect on their work engagement than office design.

The change to ABW in an academic environment showed negative effects of ABW on job satisfaction and commitment (Berthelsen et al., 2018). This can be simply understood that in contrast to cellular offices, ABWs were not able to provide the privacy and silence that knowledge workers needed to do their job satisfactorily.

Generally, the level of noise and distraction in the workplace has a negative relationship with job satisfaction because of deteriorating cognitive capabilities and an associated decline in engagement with work. Hodzic et al. (2020) found a main effect of distraction on work engagement and job satisfaction. Variability in the mixed assigned locations, versus the availability of some quiet spaces in the ABW, likely explains the neutral results for the office type comparison. Particularly, workers who suffered from work stressors such as time pressure and unpredictability experienced a greater decline in their job satisfaction and work engagement when distraction increased. The group size also may contribute to job satisfaction. Bodin Danielsson and Bodin (2008), finding less job satisfaction among workers in medium OPOs than large OPOs, suggested that the group size (i.e. 10-24 people) was not large enough to let subgroups to form and not small enough to allow workers to get to know each other very well.

3.7. Job characteristics

Six studies focused on the effects of office type on what workers experience in terms of job demands and autonomy (see Table 10). Following a similar pattern to other outcomes, there is a gradient in the results depending on the comparison. ABWs performed worse than medium-OPOs and could not outperform cellular offices. In contrast, ABWs showed better outcomes than large OPOs and mixed assigned locations. Small room offices were not investigated in these studies.

Two studies were recognized as strong research designs. Both were longitudinal field studies comparing employees who moved to ABWs with those who stayed at baseline offices. Through a combination of qualitative and quantitative methods applied in an academic area, Lansdale et al. (2011) revealed that respondents felt lower autonomy in the ABW compared to the medium open-plan research environment. This result can be explained by the loss of privacy, the inability to distribute work materials within the workstations, and a lack of ability to personalize workstations. Although ABWs are designed to with the expectation that increased choice in how, when, and where to work will improve autonomy, in this instance the result was a reduction in autonomy.

Haapakangas et al. (2019) conducted a controlled natural intervention in transport administration offices to investigate the effects of relocation to an ABW on work demands including quantitative demands, emotional demands, and work pace. Work demands remained the same for employees who moved from mixed assigned locations into an ABW. For those who moved from cellular offices, work pace did not change after the relocation, but small, mostly short-term, negative effects were observed on quantitative and emotional demands. How employees respond to the change depends on what office type they are changing from.

Table 9
Summary for job satisfaction and commitment in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	More seeking new job (Turnover); Job Satisfaction	-	Berthelsen et al., 2018
	Job Satisfaction		Bodin Danielsson & Bodin, 2008
Small room office	Engagement	-	**Pitchforth et al., 2020**
	Job Satisfaction		Bodin Danielsson & Bodin, 2008
	Energy		**Pitchforth et al., 2020**
Medium OPO	Job Satisfaction		Bodin Danielsson & Bodin, 2008
	Engagement; Energy		**Pitchforth et al., 2020**
Large OPO	Job Satisfaction		Bodin Danielsson & Bodin, 2008
	Engagement; Energy		**Pitchforth et al., 2020**
Mixed assigned locations	Job Satisfaction		Bodin Danielsson & Bodin, 2008
	Job Satisfaction		**Arundell et al., 2018**
	Job Satisfaction; Work Engagement		Hodzic et al., 2020

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

Table 10
Summary for job characteristics in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	Work demands (Quantitative demands & Emotional demands)	-	**Haapakangas et al., 2019**
	Job Demands		Berthelsen et al., 2018
	Work Pace		**Haapakangas et al., 2019**
Medium OPO	Autonomy	-	**Lansdale et al., 2011**
Large OPO	Lower Pressure to forgo flexible hours	+	Gonsalves, 2020
Mixed assigned locations	Work demands (Quantitative demands, Emotional demands, Work pace)		**Haapakangas et al., 2019**
	Job Autonomy	+	Rolfö, 2018

