

# A subjective investigation on the impact of irrelevant speech noise on health, well-being and productivity in open-plan offices

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## Summary

The popularity of open-plan offices in recent years has led to increased research on their acoustic comfort. Noise may be defined as one of the most disturbing factors in terms of health, well-being and performance of employees in the working environment. In particular, irrelevant speech noise tends to be mentioned as the most distracting noise source in open-plan offices. The present study concerns a subjective online survey that has involved several companies, two research centers and one university in Italy. The objective was threefold: 1) to investigate workers' perceived impact of irrelevant speech noise related to their health, productivity and atmosphere between colleagues, 2) to determinate whether open-plan offices are acoustically treated, and 3) to evaluate the attitude of workers towards the use of an active light-system to control their voice volume.

The results based on about 500 questionnaires confirm that irrelevant speech noise is perceived as annoying in open-plan offices. Workers declare a decrease of productivity and loss of concentration is the main feeling due to irrelevant speech noise. The noise disturbance perceived is related to room acoustic design. The results also emphasize that workers would pay attention to a light-system for personal voice control.

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## 1. Introduction

Open-plan offices have been investigated widely in literature. They are affected by several problems related to physical environment and its effect on work performance, health and well-being. Noise was found to be one of the most frequent sources of dissatisfaction in open-plan offices [1-3]. In particular, irrelevant speech noise tends to be mentioned as the most distracting noise source by office workers [1-2]. The intermittent and high intelligibility of the background speech causes greater annoyance compared to the continuous speech [4-6].

However, a little amount of studies has been carried out to investigate the perceived annoyance caused

by irrelevant speech related to room acoustic design.

In recent years, a growing body of research has adopted a survey method to study the effects of open-plan office noise on subjective perception and dissatisfaction of working environment. Pierrette et al. [7] developed an assessment questionnaire to be filled by workers of open-plan offices. The survey demonstrated that the intelligible conversations are the main source of noise annoyance. Some cross-sectional office surveys were used by researchers to compare different office layouts related to office noise [3,8,9]. Denielsson [9] suggested that dissatisfaction related noise was highest in large open-plan offices than in cellular offices. In accordance with Kaarlela-Tuomaala et al. [10], Denielsson [9] also found that dissatisfaction was

associated with lack of privacy. Pejtersen et al. [3] demonstrated that occupants' complaints about noise increased tenfold in open-plan offices compared to cellular offices. Therefore, extensive research suggests that various factors, such as job and environment satisfaction, lack of acoustic and visual privacy and distraction by noise, lead to open-plan offices be more detrimental than private offices.

Previous studies have explored the relationships between noise and health. Office symptoms, such as fatigue, headache, difficulties in concentration, psychosocial stress, loss of motivation and increased cognitive workload are found as negative factors in open-plan offices. Pejtersen et al. [3] specified that fatigue, headache and difficulties in concentration are widely related to office size. Moreover, an increased sickness absence at work was observed by Pejtersen et al. [11] and Denielsson [12].

Regarding the work productivity, previous researches have found a self-estimated loss in performance caused by open-plan office noise [8,10]. A recent number of laboratory experiments suggested that cognitive performance is negatively affected by irrelevant speech noise [1].

A little body of literature has investigated whether the effects of speech could be reduced by room acoustic design. In experiment conducted in an open-plan office laboratory, Haapakangas et al. [13] found that disturbance due to intelligibility background speech can be reduced by an optimal and accurate room acoustic design when the speaker is at least four-to-six meters away from listener. In this framework, further studies are required in order to investigate largely the importance of acoustic refurbishment on negative effects of irrelevant speech noise. Therefore, in the present study a subjective evaluation was carried out in order to evaluate whether annoyance due to irrelevant speech noise is related to acoustic treatment used in the open-plan offices.

In line with Hongisto et al. [1] an additional method to control irrelevant speech noise could be used in order to encourage workers toward lower voice effort or changing room. Therefore, the present study aimed to evaluate the attitude of workers to pay attention to an active light-system, which indicates noise conditions in order to encourage workers toward personal voice control and behaviour.

Since the previous subjective investigations studied the effects of external and internal noise, the third

purpose of the present survey is to investigate the perceived impact of irrelevant speech noise on productivity, health and well-being of workers in open-plan offices.

