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# NOISE IN OPEN-PLAN OFFICES: A HOLISTIC RESEARCH STRATEGY

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## ABSTRACT

The present paper will adopt several approaches to evaluating the effects of noise in open-plan offices. The starting point will be a review of the literature. This confirms many general statements about noise's effects, namely that they will depend on the type of noise, the outcome measures considered, and the characteristics of the person exposed to it. The second approach will involve a survey to assess the effects of noise on the well-being and job satisfaction of office workers. The results showed that noise exposure predicted negative well-being but not positive well-being. In contrast, environmental satisfaction predicted positive well-being but not negative well-being. These effects remained significant when personality, health-related behaviours and job characteristics were included in the analyses. Finally, an intervention study demonstrates some noise-related issues in open-plan offices. Here, the benefits of changing the office structure were counteracted by more people moving into the office.

**Keywords:** *Noise, open-plan office, literature review, survey, intervention.*

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## 1. REVIEW OF THE LITERATURE: PRIVACY AND NOISE

Privacy gives employees more control over their accessibility to others, is generally preferred, and has been linked to increased workplace and job satisfaction [1]. Lack of privacy and increased noise are common complaints in open-plan offices [1-5]. Perceived noise has been shown to mediate lower office satisfaction with more open-plan offices [6]. Working in a more open environment results in less visual and auditory privacy, as employees can be observed, and their conversations can be heard. Confidential discussions can be difficult unless there are separate areas for private meetings. Irrelevant speech, such as from conversations, has been linked with decreases in well-being and productivity and increases in noise annoyance, more in open-plan offices than shared offices. There is strong evidence from the literature that working in open-plan offices reduces privacy and limited evidence that close workstations are associated with less privacy [3]. In a small office relocation study, Oldham [7] found that moving from an open office to a low-density open or partitioned office positively affected privacy, crowding, and environmental satisfaction. In another study, there was no relationship between perceived privacy and task performance (assessed by managers' ratings) or job satisfaction [8]. Maher & von Hippel [8] found evidence to suggest that when perceived privacy is low and task complexity is high, people with a weaker ability to inhibit stimuli report lower job satisfaction.

Lack of privacy in open-plan environments can make it difficult for employees to have confidential conversations. Sundstrom et al. [9] found that among employees moving from different office types to an open-plan office, managerial staff in private, enclosed offices experienced the

most significant decline in satisfaction with visual and auditory privacy. Their questionnaire data and acoustic measurements suggested that the decrease in satisfaction with privacy was linked to a reduction in the ability to have confidential conversations in the open-plan environment. In the study, satisfaction with communication and privacy were strongly correlated, contradicting the belief that open-plan environments facilitate communication. Lack of privacy and difficulty having confidential conversations also affect non-managerial employees. In a longitudinal study measuring employees' satisfaction with relocating from a traditional office to an open-plan office, the main complaints were lack of privacy and confidentiality and increased noise [2]. Brennan et al. [2] also found a decrease in team member relations after relocation to the new office, which did not improve 6 months after the move. The researchers recommended some solutions to the client to combat problems with privacy and noise: additional break-out rooms for confidential conversations, meetings, and phone calls and establishing and encouraging open-plan office protocols.

Bridger and Brasher [10] state that when a lack of privacy increases the need for self-control, privacy is essential in maintaining mental well-being in employees doing cognitively demanding work. In a study comparing outcomes between participants in a large open-plan building to several smaller buildings with ten people or less per room (N = 196), it was found that mental wellbeing was more closely linked to an interaction between cognitive task and self-control demands in the open-plan layout [10]. Previously, the occupants of the sizeable open-plan building had completed another survey and had complained about a lack of privacy. The open-plan employees' complaints about privacy varied from sitting next to staff of different levels of seniority, distractions from phones and conversations, and public visibility of their computer screens.