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

The gradient seen in the results for job characteristics follows the pattern seen above for environmental satisfaction, social relations, personal space, and cognitive abilities, and seems likely to arise from the influence of these outcomes on job demands and autonomy. Workers who work in shared offices are more likely to experience privacy issues (being overheard and overlooked) that can lead to the loss of autonomy over the workspace (Wohlers & Hertel, 2017), which can be a stressor (Herbig et al., 2016; Karasek, 2008). Moreover, a high level of distraction and acoustic problems in highly shared offices can increase perceived task demands (Haapakangas et al., 2011), and this likely also explains the results for the mixed assigned locations that were the comparison group for Rolfö (2018). She observed that the ABW layout included back-up rooms that provided the possibility of privacy.

Perceptions of office policy might also change with a shift to an ABW layout: Gonsalves (2020) observed that the ABW design strategy reduced employees' feelings of pressure to forgo flexible hours. Employees in large OPOs did not use flexible work policies and spent long hours physically present at the office due to a fear of career penalties and in order to demonstrate their commitment to managers and colleagues. However, in the ABW layout, absence signals were not as noticeable, and evaluations were based on work output instead of attendance, and in turn, employees felt less pressure to show their work devotion.

3.8. Health and well-being

Eight studies investigated the effects of working in ABWs on employees' health and well-being compared to other office layouts (see Table 11). Cellular offices were the only type that outperformed ABWs in any study. Overall, neutral results were more numerous than positive or negative results in comparing ABWs to all other office types. Notably, all studies of these outcomes lacked a strong research design.

The health benefits of ABWs are unlikely to outweigh those of cellular and small offices. Only one study indicated a lower rate of sick leave in ABWs than in cellular and small offices, but it showed the same results in comparison to all office layouts (Bodin Danielsson & Bodin, 2008). The authors explained the results by the possibility of undeclared sick leave in ABWs because its workers could work from home up to 30% of their work time.

Table 11
Summary for health and well-being in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Cellular office	Higher Short sick leave spells- for men only	-	Bodin Danielsson et al., 2014
	More Cognitive stress	-	Seddigh et al., 2014
	Higher Sickness absence days (employer-recorded only)	-	Platts et al., 2020
	General Health; Physical and Psychological problems; Sleep and Emotional health		Bodin Danielsson & Bodin, 2008
	Long sick leave spells- for women; Short sick leave spells- for women		Bodin Danielsson et al., 2014
	General Health; Exhaustion; Burnout		Seddigh et al., 2014
	Lower Sick leave	+	Bodin Danielsson & Bodin, 2008
Small room office	General Health; Physical and Psychological problems; Sleep and Emotional health		Bodin Danielsson & Bodin, 2008
	Long sick leave spells- for women only; Short sick leave spells		Bodin Danielsson et al., 2014
	General Health; Exhaustion; Cognitive stress; Burnout		Seddigh et al., 2014
	Cognitive stress		Bäcklander et al., 2019
	Sickness absence		Platts et al., 2020
	Lower Sick leave	+	Bodin Danielsson & Bodin, 2008
Medium OPO	General Health; Physical and Psychological problems; Sleep and Emotional health		Bodin Danielsson & Bodin, 2008
	Long sick leave spells- for women only; Short sick leave spells		Bodin Danielsson et al., 2014
	General Health; Exhaustion; Cognitive stress; Burnout		Seddigh et al., 2014
	Cognitive stress		Bäcklander et al., 2019
	Sickness absence		Platts et al., 2020
	Lower Sick leave	+	Bodin Danielsson & Bodin, 2008
Large OPO	General Health; Physical and Psychological problems; Sleep and Emotional health		Bodin Danielsson & Bodin, 2008
	Long sick leave spells- for women only; Short sick leave spells		Bodin Danielsson et al., 2014
	General Health; Exhaustion; Cognitive stress; Burnout		Seddigh et al., 2014
	Sickness absence		Platts et al., 2020
	Lower Sick leave	+	Bodin Danielsson & Bodin, 2008
	Lower Back pain	+	Foley et al., 2016
Mixed assigned locations	General Health; Physical and Psychological problems; Sleep and Emotional health		Bodin Danielsson & Bodin, 2008
	Long sick leave spells- for women only; Short sick leave spells		Bodin Danielsson et al., 2014
	Fatigue		Hodzic et al., 2020
	Health; Well-being in the workplace		Wijk et al., 2020
	Lower Sick leave	+	Bodin Danielsson & Bodin, 2008

