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The effect of office concepts on worker health and performance: a systematic review of the literature

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Conventional and innovative office concepts can be described according to three dimensions: (1) the office location (e.g. telework office versus conventional office); (2) the office lay-out (e.g. open lay-out versus cellular office); and (3) the office use (e.g. fixed versus shared workplaces). This review examined how these three office dimensions affect the office worker's job demands, job resources, short- and long-term reactions. Using search terms related to the office concept (dimensions), a systematic literature search starting from 1972 was conducted in seven databases. Subsequently, based on the quality of the studies and the consistency of the findings, the level of evidence for the observed findings was assessed. Out of 1091 hits 49 relevant studies were identified. Results provide strong evidence that working in open workplaces reduces privacy and job satisfaction. Limited evidence is available that working in open workplaces intensifies cognitive workload and worsens interpersonal relations; close distance between workstations intensifies cognitive workload and reduces privacy; and desk-sharing improves communication. Due to a lack of studies no evidence was obtained for an effect of the three office dimensions on long-term reactions. The results suggest that ergonomists involved in office innovation could play a meaningful role in safeguarding the worker's job demands, job resources and well-being. Attention should be paid, in particular, to effects of workplace openness by providing acoustic and visual protection.

Keywords: Office; Health; Performance

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1. Introduction

With the introduction of Information and Communication Technology and more flexible ways of organizing work processes, the work environment of office workers has changed substantially in the last decades. The changing nature of the office worker's environment is exemplified by the growing number of organizations that move from conventional offices with fixed workplaces to more open and transparent offices with shared workplaces (Vos and Van der Voordt 2002). Another example is the increasing number of organizations that allow office workers to work at home as a teleworker (Standen *et al.* 1999).

The introduction of innovative office concepts may allow organizations to save office space, reduce general and technical service costs and increase flexibility of office use. From a cost-efficiency point of view, therefore, the introduction of these office concepts seems advantageous. However, new office concepts may affect office worker health as well as office worker performance. An office concept characterized by an open and transparent lay-out, may, for instance, increase distraction and irritability and, as a consequence, threaten the health and performance of the office worker in the longer term. Potential effects of office concepts on health and performance, therefore, should also be considered in the development and introduction of new office concepts (Pullen and Bradley 2004).

2. Conceptual model

Building on architectural nomenclature (Vos *et al.* 1999), social relations approach, cognitive overload theory (Desor 1972; Geen and Gange 1977; Oldham *et al.* 1991; Evans and Lepore 1992), privacy theory (Sundstrom *et al.* 1980), the demand-resources theory of occupational stress (Demerouti *et al.* 2001) and the model of workload and capacity (Van Dijk *et al.* 1990) a general conceptual model was constructed for this study. This model depicts the relationship between office concepts and worker health and performance (see figure 1). For the purpose of this study, office concepts are defined in the model by three office dimensions, namely, the office location, the office lay-out and the office use (albeit the relevance of other office aspects such as office furniture and office climate is recognized). According to the model, office concepts in terms of these three dimensions influence work conditions in terms of job demands and job resources. These work conditions, in turn, may result in (un)favourable psychophysiological short-term reactions. Office concepts may also influence these short-term reactions independently of job demands and job resources. In the longer run, short-term reactions may affect office worker health and performance, termed long-term reactions in the model. The concepts of the model are described below.

2.1. Office concepts: location, lay-out and use

Three dimensions can be used to describe office concepts (Vos *et al.* 1999): the office location; the office lay-out; and the office use. The *office location* refers to the place at which the office worker carries out his/her activities. The office worker may work in the conventional office, or he/she may work in the telework office at home. The *office lay-out* refers to the arrangement of workplaces and type of boundaries in an office (Oldham *et al.* 1995). Two core features of the office lay-out are included in the conceptual model, namely, the workplace openness and the distance between workstations. The *office use* refers to the manner in which workplaces are assigned to office workers. One single