This study presents a subjective online survey that has involved three companies, two research centers and one university in Italy. The objective was threefold: 1) to investigate self-estimated impact of irrelevant speech noise on health, productivity and atmosphere between colleagues, 2) to explore room acoustic design of open-plan offices and how it is related to noise annoyance perception 3) to evaluate the attitude of workers towards the use of an active light-system to control their voice volume and their behaviour in open-plan offices.

## 2. Methodology

### 2.1 Subjects

The questionnaire online was administrated to workers of more than three medium and large companies, two research centers and one university in Italy during year 2017. The responses of subjects that shared office with five and more colleagues [1] were selected for the present analysis in order to provide a significant sample of open-plan office layout. A total of 481 subjects took part in the present study, while about 700 respondents occupying single or shared office (from 2 to 4 people) were excluded. The group of subjects is made of 293 men and 188 women. The survey always targeted the workers of different departments and professional sectors in order to represent a wide range of professions. Background information related to number of workers in the office, age and professional sectors is reported in Table I, II and III.

### 2.2 Questionnaire survey

The questionnaire items and list of alternatives was drawn up based on bibliographic research and directive interviews. The questionnaire had three sections: *Aim of the survey*, *Background questions and Subjective opinions*. The first section explained the goal of the survey and the significance of irrelevant speech noise that is defined as the noise generated from conversations between colleagues, telephone calls and laughter. The *Background questions* were aimed to elicit general information about gender, age, companies and professional sector. After these preliminary questions, the subsequent ones related to the section, *Subjective*

*opinions*, that covered the following aspects: annoyance due to irrelevant speech noise, its effects on work performance and atmosphere between colleagues, workers' strategies used to cope with irrelevant speech noise, the main feeling or symptom due to people's speech. Moreover, workers were invited to indicate whether the acoustic treatment is presented in their office, and in case of positive answer they were specified the type of acoustic solutions choosing from a list of alternatives. The last question investigated the attitude of workers to pay attention to an active light-system for personal voice control. The employees had to indicate their level of agreement with the statement proposed, using a five-point scale (1. Strongly disagree to 5. Strongly agree) in most of the questions. In other items, they were invited to choose "yes" and "no" answers, while some questions were based on a five point-ordinal scale where the first and last had the opposite descriptors "not at all" and "extremely". Single choice questions with "other" option were also used in the questionnaire.

Table I. Background information related to number of workers in the office.

<i>People in a room</i>	<i>Number of respondents</i>
5-10	353
11-20	114
21-30	7
31-40	4
50-100	2
150-200	1

Table II. Range of workers' age.

<i>Age in years</i>	<i>Number of respondents</i>
18-25	26
26-35	182
36-50	98
51-65	175
65+	0

Table III. Background information related to professional sectors of workers.

<i>Professional sector</i>	<i>Number of respondents</i>
Technical	102
Engineering	121
Management	37
Administration	135
Design	9
Architecture	11
Creative	7
Other	59

### 3. Results

#### 3.1 Subjective responses

The present results are based on the responses of 481 subjects that shared office with five and more colleagues.

The results related to noise annoyance are shown in Figure 1. The graph shows that 67% percent of the workers are annoyed due to irrelevant speech noise moderately (35%), highly (21%) and extremely (12%).

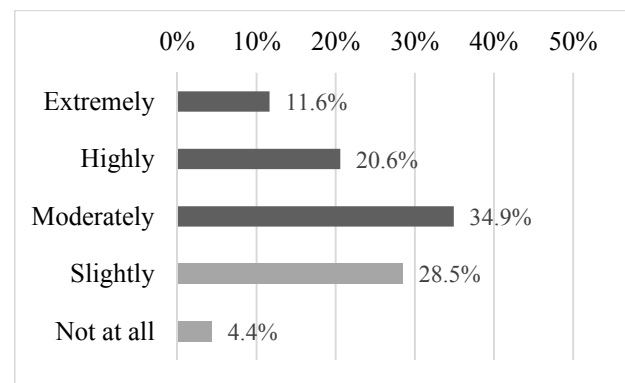


Figure 1. Annoyance: How much does people chatting in your office annoy you?

Concerning work productivity, the workers indicated their level of agreement with the statement proposed. In response to these questions, 55% of workers affirmed that their work performance is often interrupted by irrelevant speech noise during working time (Figure 2), and the productivity decreases significantly for 47% of subjects (Figure 3).

As Figure 4 shows, the irrelevant speech noise are defined as a factor that compromise harmony between colleagues by 33% of workers.