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

The apparent health benefits of cellular offices could be caused by a higher infection risk among people sharing an office, more exposure to work stressors and environmental stressors like noise, and less control over these threats in more crowded offices, although class differences between office types ought also to be controlled. Seddigh et al. (2014) conducted an online survey in five IT organizations in different office types including ABW, finding a lower level of distraction and cognitive stress in cellular offices in analyses that controlled for age, sex, education and labor market sector, but not job rank. As office environments became more shared, employees reported more distraction and cognitive stress, particularly for people who reported a high need for concentration. The office type did not appear to be significantly associated with general health. Similarly, Hodzic et al. (2020) found a positive relationship between distraction at the office and perceived fatigue in non-manager employees, which was moderated by work stressors (i.e. time pressure and unpredictability).

Office design might influence occupants' health via its effects on working posture and activity levels. Foley et al. (2016) suggested that the reduced time sitting in an ABW could be a reason for the reduced incidence of lower back pain of employees who moved from large OPOs.

In the absence of a significant association between the office type and health-related outcomes in most of the studies, some studies identified other factors that influenced employees' health. Bäcklander et al. (2019) showed that the presence and usage of personal and job resources such as self-leadership, goal-setting, information richness, and job autonomy explained most of the variance in employees' cognitive stress. Moreover, Wijk et al. (2020) pointed to the sense of coherence including meaningfulness, manageability, and comprehensibility as predictors of overall health and well-being. Work type regarding the required concentration or physical activity also moderated the effect of office

type on workers' stress (Seddigh et al., 2014). Furthermore, personal variables such as sex and age were identified as contributing factors to employees' health in terms of sick leave, physiological and cognitive stress (Bäcklander et al., 2019; Bodin Danielsson et al., 2014; Platts et al., 2020).

3.9. Physical activity

Three studies comparing ABWs to other office layouts examined how office type affects employees' physical activity (see Table 12). Only large OPOs and mixed assigned locations were compared to ABWs.

Two studies applied a strong research design, but revealed mixed findings. Using a pre-post design, both studies compared employees who moved to ABWs with those who continued working at mixed assigned locations. Hallman et al. (2018) measured the time and pattern of sitting, standing, and walking of workers in five office sites before and two times after the relocation. Relative to the comparison group, the walking time of ABW employees increased twelve months after the relocation. However, results did not show a significant association between the office type and workers' sitting and standing time. The authors suggested that the office size might have a positive relationship with activity pattern; larger facilities can affect employees' sitting and walking time due to the longer distances between locations. Also, fewer seats per worker in the ABW might increase the time spent searching for a suitable workstation. Arundell et al. (2018) reported no change in employees' sedentary time, and light- and moderate-to-vigorous intensity physical activity after the move to an ABW. On the other hand, employees in the ABW reported a higher level of perceived organizational support for being active in the workplace compared to the comparison group.

Job type can contribute to the level of physical activity. Zhang et al. (2011) revealed the influence of job type on employees' stay and movement patterns, which can also be considered indirect evidence of environmental satisfaction (see section 3.1). Through a cross-sectional field study in an architecture construction company, they found that architects stayed longer in their workstations than engineers willing to visit architects, project leaders had more movement than regular staff, and temporary staff spend more than 75% of their work time staying in the "own-seat nearby zone".

Self-reported and objectively measured outcomes also can differ. Foley et al. (2016) used both accelerometer measurement and self-reported data to compare the effects of working at a large OPO with an ABW. Accelerometer measurement led to neutral results in sedentary time, sedentary breaks, and step counts while self-reported data revealed significant positive changes in all those variables after a four-week experience of the ABW environment and also significant negative changes in physical activity after moving back to the baseline office.