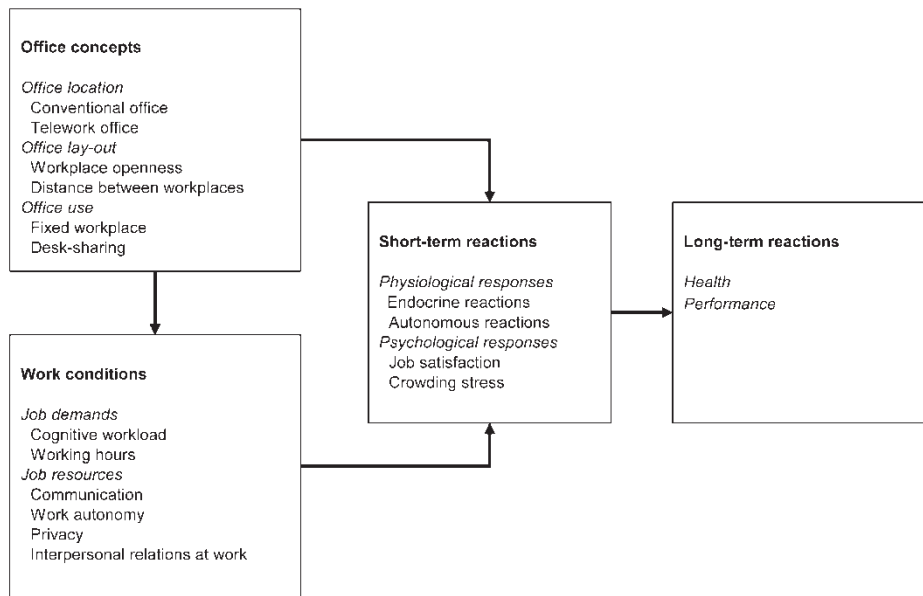


Figure 1. Conceptual model that depicts the hypothesized relation from office concepts in terms of office location, office lay-out and office use (via) demands and resources to short- and long-term reactions.

workplace may be assigned to one single office worker (i.e. the fixed workplace), or one workplace may be assigned to a range of office workers, hereafter termed desk-sharing.

2.2. Work conditions: job demands and job resources

Job demands are work conditions that require physical, mental or emotional effort (Demerouti *et al.* 2001). Office concepts may impact on several job demands. In the model two demands are distinguished: (a) cognitive workload, i.e. the extent to which office stimuli, such as noise, place an elevated demand on cognitive-attentional processes; and (b) working hours, such as irregular working hours due to desk-sharing. *Job resources* are work conditions that are supportive in achieving work goals, reduce job demands at the associated physiological and psychological costs, or stimulate personal growth and development. Office concepts may also influence job resources. The conceptual model differentiates four resources: (a) communication (e.g. desk-sharing may stimulate communication); (b) work autonomy (e.g. teleworking may increase autonomy over work scheduling); (c) psychological privacy (e.g. an open office may reduce psychological privacy); and (d) interpersonal relations at work (e.g. teleworking may reduce social support from co-workers).

2.3. Short-term reactions

According to the conceptual model, office concepts may directly or indirectly, via job demands and job resources, result in physiological and psychological short-term reactions, such as crowding stress, i.e. the psychological state of inadequacy of space (Stokols 1972), occupationally induced fatigue, job satisfaction, the excretion of cortisol and increased levels of blood pressure.

2.4. Long-term reactions

Accumulation of short-term reactions may, in the long term, result in more serious reactions. These long-term reactions include decreased performance (Cotton and Hart 2003) and negative health outcomes, such as psychosomatic health complaints including chronic fatigue, burnout and musculoskeletal disorders (De Lange *et al.* 2002; Sluiter *et al.* 2003).

3. Research aims

Narrative reviews of research on office effects have provided us with useful information (Wineman 1982; Davis 1984; Oldham *et al.* 1995; Gifford 1997; Standen *et al.* 1999; Brennan *et al.* 2002). However, to the authors' knowledge, an updated review in which the evidence is searched and synthesized in a systematic and critical manner has not been conducted. This study, therefore, systematically reviewed the scientific literature on effects of office concepts. To this end, the relations depicted in the conceptual model were translated into three research questions.

1. What is the effect of office location on work conditions (demands and resources), short- and long-term reactions?
2. What is the effect of office lay-out on work conditions (demands and resources), short- and long-term reactions?
3. What is the effect of office use on work conditions (demands and resources), short- and long-term reactions?

4. Methods

4.1. Literature search and selection

A literature search was conducted with a range of search terms in the title and/or abstract (see table 1). The search was conducted in: 1) Picarta (Dutch research reports) 2); OSHROM (1970–2003); 3) PsycINFO (1970–2003); 4) Biological abstracts (1972–2003); 5) Sociological abstracts (1970–2003); 6) Embase (1980–2003); and 7) Ergonomic Abstracts (1985–2003). Furthermore, to find additional publications a reference check of the identified studies was performed and conversations with four Dutch experts in the field of office innovation were conducted.

