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The Use of Protective Hearing Devices and Perceived Noise Disturbance and Social Climate in Open Office Environments

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ABSTRACT

Open office environments are architectural solutions that are believed to economize the use of office space and facilitate social interactions at work. However, research has shown that employees in open office environments may experience lower job satisfaction, stress reactions, and exhibit poorer performance. Exposure to noise in open office environments may prompt avoidance behaviours such as working from home, using meeting rooms for single use at work, or using protective hearing devices. We examine to what extent open office workers used protective hearing devices, and whether this use was related to reports of noise disturbance and if this use seemed to influence the perception of the social climate at work. Sixty-eight participants working in open office environments completed the survey. The participants worked within the same company and building but on three different floors. The use of protective devices, disturbance from noise, and social climate at work were assessed with questionnaires. The results showed that the participants were primarily disturbed by noise generated by colleagues. The social climate at work was in general perceived as *relaxed and comfortable* and *encouraging and supportive*. Fifty-four percent of the participants used protective hearing devices often or always, however this use was not significantly associated with perceived disturbance, self-rated hearing nor seemed to interact with the participant's experience of the social climate at work. However, the participants' frequent use of protective hearing devices is a behaviour that may interfere with the effectiveness of architectural and technical solutions such as sound masking that aim to add sounds designed to improve the intelligibly of speech and reduce overhearing.

Keywords: Open office, Self-rated hearing, Social climate, Sound masking

INTRODUCTION

The Swedish Working Environment Authority has reported that circa 60 % of the Swedish labour force work in offices and that, among these, 70 % share office space, or work in an open office environment (Arbetsmiljöverket, 2018). While open office environments are believed to economize the use of office space and facilitate social interactions and essentially has become

the norm for office planning, research has nuanced the picture by showing that employees in open offices may experience lower job satisfaction, stress reactions, and exhibit poorer performance due to the office environment (Danielsson & Bodin, 2008; Engelen et al., 2019; Richardson et al., 2017).

A contributing factor to the negative reactions on open office solutions is believed to be the exposure to unwanted sounds (i.e., noise), in particular human speech from other office occupants and/or visitors (Schlittmeier & Liebl, 2015). Apart from cognitive (e.g., distraction) and emotional implications (e.g., irritation), exposure to noise may also trigger avoidance behaviours such as working from home, using unoccupied meeting rooms at work, or using protective hearing devices (e.g., ear protectors and headphones) to cancel out noise.

The prevalence proportion, and possible consequences, of using protective hearing devices in an open office environment has been less explored in the scientific literature. However, because the use of protective hearing devices is likely to affect how the individual employee socially interacts with colleagues and other people at work, it is conceivable that these behaviours also affect how users of protective hearing devices gauge job satisfaction and the social climate at work. For this reason, and as part of an ongoing intervention project on sound masking in open office environments, we examined (a) to what extent office workers used protective hearing devices and whether the use of protective hearing devices was (b) related to reports of disturbance from various sources of unwanted sounds at work, and (c) reports of the social climate at work. Presumably, this knowledge could be useful for various stakeholders (e.g., architects, property owners, employers, and sound designers) when making decisions concerning floor plan and sound masking solutions to target speech intelligibility and reduce overhearing in open office environments.

METHODS

Study Design

The present cross-sectional analysis comprised baseline data collected within the project "*Sound masking in open office environments: Intervention study of effects on work environment and personnel*" (AFA Försäkring, dnr. 190273). Data on use of protective hearing devices, experienced noise disturbance and social work climate etc. was collected from employees in open office environments via an electronic survey in March 2023 using the RedCap software. The project had ethical approval from the Swedish Ethical Review Authorithy (2022-02565-01).

Participants

Access to participants were granted via an external partner. The external partner identified a suitable five floor office building and provided contact with the company's divisions occupying open office sections at floor two, three and four. Ninety-eight employees were invited to take part in the study out

of which sixty-eight decided to participate (32 women, 35 men, and 1 undisclosed). The participants were between 24 and 66 years of age (Mean age =38.9 years; SD 10.2 years).