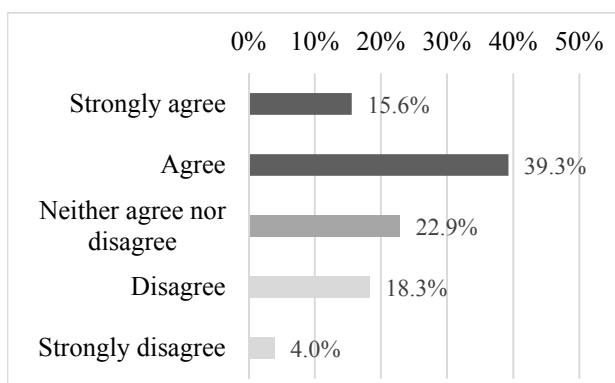


Figure 2. How much do you agree with the following statement? "People chatting around often interrupts me during my work tasks"

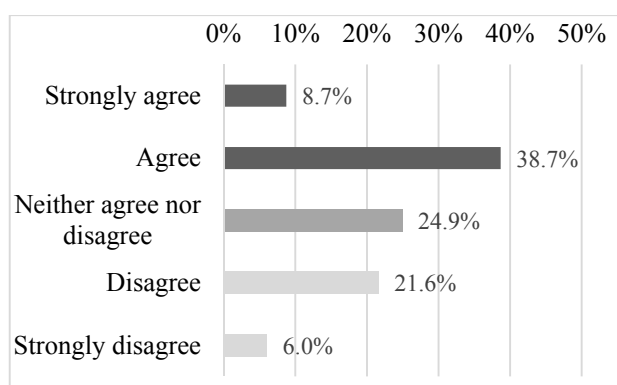


Figure 3. How much do you agree with the following statement? "People chatting around significantly reduces my work performance".

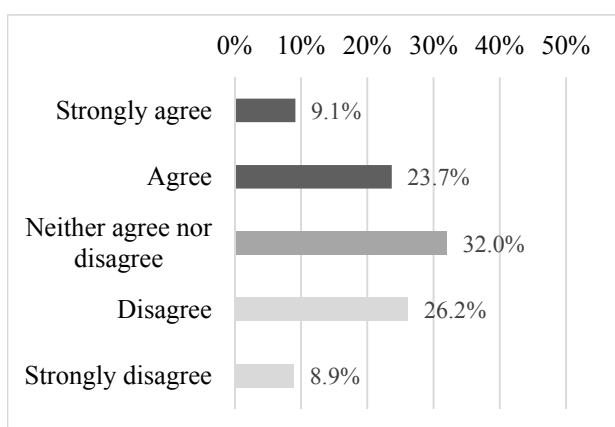


Figure 4. How much do you agree with the following statement? "People chatting compromises the harmony of the entire office"

Almost two-thirds of the participants (66%) consider loss of concentration as the main feeling due to irrelevant speech noise. While loss of motivation, stress, tiredness, overstrain, feeling displeased and negative feeling towards colleagues are indicated by 23% of workers (Figure 5). Loss of concentrations (*If*) can be defined as an immediate feelings caused by irrelevant speech, while the other ones can be identified as feeling and symptoms in the long term (*Lf*).

As Figure 6 shows, subjects use several types of strategies in order to reduce annoyance due to irrelevant speech noise. Technological tools, such as headphones with music (29%) and noise cancelling headphones (3%), are the main solutions used by workers, while 23 % of subjects perform adaptive behaviour [14,15], such as take a break (14%), change working space (4%) and work task (2%), close the office door (2%) and work from home (1%). Conversely, 20% of workers prefer asking colleagues to reduce voice volume.

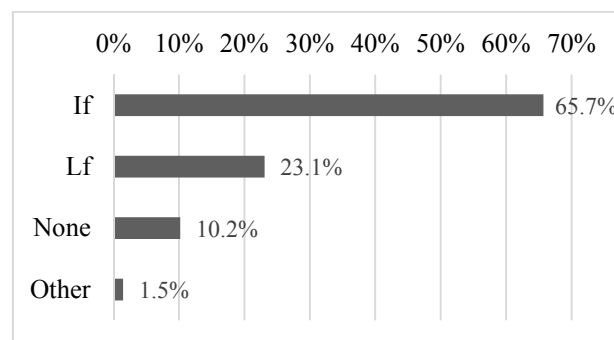


Figure 5. Feeling: What is the main feeling (or symptom) related to people chatting during your work tasks?