Study selection was carried out in two stages. In the first stage, studies were included on the basis of title and abstract using four inclusion criteria: (a) original study (no review or opinion article); (b) the study examines office location, office lay-out or office use as independent variables; (c) the study is conducted among individuals who perform paid office work in an office environment; and (d) analogous with the conceptual model, the study examines work conditions, short- or long-term reactions as dependent variables. In the second stage, studies were included on the basis of the whole manuscript using the same four criteria.

4.2. Methodological quality assessment

Using generally accepted criteria as the point of departure (Altman 2001), the quality of the included studies was evaluated on the basis of: (a) the response percentage (> 50%):

Table 1. Terms in title or summary used for the search.

Activity-related office	Landscape office	Virtual \cap office
Lean office	Office renovation	Telework \cap office
Clean desk	New office	Working at home \cap office
Cocon ^a concept	Innovative workplace	Private \cap office
Cocon office	New office layout	Open(ness) \cap office
Combi-office	Non territorial office	Closed \cap office
Concentration workplace	Non-territorial office	Density \cap office
Conventional office	Open office	Dense \cap office
Desk-sharing	Open plan office	Crowding \cap office
Wireless office	Team office	Enclosures \cap office
Dynamic ^b office	Traditional office	Spatial \cap office
Experimental office	Variety office	Boundaries \cap office
Flexible office	Office transformation	Distance \cap office
Flexible workplace	Virtual office	Accessibility \cap office
Shared office	Innovative office	Visibility \cap office
Group office	Workplace innovation	Partitions \cap office
Hotel office	Shared workplace	Noise \cap office
Innovative office	Office innovation	Privacy \cap office
Innovative workplace concepts		Flexible \cap office

Note. ^aCocon office is derived from the terms communication and concentration and is characterized by separate and small workstations destined for carrying out individual tasks and a large communal room reserved for consultations. ^bDynamic office concerns an office concept that allows office workers to search for a workstation that is fitted to the very task at hand. At office management the office worker may book a workstation in advance.

(b) the adequacy of the statistical tests that were used; and (c) the quality of the study design (see Table 2 for an explanation). Studies were classified as high quality studies when they met all three quality criteria. Studies that met one or two quality criteria were classified as medium quality studies. Studies that did not meet any quality criterion were labelled low quality studies and were excluded from further review in spite of their preceding inclusion.

4.3. Synthesis of the evidence

On the basis of the quality and consistency of the findings in the literature (Ariëns *et al.* 2001; Lievens *et al.* 2002), the information on office effects was synthesized into four levels of evidence: (1) *insufficient evidence*: less than three studies are available; (2) *limited evidence*: consistent findings in one or two high-quality studies and at least two medium quality studies; (3) *strong evidence*: consistent findings in at least three high quality studies; and (4) *inconsistent evidence*: the remaining cases. It should be noted that only statistically significant findings were taken into account in the evidence synthesis.

5. Results

The search in the databases and the reference lists, as well as the conversations with the experts, resulted in 1091 publications. After the first inclusion stage, 80 publications were withheld. After the second inclusion stage, 49 of these 80 publications remained in the study for review.

Table 3 gives information on the independent and dependent variables, the country in which the study was conducted, the occupational setting, the response percentage, the

Table 2. Description and evaluation of the four study designs

Type of design	Description	Evaluation (0–1)
Laboratory design	Design in which a specific office environment is simulated and potential effects on work conditions, health and well-being are examined under controlled conditions	1
Prospective field design	Design in which work conditions, health and well-being of the same office workers are observed before and after an office transformation	1
Retrospective field design	Design in which office workers who occupy a new office are asked to compare work conditions, health and well-being in the current office environment with work conditions, health and well-being of their former office	0
Cross-sectional field design	Design in which work conditions, health and well-being of two groups of office workers in different office environments are compared	0

Note. 0 = design is of low to medium quality; 1 = design is of high quality.

adequacy of statistical testing, the study design and the quality rating. Inspection of table 3 reveals that twelve studies met all three quality criteria (high quality studies); 35 studies met one or two criteria (medium quality studies); and two studies met no criteria (excluded low quality studies). Three, seven and 37 studies investigated the office location, the office lay-out and the office use, respectively, as the independent variable. Furthermore, the effect on work conditions, short- and long-term reactions was examined in 25, 26 and 17 studies, respectively. Please note that several studies examined more than one dependent variable.