Office Environments

The three office environments had highly similar floor plans and acoustical conditions. When unoccupied, the A-weighted sound levels in these office environments varied between 21.0 dBA and 26.5 dBA. This was determined by using two measurement positions on each floor, and the measurements were made outside office hours in March 2023 and lasted 10 seconds.

Assessment of Self-Rated Hearing

Three single items assessed aspects of self-rated hearing. The first item assessed self-rated hearing in general and read: "*Imagine that a person with intact hearing has a hearing ability score of 100 and a deaf person a hearing ability score of 0. With origin in that imagination, mark the score you feel expresses your own hearing ability"* and was responded to on an 11-step scale from 0 to 100 with increments of 10 (Lund et al., 2010). The question "*Do you use a hearing aid?*", responded to with *Yes* or *No*, assessed whether the participant compensated for reduced hearing. The question "*Is your hearing reduced to such an extent that you have difficulties in following a conversation when several people are gathered (without use of a hearing aid)*" was responded to with *Yes* or *No*.

Assessment of the Use of Protective Hearing Devices

The participants' use of protective hearing devices was assessed with one single item question that was tailored for this study. The question read *"In your work, do you use protective devices to protect yourself from unwanted sounds (e.g., ear protectors, earplugs, listen to music etcetera)"* that was responded to on a five-point likert scale "*Always, often, sometimes, seldom, rarely/almost never*".

Assessment of Disturbing Sounds at Work

The participants' experience of being disturbed by noise at the office was assessed with a question used in previous research on school-teachers (Kristiansen et al., 2011). The question read "*How disturbing have you experienced sounds from the following sources during the last 4 weeks*" which was followed by five descriptive items: (1) *Road, Train or Air traffic or other sounds from outside surroundings*, (2) *Corridors or adjacent rooms*, (3) *From colleagues (e.g., conversations, rattling of furniture etcetera)*, (4) *From ventilation or other apparatuses or machines,* and (5) *other sources of sounds*. All items were responded to on a 7-point scale, with verbal anchors at the endpoints indicating degree of disturbance: "*Not at all disturbed = 1*" to "*Almost unbearably disturbed = 7*".

Assessment of the Social Climate at Work

The participants perception of the social climate at work was assessed with a question from the General Nordic Questionnaire for Psychological and Social Factors at Work (QPS-Nordic) (Dallner et al., 2000) that has been used in previous research about acoustical conditions (Persson et al., 2013). The question read "*How would you describe the social climate at your workplace…*" and was followed by five descriptive items, that is, (1) "*Competitive*," "*encouraging* and *supportive*," (2) "*Distrustful and suspicious*", (3) "*Relaxed and comfortable*," (4) "*Rigid and rule based*", and (5) "*Conflict laden*". All items were responded to on a 5-point scale: *Not at all = 1, To a small degree = 2, Partly = 3, To a high degree = 4,* and *To a very high degree = 5*.

Statistical Analysis

Using the IBM SPSS software version 29 (*IBM SPSS statistics 29.0 for windows*, 2023), we applied descriptive analyses and traditional methods for non-parametric testing. Two-tailed alpha level ≤ 0.05 was considered statistically significant. Descriptive and explanatory modelling approaches were applied to analyse data (Shmueli, 2010). Spearman rank order correlations were used to estimate the strength of association between continuous variables. Kruskal-Wallis H-test tests were used to evaluate whether groups of participants defined by their use of protective hearing devices differed regarding their reporting of sources of unwanted sounds at work and perceived social climate. For purpose of analysis, the variable on use of protective hearing devices was trichotomized into "*Often or always*", "*Sometimes*", and "*Seldom or never*". In the present analyses, all participants that responded to the baseline questionnaire were included irrespective work-hours and/or whether they reported reduced hearing ability.