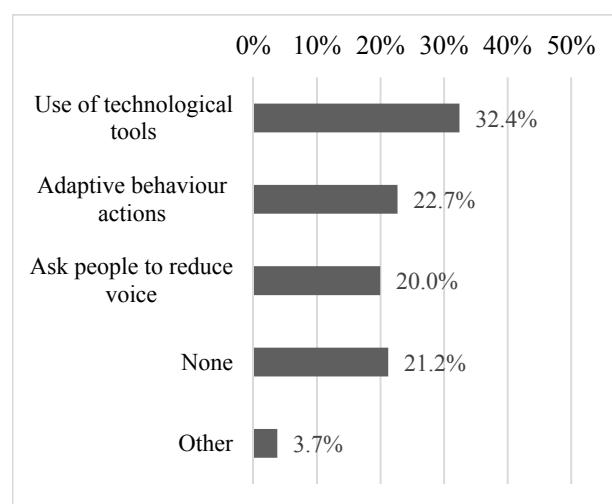


Figure 6. Strategies: What is the main strategy that you use to reduce the annoyance due to people chatting?

The results show that acoustic treatments are present in only 20% of open-plan offices involved in the survey and 14% of workers declare that screens between workstations ( $S_w$ ) are the main solution used in order to improve acoustic comfort (Figure 7). While absorption panels on ceiling ( $P_c$ ) and both acoustic treatments ( $S_w$  and  $P_c$ ) are indicated by a low percentage of workers.

The majority of workers (72%) declares their attitude to control their voice volume whether there was an active light-system that indicates to them noise condition in open-plan offices (Figure 8).

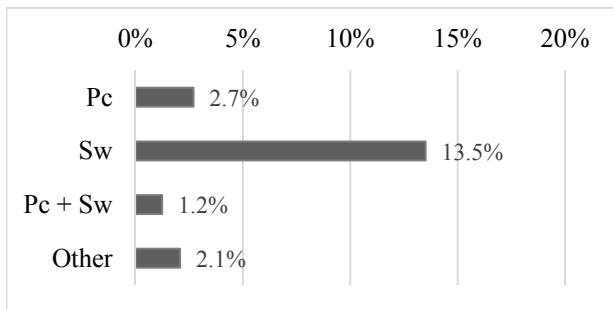


Figure 7. Acoustic treatment used in the 20% of office.

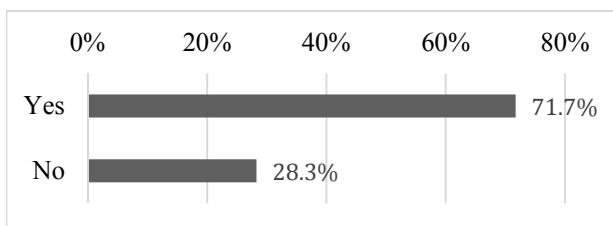


Figure 8. Would you pay attention to a light-system that advises you and your colleagues to control the voice volume in order to reduce noise due to people chatting in your workplace?

### 3.2 Relationship between acoustic treatment and noise annoyance due to irrelevant speech noise

The data were analysed using SPSS (IBM Statistics 20). The Shapiro-Wilk normality test has been performed. Since the null hypothesis of normality was rejected ( $p$ -value  $< 0.05$ ) and the two-sample size is largely differ, the Mann-Whitney U Test [16] was used in the statistical analysis. As Table IV shows, level of noise annoyance perceived by the sample of subjects (94 respondents) that work in treated open-plan office (condition A) is compared to level of noise annoyance declared by the sample of subjects (387) that work in poor acoustic office (condition B). The results (Table IV) obtained by

Mann-Whitney U test indicate that annoyance caused by irrelevant speech noise is strongly related to room acoustic treatments (two-tailed  $p$ -value  $< 0.05$ ). In particular, the level of annoyance is slightly lower in condition A to the level of annoyance perceived in condition B. Indeed, mode value is equal to 2 in condition A, while it is equal to 3 in condition B. According to five-point scale ranging from 1 “Not at all (annoying)” to 5 “Extremely” (annoying), the number 2 indicates a slightly level of annoyance compared to the number 3 that represents an higher level of annoyance, as shown in Figure 9 and 10.

Table IV. Two-tailed  $p$ -value of the significance of the difference in distribution of noise annoyance level perceived between condition A and condition B according to Man-Whitney U test. The mode value and standard deviation are also indicated.