5.1. Effects of office location on work conditions and short- and long-term reactions

5.1.1. Effect of office location on work conditions. Three studies (references 1, 2, 3 in table 3) examined the effect of office location, namely, teleworking at home, on work conditions. One study (reference 3 in table 3) established no effect of teleworking on working hours, communication, autonomy and interpersonal relations. The second study (reference 2 in table 3) showed that teleworking was associated with more overwork as compared to working in the conventional office. Furthermore, this study demonstrated that teleworkers perceive more work autonomy as compared to office workers in the conventional office. The third study (reference 1 in table 3) did not show evidence of an effect of teleworking on working hours and interpersonal relations. In short, there is *insufficient evidence* to conclude about the effect of teleworking on work conditions.

5.1.2. Effect of office location on short-term reactions. Two studies (references 2, 3 in table 3) looked into the effect of teleworking at home on short-term reactions. One study (reference 3 in table 3) failed to find an effect of teleworking on job satisfaction. The other study (reference 2 in table 3) found that, as compared to working in the conventional office, teleworking at home slowed down adrenaline recovery after work. In short, there is *insufficient evidence* to make a conclusion about the effect of office location on short-term reactions.

5.1.3. Effects of office location on long-term reactions. One study (reference 2 in table 3) investigated the association between teleworking at home and performance. This study

Table 3. Description of the 49 studies.

Reference number (reference)	Setting of study population	Country	Follow-up in months	N	Independent variable	Dependent variable			Response	Statist. test	Study design	Total score	Quality
						W	S	L					
1. (Hill <i>et al.</i> 1998)	Marketing	US	–	246	Location	✓	✓	60%	1	CFD	2	MQ	
2. (Lundberg and Lindfors 2002)	Government	Sweden	<1	26	Location	✓	✓	46%	1	PFD	2	MQ	
3. (Olson 1989)	IT	US	6	32	Location	✓	✓	100%	1	PFD	3	HQ	
4. (Banburry and Berry 1997)	Clerical	UK	–	48	Lay-out			100%	1	LAB	3	HQ	
5. (Banburry and Berry 1998)	Clerical	UK	–	48	Lay-out			100%	1	LAB	3	HQ	
6. (Becker <i>et al.</i> 1983)	University	US	–	100	Lay-out	✓		97%	1	CFD	2	MQ	
7. (Block 1989)	Clerical	US	–	169	Lay-out	✓	✓	100%	1	LAB	3	HQ	
8. (Brasche <i>et al.</i> 2001)	Diverse	Germany	NA	–	Lay-out			70%	1	CFD	2	MQ	
9. (Brennan <i>et al.</i> 2002)	Petrol company	Canada	6	21	Lay-out	✓	✓	26%	1	PFD	2	MQ	
10. (Brookes 1972)	Retail firm	US	9	100	Lay-out	✓		83%	1	PFD	3	HQ	
11. (Carlopio and Gardner 1992)	Bank	Australia	–	228	Lay-out	✓	✓	60%	1	CFD	2	MQ	
12. (Cosijn and Den Hertog 1972)	Electronics	Netherlands	36	365	Lay-out	✓		82%	0	RFD	1	MQ	
13. (Crouch and Nimran 1989)	Government	Australia	–	51	Lay-out	✓		29%	1	CFD	1	MQ	
14. (Duvall-Early and Benedict 1992)	Secretary	US	–	130	Lay-out	✓		65%	1	CFD	2	MQ	
15. (Evans and Johnson 2000)	Clerical	US	–	40	Lay-out		✓	100%	1	LAB	3	HQ	
16. (Fried 1990)	University	US	–	152	Lay-out		✓	62%	1	CFD	2	MQ	
17. (Fried <i>et al.</i> 2001)	University	US	–	93	Lay-out	✓	✓	NA	1	CFD	1	MQ	
18. (Hedge 1984)	Government	US	–	1,332	Lay-out	✓		65%	1	CFD	2	MQ	
19. (Jaakkola and Heinonen 1995)	Government	Finland	–	122	Lay-out			71%	1	CFD	2	MQ	
20. (Keller 1986)	R&D	US	–	221	Lay-out		✓	90%	1	CFD	2	MQ	
21. (Kupritz 1998)	Designers	US	–	89	Lay-out	✓		100%	1	CFD	2	MQ	
22. (Kurvers <i>et al.</i> 2001)	NA	US	–	7,822	Lay-out			NA	0	CFD	1	MQ	
23. (Marans and Yan 1989)	Diverse	Australia	–	1,000	Lay-out		✓	80%	0	CFD	1	MQ	
24. (O'Brien and Pembroke 1982)	Government	Australia	–	195	Lay-out	✓	✓	76%	1	CFD	2	MQ	
25. (O'Neill 1994)	Diverse	US	–	541	Lay-out	✓	✓	77%	1	CFD	2	MQ	
26. (Oldham and Brass 1979)	Publisher	US	5	128	Lay-out	✓	✓	91%	1	PFD	3	HQ	
27. (Oldham and Rotchford 1983)	University	US	–	114	Lay-out	✓	✓	100%	1	CFD	2	MQ	
28. (Oldham and Fried 1987)	University	US	24	109	Lay-out		✓	96%	1	PFD	3	HQ	