Regardless of office layout, the furniture type also influences the level of physical activity. For instance, providing workers with adjustable sit-stand workstations, giving individuals options to sit or stand while working in their own workstations, can be considered an activity permissive strategy (Chau et al., 2014). This is a simple strategy that can be adopted in any office type to promote workers' physical activity and health.

4. Discussion

4.1. Overall effects of ABW on contributors to organizational productivity

Organizations manage their productivity by seeking to reduce input costs and increase output value (Pritchard, 1992). Many input costs are easy to tabulate because they are bills to be paid, such as office rent or salaries. Less obvious costs include staff turnover, slower work output from distracted employees, or time lost to poor social relations among team members. These and other factors all contribute to the overall effect of working conditions on organizational productivity.

ABW designs are promoted to employees as a way to improve collaboration and communication and to improve the fit between what the environment provides and what the employee needs while adding to individual control by allowing the individual to choose the space required for each activity; however, reduced space costs are powerful motivators (Parker, 2016). Fig. 2 summarizes the empirical evidence for these assumptions, displaying in a schematic way the overall effects from each of the summary tables. ABW sits at the centre of the circle, with each of the other office layouts on a spoke of the wheel. Each organizational productivity component for which there are comparisons between ABW and the respective office type is represented by a dot on the spoke. The location of the dot is closer to the office layout that showed the more positive results in the summary table. The location of the dot in relation to one of the ends of the spoke roughly reflects the relative number of studies in each comparison category in favor of the relevant office type.

Fig. 2 reveals, for the comparison between cellular offices and ABW, that the dots cluster on the outer ring of the figure (with the exception of physical activity, for which there were no studies meeting the inclusion criteria), which indicates that cellular offices generally deliver better conditions. The reverse was true when large OPOs were compared to ABW (the dots cluster on the inner ring of the figure). There is an apparent gradient between these extremes, with results progressively favouring ABW as the size of the OPO increases. The category of "mixed assigned locations" often included mostly large OPOs, which likely explains the similar results for this comparison to the results for the large-OPO comparisons.

The figure treats all categories as if they were of equal importance, but arguably cognitive performance should have a higher priority

Table 12
Summary for physical activity in ABW compared to other office layouts.

Office layouts	Summary results	Direction	Citation
Large OPO	Sedentary time, Sedentary breaks, and Step count (all accelerometer measurement)		Foley et al., 2016
	lower Sitting-time, higher Standing-time, Walking time (all self-reported)	+	Foley et al., 2016
Mixed assigned locations	Sedentary time; Physical activity		**Arundell et al., 2018**
	Sitting time; Standing time		**Hallman et al., 2018**
	Perceived organisational support for being physical active in the workplace	+	**Arundell et al., 2018**
	Walking time	+	**Hallman et al., 2018**

Note. Summary results are shown for ABW in comparison with each one of five office layouts. Red cell (Direction -) = the outcome is worse in ABW than the given layout; Green cell (Direction +)= the outcome is better in ABW than the given layout; Grey cell (Direction blank) = the office layout had no effect on the outcome; Asterisked white cell = findings are described in the text; **Bold** citation= the strongest research designs (study type 1 or 4).