One method of dealing with the problem of lack of visual and auditory privacy in an open-plan environment is using partitions. Partitions around workstations have been shown in some studies to be related to increased satisfaction with privacy, office satisfaction, and job satisfaction [1, 7]. In a study by Oldham [7], employees moving from an open-plan office to one with three sound-absorbing partitions around their workstations of 4 to 6 feet in height experienced improved perceptions of privacy. Interestingly, Y. S. Lee [11] found that workers in open-plan offices without partitions had more satisfaction with auditory privacy and noise levels than workers with high partitions. They found no significant difference in satisfaction with visual privacy between open-plan office workers with high partitions and those without. The authors suggested visual cues may help with noise and privacy, e.g., co-workers can visually assess if a colleague can be interrupted. In the latter study, it is possible that some respondents had differing needs for privacy related to the office layout, i.e., more open-plan environments. Offices may have been designed for collaboration, which was necessary for some jobs. Similarly, Maher & von Hippel [8] found that high privacy affected lower job satisfaction in certain participants. They proposed that the higher partitions in their study provided visual privacy but not auditory privacy, causing more significant problems for the occupants. In contrast, employees in another open-plan office study had higher satisfaction with privacy satisfaction with higher partitions (140 cm) vs lower partitions (120 cm). Employees with high partitions and access to a window were most satisfied with privacy [12]. Some complaints from participants sitting away from windows indicated that they were disturbed more by colleagues (e.g. using a corridor), so the relationship between window access and privacy may have been an artefact of being further from the pathway. The evidence suggests that there may be a benefit in using partitions, but very high partitions may be undesirable.

The workplace density may also impact the perception of privacy [7]. Oldham [7] found that employees experienced improvements in perceived privacy when moving from an open-plan office to either a low-density open-plan office or an office that had partitioning around the workstations. Although there were improvements in the perception of privacy in both offices, there were more positive improvements in work satisfaction from employees who moved to the low-density open-plan office. More research needs to be done in this area, but density may be another factor to consider when designing offices that provide privacy for the occupants.

In conclusion, privacy and noise disturbance may be problematic in some office environments and impact occupants' well-being, environmental satisfaction, and communication with colleagues. Several design considerations may ameliorate the lack of privacy in open-plan environments, such as partitions, increased density, and separate areas to use outside of open-plan areas. Lack of privacy in open-plan environments may be viewed as an absence of environmental control, a concept discussed in the next section.

## 2. NOISE EXPOSURE AND WELL-BEING: A SURVEY

Few studies measure psychological well-being outcomes. Wellbeing is challenging to conceptualise, and our approach is given in the next section. The "well-being process model" [13-15] is a holistic approach that attempts to provide a theoretical framework that has led to the development of a questionnaire that could be useful in policy and practice. Positive appraisals and outcomes, such as life satisfaction and happiness, form the basis of many approaches to subjective well-being. However, including negative and positive well-being features is essential, as they are not the endpoints of a single dimension but involve different CNS mechanisms. The general rationale behind the present study was to examine whether the perceptions of noise in open-plan offices were associated with positive and negative well-being. Established predictors of well-being were statistically controlled, as was the general satisfaction with the working environment.

### 2.1 Methods

Participants were 215 office employees (108 females, 107 males) recruited from a Qualtrics research panel. The inclusion criteria required participants to be over 18 years old, residing in the United Kingdom, and working in an office for at least one month before participating in the study. Participants received a financial incentive for completing the questionnaire. Most participants (95%) worked 35 hours a week or more. Only one participant was in a private office, and the remainder were in shared (17%) or open-plan offices (82%). More participants were allocated fixed desks (78%) rather than flexi-desks or hot desks (21%).

### 2.2 The Questionnaire

Twenty-nine environmental satisfaction questions were included. They were derived from questionnaires used in environmental satisfaction research [8] and a previous study conducted by the authors. An example question was, 'What is your degree of satisfaction with the following areas in your workplace for meetings?'. Items were rated on a 7-point Likert scale from 1 'very unsatisfactory' to 7 'very satisfactory'.

Wellbeing was measured using the Smith Wellbeing Questionnaire (SWELL) [16] and the WHO-5 wellbeing scale [17]. The SWELL includes 21 items, some of which are predictors of wellbeing (e.g. job demands), and others are wellbeing outcomes (e.g. work-related anxiety and depression). Furthermore, the scale measures both positive and negative well-being, resulting in four well-being components: positive predictors, favourable outcomes, negative predictors, and adverse outcomes. Seventeen items are rated on a 10-point Likert scale; three are binary response items (yes/no), and one is a scale response item. An example question is, 'Thinking about the last 6 months: Are you anxious or depressed because of work?' rated on a scale from 1 'never' to 10 'very often'.