(continued)

Table 3 (continued)

Reference number (reference)	Setting of study population	Country	Follow-up in months	N	Independent variable	Dependent variable			Response	Statist. test	Study design	Total score	Quality
						W	S	L					
29. (Oldham 1988)	Insurance	US	3	65	Lay-out	✓	✓	✓	51%	1	PFD	3	HQ
30. (Oldham <i>et al.</i> 1991)	Government	US	–	298	Lay-out	✓	✓	✓	100%	1	CFD	2	MQ
31. (Rishi <i>et al.</i> 2000)	Bank	India	–	85	Lay-out	✓	✓		100%	1	CFD	2	MQ
32. (Sundstrom <i>et al.</i> 1980)	Diverse	US	–	213	Lay-out	✓	✓	✓	74%	1	CFD	2	MQ
33. (Sundstrom <i>et al.</i> 1982b)	Diverse	US	–	228	Lay-out	✓	✓		76%	1	CFD	2	MQ
34. (Sundstrom <i>et al.</i> 1982a)	NA	US	2	70	Lay-out	✓			54%	1	PFD	3	HQ
35. (Sutton and Rafaeli 1987)	University	US	–	109	Lay-out		✓	✓	100%	1	CFD	2	MQ
36. (Szilagy and Holland 1980)	Petrol company	US	4	96	Lay-out	✓	✓		100%	1	PFD	3	HQ
37. (Wollmann <i>et al.</i> 1994)	University	US	–	293	Lay-out		✓		59%	1	CFD	2	MQ
38. (Zahn 1992)	Industry	US	–	45	Lay-out	✓			48%	1	CFD	1	MQ
39. (Zalesny and Farace 1987)	Government	US	11	247	Lay-out	✓			52%	1	PFD	3	HQ
40. (Zhou <i>et al.</i> 1998)	University	US	–	75	Lay-out	✓			62%	1	CFD	2	MQ
41. (Allen and Gerstberger 1973)	Product engineers	US	12	10	Use	✓	✓	✓	41%	1	PFD	2	MQ
42. (Barten 2001)	Bank	Netherlands	11	72	Use	✓	✓		33%	0	RFD	0	LQ
43. (Beunder 2000)	Bank	Netherlands	12	30	Use	✓		✓	75%	0	RFD	1	MQ
44. (Boerstra and Raue 2000)	Government	Netherlands	6	19	Use	✓			58%	0	RFD	1	MQ
45. (De Jonge and Rutte 1999)	Insurance	Netherlands	24	122	Use	✓	✓	✓	20%	1	PFD	2	MQ
46. (Heerink and Vermeulen 2001)	Accountancy	Netherlands	NA	211	Use	✓	✓	✓	53%	0	RFD	1	MQ
47. (Van den Brink 2000)	Bank	Netherlands	13	159	Use	✓			63%	0	RFD	1	MQ
48. (Van Wijk 1999)	NA	Netherlands	5	257	Use	✓			30%	0	RFD	0	LQ
49. (Vos and Dewulf 1998)	Government	Netherlands	24	152	Use	✓			66%	0	RFD	1	MQ