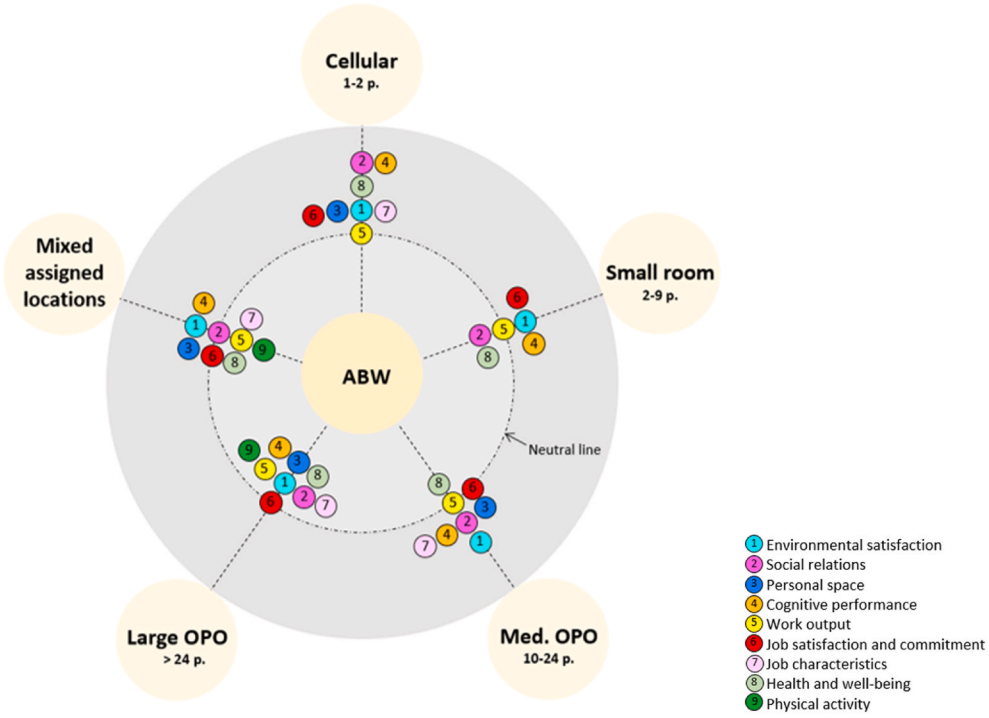

Fig. 2. Summary of ABW comparisons to other office layouts by outcome category.

because this captures the ability of knowledge workers to perform the work for which they are paid. From call centre operators to nuclear physicists, office workers need distraction-free spaces in which to concentrate. Fig. 2 shows that people want and need spaces that support attention and focus, as has been known for decades (Brill et al., 2001). When their workplaces provide this, as for people with cellular offices, their needs are generally well met; when they do not, as in large OPOs, needs are generally not met. ABWs can be seen as an improvement over an OPO because they do provide some space for focus, although perhaps not to the extent that all employees would prefer. This is evident from the weaker relationship between cognitive performance for the large OPO comparisons and ABW, versus the cellular office-ABW comparison.

All workplace types generally provide meeting spaces and break rooms, where gatherings can occur. The privacy afforded by a cellular office enables people to manage their social relations and communications effectively more of the time, while also affording personalization and place attachment that are impossible in ABW installations. Large OPOs have meeting spaces and break rooms also, and might permit personalization, but often completely lack spaces that provide focus. Overall, more enclosure, with an assigned space, is the workplace design that has the most support in the literature.

4.2. Possible moderators

Most investigations included demographic characteristics as covariates, which is of course an important methodological control; for example, Bäcklander et al. (2019) found that women were less likely to work in cellular offices than men, and (counterintuitively) the mean age of people in cellular offices was lower than the mean age of people in OPOs with assigned seating. They also found that women experienced greater cognitive stress than men, regardless of office type. However, their data set, and indeed most investigations', lacked the statistical power to look at interactions of these demographic variables and office type, tests of which could tell us whether or not these characteristics influence the response to office layouts.

This systematic review revealed complex evidence that sex might moderate the effects of workplace layout on some organizational productivity outcomes. Bodin Danielsson et al. (2015) found that ABW led to conflict and poorer social relations for women, and that women's concentration was better in cellular offices than ABW. Conversely, Bodin Danielsson and Theorell (2019) specifically set out to study sex differences by analyzing a stratified large data set, and found that office layouts having shared spaces were less satisfactory to men than women, but women's perception of supportive facilities such as spaces for meetings was lower than men's. The ABW comparisons in these analyses, however, were equally negative for both men and women.