Cond.	Acoustic treatment	Sample size	Mode (SD)	M-W U test p-value
A	yes	94	2 (1.01)	0.03
B	no	387	3 (1.07)	

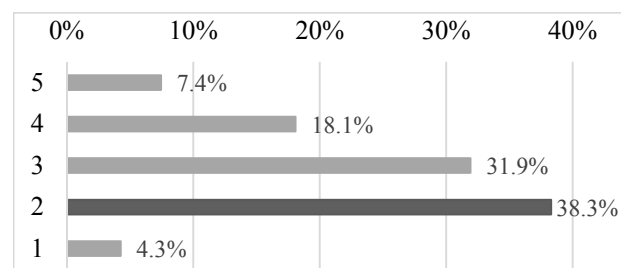


Figure 9. Percentage of annoyance perceived by workers in condition A. Scale 1-5, with 1 indicating no annoyance and 5 indicating highest level of annoyance, in particular 2 = slightly

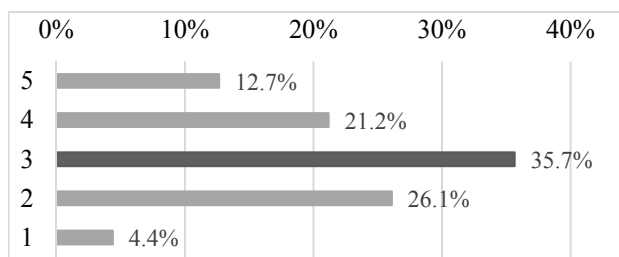


Figure 10. Percentage of annoyance perceived by workers in condition B. Scale 1-5, with 1 indicating no annoyance and 5 indicating highest level of annoyance, in particular 3 = fairly.

## 4. Conclusion

In this study a subjective online survey was performed in order to study the correlation between irrelevant speech noise and perceived annoyance related to health, well-being and performance in open plan offices. In addition, the effects of room acoustic design on perceived annoyance was also investigated. This study is the first step to evaluate the effective role of an active light-system in controlling of irrelevant speech noise.

The results confirm that irrelevant speech noise is a detrimental disturbing factor in open-plan offices in terms of annoyance, work performance, health and well-being of workers.

In line with the previous studies, irrelevant speech is annoying or strongly annoying in open-plan offices. The present study confirms as in [2], that workers tend to use several strategies to cope with irrelevant speech noise. They use headphones with music or change their behavior, i.e. taking a break. This study supports findings from previous studies in terms of work performance [2,4]. Workers report a decrease of productivity. Indeed, speech coming from colleagues often interrupts workers' performance. Irrelevant speech noise has an immediate effect, such as loss of concentration and long-term feelings and symptoms, such as loss of motivation, stress, and tiredness and overstrain.

The results highlight that annoyance due to irrelevant speech noise is lower in open-plan offices with acoustic treatment compared to open-plan offices without acoustic solutions. Since the questionnaire had to be short in order to not bore the subjects, the following limits exist regarding the room acoustic design questions: 1) workers had not specify the distance between desks, 2) the room acoustic design is not investigated deeply through objective measurements 3) workers evaluation on presence of acoustic treatments in their offices is biased by their ability to recognize the acoustic solutions applied. In accordance with Hongisto et al. [1] the distance between work desks and an optimal acoustic treatment are important in terms of STI and noise annoyance. Annoyance due to irrelevant speech noise cannot be solved only through room absorption and screen between work desks. Indeed, optimum acoustic treatment is not enough to reduce annoyance caused by speech from nearest desk [1]. Therefore, in addition to room acoustic design several methods can be used to solve problems related to irrelevant speech noise. An active light-system able to indicate noise

conditions due to irrelevant speech could be another way to reduce distraction and annoyance in the open-plan offices. The results of the subjective evaluation highlight that a large number of workers ask to colleagues to reduce voice volume in order to cope with irrelevant speech noise. Moreover, the majority of subjects confirm their attitude to pay attention to an active light-system that helps them in voice reduction. Therefore, the present study could predict the effective role of a light-system in order to reduce irrelevant speech noise and improve acoustic condition in open-plan offices involving occupants actively.

The future work aims to develop and investigate in-situ the use of a table prototype of the active light-system. An example of a kind of this system has been used in classrooms as an educational tool for irrelevant speech noise control. It consists to a transparent panel with a sound level meter device and a colored warning light activation that indicates the increase in the overall sound level [17].

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