Note. NA = information is not available; Follow-up = duration of follow-up in months; N = number of participants; Independent variable: location = workplace location; lay-out = workplace lay-out; use = workplace use; Dependent variable: W = work conditions (job demands or job resources); S = short-term reactions; L = long-term reactions; Response = percentage of office workers who participated; Statist. test = the adequacy of the statistical test that was used in the study (0 = insufficient; 1 = sufficient); Study design: LAB = laboratory design; PFD = prospective field design; RFS = retrospective field design; CFD = cross-sectional field design; Total score = the number of quality criteria that were fulfilled (0–3); Quality: HQ = high-quality study, MQ = medium-quality study, LQ = low-quality study (excluded from the review).

failed to establish an association between teleworking and performance. Thus, there is *insufficient evidence* to conclude on the effect of office location on long-term reactions.

5.2. Effects of office lay-out on work conditions and short- and long-term reactions

5.2.1. Effects of office lay-out on work conditions. Twenty-four studies examined the effect of workplace openness, or distance between workplaces on cognitive workload, communication, interpersonal relations, autonomy, or psychological privacy (references 6, 7, 9–14, 17, 18, 21, 24–27, 29, 31–34, 36, 38–40 in table 3). Table 4 indicates there is *strong evidence* that working in open workplaces reduces the office worker's psychological privacy and there is *limited evidence* that working in open workplaces intensifies cognitive workload and worsens interpersonal relations. As is also shown in table 4, *inconsistent*

Table 4. Results of the synthesis of evidence with regard to the effect of office lay-out (workplace openness and distance between workstations) on work conditions (cognitive workload, communication, interpersonal relations, autonomy and privacy).

	Studies, first author (reference number)	Association (reference number)	Evidence (direction)
Effect of workplace openness on:			
Cognitive workload	2 HQ: Block (7), Oldham (26) 5 MQ: Becker (6), Crouch (14), Kupritz (21), O'Neil (25), Oldham (27)	Positive (7, 26) No (25, 27); Positive (6, 14, 21)	Limited (positive)
Communication	3 HQ: Oldham (26), Sundstrom (34), Zalesny (39) 3 MQ: Cosijn (12), O'Neil (25), Oldham (27)	No (26, 34); Negative (39) No (27); Negative (12, 25)	Inconsistent
Interpersonal relations	1 HQ: Oldham (26) 3 MQ: Brennan (9), Fried (17), Oldham (27)	Negative (26) No (17); Negative (9, 27)	Limited (negative)
Autonomy	2 HQ: Oldham (29), Zalesny (39) 2 MQ: Oldham (27)	No (29, 39) Negative (27)	Inconsistent
Psychological privacy	4 HQ: Brookes (10), Oldham (29), Sundstrom (34), Zalesny (39) 10 MQ: Becker (6), Carlopio (11), Crouch (12), Duvall-Early (14), Kupritz (21), O'Neil (25), Oldham (27), Rishi (31), Sundstrom (32, 33)	Negative (10, 29, 34, 39) Negative (6, 11, 12, 14, 21, 25, 27, 31, 32, 33)	Strong (negative)
Effect of distance between work stations on:			
Cognitive workload	2 MQ: O'Neil (25), Oldham (27) 1 HQ: Oldham (29)	Negative (25, 27) Negative (29)	Limited (negative)
Communication	1 HQ: Szilagyi (36) 2 MQ: Oldham (27), Zahn (38)	Negative (36) No (27); Negative (38)	Inconsistent Inconsistent
Autonomy	1 HQ: Szilagyi (36) 1 MQ: Oldham (27)	Negative (36) No (27)	Inconsistent
Psychological privacy	1 HQ: Oldham (29) 4 MQ: Duvall-Early (14), Oldham (27), Rishi (31), Sundstrom (32)	Positive (29) No (32); Positive (14, 27, 31)	Limited (positive)

Note. HQ = high-quality study; MQ = medium-quality study.

evidence was found for an effect of workplace openness on communication and autonomy. Moreover, there is *limited evidence* that a close distance between workplaces intensifies the office worker's cognitive workload and reduces his/her psychological privacy. Finally, there is *inconsistent evidence* for an effect of distance between workstations on communication and autonomy.

5.2.2. Effects of office lay-out on short-term reactions. Twenty-one studies examined the effect of workplace openness or distance between workstations on short-term reactions (references 7, 9, 11, 15–17, 20, 23–33, 35–37 in table 3). From table 5 it can be seen there is *strong evidence* that working in open workplaces reduces job satisfaction. Table 5 also shows there is inconsistent evidence for an effect of close distance between workstations on job satisfaction and for an effect of workplace openness and distance between workstations on crowding stress.