It is almost trivial to say that the response to an ABW layout will depend on the tasks and requirements of the job. If a workplace does not provide the resources to perform the job, it is unlikely to result in satisfied or effective employees. This is evident in the results of Berthelsen et al., 2018, who observed that academics were dissatisfied with their new ABW environment, less likely to work on-site at university offices, and more likely to seek other employment. Conversely, De Been and Beijer (2014) studied a diverse sample of individuals in various job types and organizations, and found a positive effect for the comparison between ABW and cellular offices. Zhang et al. (2011) observed that people with different job functions used ABW spaces differently, as might be expected, although their investigation had no measures of satisfaction, so it is not possible to determine whether the spaces provided were considered suitable for the jobs. As was the case for demographic variables, few investigations had large enough sample sizes to provide sufficient statistical power for subgroup comparisons. Investigations that are designed to support comparisons between job types would be valuable.

4.3. Strengths and limitations

Literature reviews are only as comprehensive as the studies identified. Our search strategy returned a large number of studies, but it is possible that some were overlooked. We also took a conservative approach to study inclusion, resulting in only 23 studies in the final set; some readers might disagree with these exclusions. The seven studies that were excluded in the bias assessment step are listed in the supplementary material along with the reasons for their exclusion.

Researchers wishing to conduct quasi-experiments and field investigations in functioning organizations face many challenges, which no doubt explains the small number of studies (5 out of 23) that meet the criteria for the strongest causal inferences about the effects of office layout on organizational productivity outcomes (Cook & Campbell, 1979). Nonetheless, this does place limits on the overall conclusion strength of this or any review of the literature. We note with disappointment that few researchers appeared to comment on research design issues in their reports, and look for renewed attention to the factors identified by Cook and Campbell as threats to validity (Platts et al., 2020). Not all of these are amenable to statistical control, but some threats can be minimized if steps are taken to collect additional information on potential covariates, moderators, and historical events during longitudinal studies. Better attention to these matters would improve the evidentiary value of each study.

The quality of reporting in the reviewed studies can also limit the quality of review conclusions. Often it is not possible to provide photographs or layouts of the spaces studied, whether for privacy reasons or journal space limitations, both when the authors are familiar with the spaces that respondents occupied, or because they are unknown in a fully online survey. Nonetheless, having information about the each space's spatial arrangement, window location and view-content, ceiling height, interior finishes, and so on, would help to determine to what extent differences in the outcome measures might have been influenced by these differences and not by the use of an unassigned ABW design. When the ABW space is new and other office layouts are old and unrenovated, this information would have been particularly relevant.

In most studies, the ABW condition was relatively new to employees experiencing it, whereas other office layouts were familiar. The change process followed for this transition – and employees' response to it – might also moderate the effects observed here, but is unknown for most investigations. Change can be a stressor, but the ill effects can be mitigated by a change process that provides a sense of coherence – that is perceived as meaningful, comprehensible, and manageable (Antonovsky, 1996) and can result in better acceptance of the ABW layout (Brunia et al., 2016; Rolfö, 2018). In contrast, nonparticipation in the change process may cause employees' resistance to moving into the new premises and adverse outcomes of working in an ABW (Berthelsen et al., 2018). To the extent that the post-move data in studies reviewed here was collected early enough after the move that adaptation to the new conditions was incomplete, this would limit the strength of the conclusions drawn.

A strength of this review is its integration of diverse studies into a conceptual structure to facilitate comparisons. We identified over 70 outcome measures (dependent variables) in the reviewed studies, and created a conceptual framework with 9 categories; we further took the many ways in which various authors have parsed office layouts, and used a 6-category structure (modified from (Bodin Danielsson & Bodin, 2008) with ABW as the reference category. This structure for both dependent variables and office layouts can easily be updated with new publications; furthermore, future studies could use these categories explicitly.

5. Conclusions and future directions

During the pandemic, office workers have mostly worked from home (indeed, the authors of this paper have never met in person), with the return to offices occurring on variable schedules depending on public health orders in different jurisdictions and on the choices made by employers. Survey data suggest that many people perceive their personal productivity to be equal to or better than it was prior to March 2020 (Mehdi & Morissette, 2021), with a substantial proportion of respondents (39% in one survey) expressing a desire to work mostly or entirely from home in the future, and the same proportion seeking to work from home half of the time. These patterns were stable across sex, age, income, education and geographic location groups, but differed for workers in different industries (Mehdi & Morissette, 2021).