RESULTS

Self-Rated Hearing Ability and Use of Protective Hearing Devices

The number of participants that rated their hearing on the 0 to 100 (deaf to intact hearing) scale was as follows:

100: 15 (22%)
90: 25 (37%)
80: 19 (28%)
70: 5 (7%)
60: 3 (4%)
30: 1 (2%).

The use of protective hearing devices was distributed as follows:

13 % of the participants reported that they always used protective hearing devices at work to avoid unwanted sounds.

41 % used protective hearing devices often.

21 % used protective hearing devices sometimes.

13 % used protective hearing devices seldom.

12 % did never use protective hearing devices.

Thus, 54 % of the participants reported using protective hearing devices often or always, 21 % sometimes, and 25 % seldom or never.

A Spearman rho correlation showed no association between self-rated hearing ability and reports of using protective hearing devices (rho = −0.051, p = 0.670).

Furthermore, two participants (3 %) reported using hearing aids and eight participants (12 %) reported that they had a hearing reduction that made it difficult to follow a conversation when several people were gathered (without the use of a hearing aid).

Perceived Disturbance of Noise at Work in Relation to Use of Protective Hearing Devices

The participants' responses to the question about perceived disturbance of noise at work showed that activities from colleagues was the main source of disturbance (data not shown). Subsequent analyses showed that the profile was similar across the open office environments at the three different floor levels (data not shown) as well as subgroups defined according to their use of protective hearing devices (Table 1).

Perceived Social Climate at Work and Relations to Use of Protective Hearing Devices

The social climate at work was in general perceived as *relaxed and comfortable* and *encouraging and supportive* (Table 2). As verified by the median scores, very few participants perceived the climate as *competitive, distrustful and suspicious*, *rigid and rule based* or *conflict laden*. Subsequent analyses showed that the profile of social climate scores was similar across the open office environments at the three different floor levels (data not shown) and there was no difference between subgroups defined according to their use of protective hearing devices (Table 2).

Table 1. Descriptive median scores (Mdn) and accompanying first and third quartiles (Q1-Q3) for the perceived disturbance at work scores in relation to five sources of unwanted noise across subgroups defined by use of protective hearing devices (N = 68). P-values (*P*) refer to the outcome of a Kruskal-Wallis H-test.

	Use of protective hearing devices						
	Never or seldom (n = 17)		Sometimes (n = 14)		Often or always (n = 37)		
Sound source	**Mdn**	**Q1-Q3**	**Mdn**	**Q1-Q3**	**Mdn**	**Q1-Q3**	***P***
Road. Train or Air traffic or other sounds from outside surroundings	1.0	1.0-1.0	1.0	1.0-1.0	1.0	1.0-1.0	.456
Corridors or adjacent rooms	1.0	1.0-2.0	2.0	1.0-3.0	2.0	1.0-4.0	.111
From colleagues (e.g., conversations. rattling of furniture etcetera	3.0	3.0-4.0	3.0	3.0-5.0	4.0	3.0-5.0	.086
From ventilation or other apparatuses or machines	1.0	1.0-2.0	1.0	1.0-2.0	1.0	1.0-2.0	.680
Other sources of sounds	1.0	1.0-1.0	1.0	1.0-1.0	1.0	1.0-2.0	.265

Table 2. Descriptive median scores (Mdn) and accompanying first and third quartiles (Q1-Q3) for the social climate at work scores in relation to subgroups defined by use of protective hearing devices (N = 68). P-values (*P*) refer to the outcome of a Kruskal-Wallis H-test.