5.2.3. Effects of office lay-out on long-term reactions. Sixteen studies examined the effect of workplace openness or distance between workstations on long-term reactions (references 4, 5, 8, 9, 13, 16, 18, 19, 20, 22, 25, 28–30, 32, 35 in table 3). The evidence synthesis shows there is inconsistent evidence for an effect of workplace openness and distance between work stations on performance and health.

5.3. Effects of office use on work conditions and short- and long-term reactions

5.3.1. Effects of office use on work conditions. Seven medium quality studies examined the effect of office use on work conditions (references 41, 43–47, 49 in table 3). Synthesis of the evidence shows there is *limited evidence* that desk-sharing improves communication

Table 5. Results of the synthesis of evidence with regard to the effect of office lay-out (workplace openness and distance between workstations) on short-term reactions (crowding stress and job satisfaction).

	Studies, first author (reference number)	Association (reference number)	Evidence (direction)
Effect of workplace openness on:			
Crowding stress	1 HQ: Oldham (29)	Positive (29)	Inconsistent
	5 MQ: Carlopio (11), Oldham (27), Rishi (31), Sundstrom (32), Zhou (34)	No (11, 27, 34); Positive (31, 32)	
Job satisfaction	4 HQ: Block (7), Oldham (26, 28, 29)	Negative (7, 26, 28, 29)	Strong (negative)
	6 MQ: Oldham (27, 30), Rishi (31), Sundstrom (32, 33), Sutton (35)	No (27, 32, 33); Negative (30, 31, 35)	
Effect of distance between work stations on:			
Crowding stress	1 HQ: Oldham (29)	Negative (29)	Inconsistent
	5 MQ: O'Brien (24), Oldham (27), Rishi (31), Sundstrom (32), Zhou (34)	No (24, 31, 32, 34); Negative (27)	
Job satisfaction	2 HQ: Oldham (29), Szilagyi (36)	Positive (29), Negative (36)	Inconsistent
	9 MQ: Fried (17), Keller (20), O'Brien (24), Oldham (27, 30), Rishi (31), Sundstrom (32, 39), Sutton (35)	No (20, 27, 31, 32, 39); Positive (17, 24, 30, 35)	

Note. HQ = high-quality study; MQ = medium-quality study.

between office workers. In addition, *inconsistent evidence* was found that desk-sharing intensifies cognitive workload.

5.3.2. Effects of office use on short-term reactions. Three studies investigated the effect of office use, i.e. desk-sharing, on short-term reactions (references 41, 45, 46 in table 3). Due to the small number of studies the evidence is *insufficient* to make inferences about the effect of office use on short-term reactions.

5.3.3. Effects of office use on long-term reactions. Four studies examined the effect of office use, namely, desk-sharing, on long-term reactions (references 41, 43, 45, 46 in table 3). Due to *insufficient evidence* no inferences about the effect of desk-sharing on long-term reactions can be made.

6. Discussion

6.1. Effects of office innovation

This review failed to provide evidence for an effect of office location, namely, teleworking at home, on work conditions, short- and long-term reactions. In contrast, evidence was provided for an effect of office lay-out on work conditions and short-term reactions. In particular, strong evidence was found that working in open workplaces reduces the office worker's privacy and job satisfaction. Also, limited evidence was found that close distance between workstations intensifies cognitive workload and reduces psychological privacy. In accordance with the conceptual model (see figure 1), therefore, office concepts do affect the office worker's job demands, job resources and short-term reactions. More specifically, consistent with overload theory (Desor 1972; Oldham and Fried 1987), open workplaces and high-density offices increase cognitive workload, it is thought, due to too many people and interactions and too close proximity to others. Consequently, office workers have difficulty concentrating, react negatively to interactions and become dissatisfied with their job. Furthermore, compatible with privacy theory (Sundstrom *et al.* 1980), the lack of acoustic and visual isolation in open workplaces diminishes the control over interaction with others and hinders workers in discussing personal topics in confidence.

Also in agreement with the conceptual model, office use, in terms of desk-sharing, was found to stimulate communication between office workers. In particular, the evidence synthesis provided limited evidence that desk-sharing improves this job resource. Presumably, office workers who share desks need to change workplaces repeatedly. This increases the opportunity to interact and, as a consequence, improves communication (Vos and Van der Voordt 2002).