Working from home differs from working at the employer's location in many ways, but for many individuals it provides an assigned enclosed space where focused work is possible. For many (although not all) people, the home office provides privacy, control over environmental conditions, territory, personalization, and freedom from distractions, as well as avoidance of a long commute. We know of no surveys yet that have related employees' pre-COVID workplace to their preferred workplaces in a post-COVID time, but it could be that the preference for working from home is a rational response to unsatisfactory conditions experienced before the pandemic.

Since the rapid shift to working from home in March 2020 there have been abundant news articles proclaiming "the death of the office" (e.g., Megahed & Ghoneim, 2020), speculating about the effects of a societal shift to widespread, permanent working from home (e.g., Wong, 2020) and arguing that organizations risk losing valuable connections between employees if they forego meeting in person (e.g., Tisch, 2020). It remains unclear when the pandemic will be said to have ended, so that a new and more stable relationship between employees, employers, and work practice can emerge.

Organizations might seek to further reduce their real estate costs by promoting a hybrid workplace to which employees go for part of the week, and use this model to justify adopting an unassigned (ABW) model in which there are fewer seats than potential users on any given day (Mahdavi & Unzeitig, 2005). This model of workplace use was largely unknown at the time of the investigations reviewed here, and we know of no formal investigations of it in the post-pandemic context. The present review can provide some guidance for the creation of suitable workplaces, and other guidance to those who would study these new office layouts and use patterns.

Successful workplaces will provide spaces that support concentration, even if it is expected that people are on site primarily to meet with others. Even on a meeting day, individuals will need time to respond to e-mails, attend other virtual meetings without disturbing others, to prepare for upcoming meetings and to process information and notes at meetings that have concluded. When concentration is required, so are privacy and freedom from distraction. The degree to which this is a requirement for each individual and organization will differ, but spaces that provide privacy and individual control will permit focused attention on cognitive work, enable virtual meetings without disturbances from ambient noise that impede communications with remote participants, and allow small in-person discussions that cannot be overheard.

Successful organizations will avoid the use of large open-plan spaces, instead providing spaces that bring together modest numbers (small or medium-sized rooms) of people who share projects and goals. This can be expected to support social relations and communication, while also possibly reducing absenteeism (Newsham et al., 2022).

Such a hybrid model of work awaits systematic investigation on a large scale. Future office research will inevitably need to address this question. The strongest research design – a pre/post comparison with a no-treatment control group – is probably not possible in the short run, because all of society has experienced the historical interruption of the pandemic. Researchers should give careful thought to the range of potential confounding variables to be either controlled or measured in order to exclude alternate explanations. These will include organizational structure, culture, policies, and management style (Wohlers & Hertel, 2017), along with variables related to the change management process.

Studies that are designed to test demographic moderating variables and to provide subgroup analyses could support efforts to promote equity, diversity, and inclusion. For example, among the unanswered questions is whether junior employees will receive the mentoring they need if they infrequently encounter more experienced colleagues. Might it create a structural inequity if lower-status employees find it difficult or costly to provide adequate work spaces in their homes for the longer term? What is the effect on organizational culture if groups are always

separated?

Researchers and employers alike might do well to take the long view. As environment-behavior researcher Kent Spreckelmeyer wrote, "The difficulty with writing about dramatic change in the midst of it occurring is that the very drama of the effects unleashed by the change will be mistaken for what the future will become" (Spreckelmeyer, 1999, p. 262). Researchers who want to draw generalizable conclusions should take note of the need for patience while people process the change and develop stable responses.

Employers might be wise to tread cautiously as they consider new workplace models, as the real estate savings might be consumed by other increased costs, such as recruitment, retention, and absenteeism. The literature is clear that spaces that provide for concentration and focus best support work and also provide the best social relations, health and well-being, and job satisfaction; overall, these are the outcomes that lead to the best organizational productivity.

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Declarations of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2022.101920.

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*Denotes a paper that was included in the Results.