The questions used in the present analysis were: Noise exposure – rated on a scale of 1-10; Environmental satisfaction (total score); Healthy Lifestyle – rated on a scale of 1-10; Positive Personality- rated on a scale of 1-10; Job Demands – rated on a scale of 1-10; Job Control and Support – rated on a scale of 1-10; Positive well-being – the sum of job satisfaction and happiness ratings; Negative well-being (sum of stress, anxiety/depression and fatigue ratings); and WHO-5 total score.

### 2.3 Results

High noise exposure was significantly associated with high negative outcome scores. High job demands, low control and low positive personality scores were also associated with high negative outcome scores. The second regression had positive outcomes as the dependent variable. Noise had no significant effect on positive outcomes. High positive outcome scores were associated with a healthy lifestyle, upbeat personality, high job control and greater satisfaction with the working environment. The final regression had the WHO-5 scores as dependent variables. High WHO-5 well-being scores were not predicted by perceived noise exposure. Significant predictors were a healthy lifestyle, an upbeat personality, high job control, high satisfaction with the working environment and lower job demands.

### 2.4 Discussion

The results from the present study showed that perceptions of noise in open-plan offices were associated

with negative well-being. This effect remained significant when established predictors of negative well-being (job demands, job control and upbeat personality) were adjusted for. Environmental satisfaction was also included in this analysis, and it is essential to note that the effect of noise remained significant even when other office features were controlled. This is the first result to show an effect of noise per se rather than a combination of environmental stressors. Such effects have been shown before when much louder noise has been examined (e.g. research on rail staff) [18]. In contrast, environmental noise exposure, where the noise would have been at a lower intensity, had little effect on the well-being of a student sample [19].

The results from this study suggest that office noise is associated with greater negative well-being. This topic now requires further research, preferably using longitudinal designs with interventions to change noise levels. Studies are also needed to determine the underlying mechanisms. These may involve structural equation models to show the pathway(s) through which noise has an effect. Research that includes objective physiological measures will also be necessary in understanding the biological mechanisms underlying such changes in well-being.

## 3. PARTITIONS AND OTHER OFFICE DESIGN SOLUTIONS

Evidence indicates that well-being and productivity improve when measures are taken to reduce noise and distractions or increase privacy in open layouts. Partitions have been used historically to ensure privacy and fewer distractions in open-plan environments. Panels, bookcases, or living wall systems ("walls" made from plants) may also benefit shared office spaces. Haapakangas, Hongisto, Varjo, and Lahtinen [20] compared two groups of participants moving from private to open-plan offices and found that bother groups had higher distractions; however, only the group moving to an office with fewer quiet areas had adverse effects on environmental satisfaction, perceived collaboration, and stress. Increased distractions mediated the adverse impact on cooperation and stress, and distractions may be considered ecological demands in open-plan offices. Activity-based working (ABW) offices may offer another way of dealing with the open-plan problem of conducting focused work in a noisy, distracting environment [21]. ABW offices provide separate areas that occupants can use for specific types of work, such as quiet areas for concentrated work. A relocation study following people moving from an open-plan office to an ABW office found increased satisfaction with noise and auditory privacy; however, auditory privacy and speech levels were the environmental satisfaction items occupants were most dissatisfied with in the ABW office [22]. Interviewees commented about noise etiquette issues, such as teams having meetings in open-plan areas and some teams being noisier than others. The latter study shows that issues such as office etiquette are essential even with quiet areas for open-plan office occupants. Overall, the studies described in this section suggest that measures can be taken to ensure better working conditions concerning noise in open-plan offices, and these improvements positively impact occupants' well-being. Design considerations, such as providing quiet areas to work, encouraging working away from the desk practices, and using partitions and sound absorptive materials, may enable employees in open-plan offices to work with fewer distractions and noise disturbances. Acoustic etiquette also should be considered to minimise noise and distractions. Further studies should be conducted in this area, particularly experimental designs, as previous research is limited.

## 4. WORK BOOTHS AS A DESIGN SOLUTION

In the survey, open-plan office employees reported that noise and distractions negatively affected their well-being and impaired productivity. Employees commented on frustration and annoyance stemming from distractions affecting their ability to concentrate. Coping strategies were reported, including working away from the desk, working from home, and using headphones. The researcher's industrial partner designed a range of work booths, named Coppice, to help with the problem of noise and distractions in open-plan offices. The work booths have partial wrap-around partitioning, which can minimise both visual and auditory distractions. In addition, employees should experience less distraction when they sit at a work booth area, as they are removing themselves from their colleagues and can signal to others that they are doing focused work. To the researcher's knowledge, a longitudinal field study using work booths has not been conducted before. Much of the previous research into using partitions in open-plan offices has focused on partitioning around workstations, whereas

work booths do have partitioning but offer a different experience. When using work booths, employees may work away from their desks for a period to do some focused work. This is a central tenet of ABW, allowing occupants to exercise control and choose an appropriate area to work for their task. Providing quiet areas has shown positive results in past studies [20, 22].