In contrast to the conceptual model's propositions, inconsistent evidence was provided for the effect of office lay-out on communication, autonomy, crowding stress, performance and health. Possibly, person-, work-, or environment-related variables moderate effects of the office lay-out. Indeed, person-related variables such as low need for privacy (Oldham 1988), high screening ability (Fried 1990; Oldham *et al.* 1991) and low organizational tenure (Fried *et al.* 2001) have been found to buffer harmful office effects. Furthermore, work-related variables, such as low task complexity (Block 1989), and environment-related variables, such as favourable lighting and air conditions (Hedge 1984; Adams and Zuckerman 1991), may protect office workers from negative office lay-out effects. Integration of these variables into the conceptual model may improve its predictive validity.

6.2. *Scientific considerations*

Four aspects of this review should be commented upon to appreciate the practical implications of the findings. First, as mentioned briefly in the introduction, other aspects of the office plan may influence office worker health and performance. These aspects include characteristics of desks and chairs (de Looze *et al.* 2004), computers, monitors and keyboards (Briner and Hockey 1994; Hedge and Powers 1995), lighting conditions (Hedge 2000), colour and material use (Carlopio 1996; Gifford 1997), thermal conditions (Vasmatzidis *et al.* 2002) and the indoor air quality (Menzies and Bourbeau 1997; Kolstad *et al.* 2002; Burge 2004). To obtain a full picture of office effects, these characteristics should also be considered.

Second, although a large number of publications about effects of office concepts were found, the number of scientific studies with a prospective or laboratory design and adequate response was small. This restricted the opportunity to make inferences about several hypothesized office effects. Research that addresses the effects of office location (i.e. telework) and office use (i.e. desk-sharing), as well as research that examines health effects of office innovation in particular, is scarce. Considering the popularity of telework and desk-sharing and the high prevalence of stress-related health complaints such as fatigue and musculoskeletal complaints among office workers, this gap in knowledge is remarkable.

Third, this review examined the effect of innovative offices on work conditions and health and performance of office workers without taking the implementation process into account. Conversations with experts involved in the development of new office concepts, however, reveal that office concepts are often implemented without the participation of the office worker. Research has demonstrated that low participation during implementation of innovations may negatively affect the worker's attitude (Baruch and Hind 2003). Presumably, the involvement of office workers will promote the successful implementation of innovative offices.

Fourth, the integration of the study quality in the synthesis of the evidence (Slavin 1995) allowed more weight to be given to results obtained in high-quality studies when reaching conclusions, as compared to results obtained in medium quality studies. The best-evidence-methodology, therefore, is considered a strong aspect of this review.

6.3. *Practical implications*

The findings of this review carry practical implications for ergonomists involved in the development and implementation of innovative offices. First, the unfavourable effect of workplace openness implies that, to safeguard the well-being of the office worker, innovative offices should provide sufficient shelter from unwanted acoustic and visual stimuli. To this end, innovative offices should be supplied with an adequate number of enclosed, sound-insulated workstations. In addition, tall, enclosed or frosted glass sound-insulating partitions between open workplaces, textile floor covering, acoustic ceiling tiles and printer cabinets might be applied for this purpose. Second, the moderating effect of person-, work- and environment-related variables implies that detrimental office effects might be diminished by the application of measures directed at these variables. Ergonomists might, for instance, prevent unfavourable effects of open and crowded offices by improving lighting and climate conditions. In addition, attention might be paid to the workplace lay-out of high tenure office workers who have a higher need for privacy and low screening-ability, and are engaged in complex work. Third, the observed limited

evidence for an effect of desk-sharing on communication suggests that companies might improve organizational effectiveness by application of this office concept.

6.4. Conclusions

Strong evidence was established that working in open workplaces reduces the office worker's psychological privacy and job satisfaction. Additionally, some limited evidence was found that: (a) working in open workplaces intensifies cognitive workload and worsens interpersonal relations; (b) a close distance between workstations intensifies cognitive workload and reduces the office worker's psychological privacy; and (c) desk-sharing improves communication. These findings indicate that innovative offices may affect the organization's cost-efficiency as well as the office worker's work conditions and well-being. Therefore, the effect of innovative offices on the office worker's work conditions and well-being should be considered during the development and introduction of innovative offices.

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