	Use of protective hearing devices						
	Never or seldom (n = 17)		Sometimes (n = 14)		Often or always (n = 37)		
Sound source	**Mdn**	**Q1-Q3**	**Mdn**	**Q1-Q3**	**Mdn**	**Q1-Q3**	***P***
Competitive	2.0	1.0-2.0	1.5	1.0-2.0	2.0	1.0-2.0	.490
Encouraging and supportive	4.0	4.0-5.0	4.0	4.0-4.0	4.0	4.0-5.0	.974
Distrustful and suspicious	1.0	1.0-2.0	1.0	1.0-2.0	1.0	1.0-2.0	.774
Relaxed and comfortable	4.0	4.0-5.0	4.0	4.0-5.0	4.0	3.0-4.0	.176
Rigid and rule-based	2.0	1.0-2.0	1.5	1.0-2.0	2.0	1.0-2.0	.554
Conflict laden	1.0	1.0-2.0	1.0	1.0-1.0	1.0	1.0-2.0	.119

DISCUSSION

In the present study, as part of an ongoing intervention project on sound masking in open office environments, we examined to what extent employees in open office environments, without applied sound masking, used protective hearing devices and whether the use of such devices was related to perceived disturbance from noise at work as well as the experience of the social climate at work.

The use of protective hearing devices was common among the participants. More than half of the participants used protective hearing devices often (41%) or always (13%), while only a minority (12%) of participants reported that they never used protective hearing devices. The frequent use of protective hearing devices is perhaps at a first glance a bit surprising considering that the office environments were very quiet when unoccupied (21.0 – 26.5 dBA). The results also showed that the main source of noise disturbance at work originated from activities from colleagues and that the level of perceived disturbance was moderate, as verified by the median score of 4 on a seven-step scale ranging from *not disturbed at all* (1) to *almost unbearably disturbed* (7). Observably, there was no difference in regard to perceived disturbance of noise in the open offices across the subgroups defined by the frequency of use of protective hearing devices. This, indicates that the potential sources of noise do not substantially impact on the participants use of protective hearing devices.

Furthermore, although ten participants reported having reduced hearing, 87 % of the participants rated their hearing 80 or higher (on a 0 to 100 scale). This suggest that the present study sample was not especially affected by people with reduced hearing ability. Hence, it seems plausible that the use of protective hearing devices is driven by the fact that the low background sound levels in the open office environments enables unwanted sounds from human activities, such as small talk and typing on the keyboard, to interfere with cognitive executive functions to an extent that is perceived as disturbing.

In addition, the absence of any clear association between the use of protective hearing devices and ratings of the social climate at work suggests that

using protective hearing devices does not substantially impact on the social interaction patterns at work. In fact, as verified by the median scores, the social climate was rated in very positive terms and was perceived as *relaxed and comfortable* and *encouraging and supportive*. Indeed, very few seem to experience the social climate as *competitive, distrustful and suspicious, rigid and rule based* or *conflict laden*. In light of the pattern of ratings, it cannot be excluded that truncated distributions of scores makes it more difficult to detect any potential effects the use of protective hearing devices may have on social interaction patterns.

Strengths and Limitations

A strength of the study was that it was performed in unmanipulated office environments and that the three floor plans were highly similar. Despite the small study sample, the frequent use of protective hearing devices among the participants allowed for trichotomized levels of use. Yet, acknowledging that the present intervention study was designed as a within subject design, the here presented cross-sectional group comparisons on baseline data are slightly underpowered and only allows for finding large effects. The cross-sectional analysis also implies that any interpretations about causality should be made with caution. In addition, the fact that the participants were recruited via a non-random procedure is a limitation. Also, it cannot be excluded that there is a selection bias in this study affecting the results. Likewise, generalizations concerning the prevalence proportion of use of protective hearing devices should be made with caution.

CONCLUSION

Despite favourable acoustic conditions at work and low background sound levels, the results show that 54% of the participants use protective hearing devices often or always and that noise generated from colleagues was perceived as the major source of disturbance. Despite this perceived source of disturbance the social climate at work was generally perceived in very positive terms. Noticeably, employees in these open office environments seem to have adopted a behaviour that may interfere with the effectiveness of sound masking solutions that aim to add sounds designed to improve the perceived sound environment by masking interfering noises and reduce overhearing without excessive reduction of speech comprehension.

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