### 4.1 Method

A randomised crossover design was used, where participants were randomly assigned to one of two conditions, a Work Booth Condition and a Non-work Booth Condition, and then the participants completed the other condition. In the Work Booth Condition, participants had access to work booths to use whenever they wished for one week, whereas in the Non-work Booth Condition, participants were asked not to use the work booths for one week. Participants were invited to complete online daily questionnaires for two weeks (one week for each condition) at the end of each workday. The questionnaires asked about their use of different areas, their job satisfaction, self-assessed productivity, satisfaction with noise and privacy, workload, and mood. Average weekly ratings were calculated for each individual, and repeated measures analyses were conducted to investigate the effect of the availability of work booths. At the end of the two weeks, participants were asked to complete a user experience questionnaire, which included questions about their satisfaction with using the work booths. This research should enable a greater understanding of the relationship between well-being and work booths and explore the use of work booths as a solution for office noise.

Hypothesis 1. Participants' job satisfaction, self-assessed productivity, and satisfaction with noise and privacy would be higher during the week when work booths were available than during the week when they were unavailable.

Hypothesis 2. Participants perceived that workload would be lower in the week when work booths were available, compared to when they were unavailable.

Hypothesis 3. Participants would have more positive and less negative mood states when work booths were available, compared to the week when they were unavailable.

### 4.2 Results

There were no differences in weekly average ratings of workload, productivity, environmental satisfaction, and well-being among individuals; however, there were some significant changes when comparing specific periods of the day when participants worked at booths vs. desks. In the periods of the day participants used work booths, there were significantly lower distractions and differences in retrospective mood ratings compared to when they worked at their usual desks. There were considerably fewer distractions at the work booths during the day than at the desks/workstations. There was higher productivity, although not significant, among individuals in the same periods. Participants may have worked in several areas each day, so their overall daily ratings during the Work Booth Condition reflected on time spent in booths and other office locations. During the study debrief, some participants commented that their preference for conducting focused work was using a private room or pod if available; however, the work booths were viewed as a good second option. Considering the space and economic difficulty of providing private offices, work booths offer a satisfactory alternative.

No significant differences were found in individuals' NASA-TLX workload ratings between conditions. As mentioned above, this could be explained by participants' retrospective recall of the day and the fact that they had alternative quiet areas to use. In addition, participants reported being disturbed by colleagues while they worked at the booths, which may have affected their ability to concentrate. There were no significant differences in mood when the weekly average ratings of Work Booth Condition vs. Non-work Booth Condition were compared. This agrees with a previous lab study that indicated no difference in mood when participants worked at a desk with partitions raised [23]. It is possible that users' moods differed in the work booths, but the transient change in mood state did not impact their impression of their overall daily mood, as reported in the Daily Questionnaire. Positive changes in mood states were reported in the Coppice work booths in terms

of feeling less stressed, irritated/annoyed, and anxious, as well as more relaxed and calmer. Negative mood changes linked with the booths were feeling less energetic and more isolated/lonely. The latter mood changes perhaps indicate people's need for social interaction at work and suggest that focused work areas should be used short term, not all day. Thus, moving to work booths for part of the day may be a way for employees to manage moods in the short term, such as reducing stress and anxiety. Comments from the questionnaires indicate that further training in using work booths is recommended during implementation. In particular, employees should be educated not to disturb people working in booths and quiet areas. Other comments indicated that the placement of the work booths is essential. Due to limited available space, some booths were in a corridor with bare concrete floors and busy traffic. This resulted in a noisy and distracting environment. Ideally, the work booths should be located somewhere quieter and more private. It can be uncomfortable for some users to have people walking behind their work booth, so locating booths away from busy pathways could be beneficial, or configurations incorporating partitioning behind the users' seating area could be used. The feedback provided by participants indicated that training in office etiquette and the optimal use of work booths would be beneficial.

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