



Perception of the acoustic environment in the remote working setting during the lockdown

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Abstract

To reduce the spreading of the COVID-19 pandemic, remote working has become a common practice worldwide since the first lockdown period in Spring 2020, and is still in course. A number of positive effects were already known with respect to, e.g., increase in working performance and employee satisfaction. However, a compulsory and prolonged period spent to live and work from the home environment was never experienced before, thus long-term effects are still largely unexplored. In this study, 1934 employees from a university and from several large and small Italian companies answered to an online questionnaire on the perception of noise annoyance in the remote working environment. Besides the identification of people talking, moving, calling and listening to music as main source of noise disturbance, negative consequences of the acoustics of remote working were mainly related to a loss of concentration and to a difficulty in relaxing.

Keywords: well-being, noise annoyance, office acoustics, remote working, noise sensitivity.

1 Introduction

The first wave of infections from COVID-19 in Spring 2020 has made it necessary to reduce contacts between people in order to limit the spreading of the pandemic, therefore workers all around the world have been pushed to perform remote working. Such situation has brought a growing number of people to live and work from the same environment, that is, at home. In Italy, remote working has been engaged by 8% of microenterprises (i.e., with 3-9 workers), 19% of small size enterprises (i.e., 10-49 workers), 50% of medium size enterprises (i.e., 50-249 workers), 77% of large size enterprises (i.e., more than 250 workers) [1].

The effect of external and environmental factors such as thermal, visual and acoustic, on working from home has been studied in literature, and both positive and negative consequences have been observed.

On the one hand, when they are optimal for the use, these factors have shown very positive consequences especially on improved working performance and increasing of employee satisfaction, and in a more general perspective also on cutting of traveling costs and saving of time, which have effects on well-being in turn [2][3]. Focusing on studies that investigated on the acoustic domain effect on the remote working activity, a recent work [4] based on the indoor soundscape approach [5] summarised the benefits on (i) the workers' perceived well-being, (ii) a faster recovery from stress and (iii) better self-reported health conditions. On the other hand, detrimental effects on the perceived well-being related to the remote working condition have also been found in several studies. In particular, the continuous usage of technology and of an increased sedentary behaviour associated to longer sitting and screen time have been observed to be the main causes of persistent stress [6]-[8]. From an acoustical point of view, the lack in insulation from airborne sounds and impact

noises in buildings was proved to be the major cause of annoyance during working hours in Canadian remote workers [9].

With respect to the main source of noise annoyance when working from home, noise from dwellers was the main aspect deepened before the pandemic period. Indeed, if traffic was reported to be the first source of noise in terms of relevance (38% of answers), anthropic noise from the neighbours was found to be the second most relevant source of noise (32% of answers) when staying at home [10]. Thus, the identification of the dominant source of noise in a working environment is of great importance, as it can be contrasted in order to guarantee productivity and to reduce disturb [11]. The noise generated from colleagues who converse, laugh or talk at the phone in shared and open-plan offices was found to be one of a main cause of annoyance and reduced productivity, with consequences on mental health and well-being [12]. As a remote working environment typically hosts a whole family, anthropic-generated noise can be considered as one of the main causes of noise annoyance. To corroborate these evidences, related to the negative effects of a competitive working environment from a noise point of view, the occurrence of headaches, the loss of concentration and motivation, and a general sense of stress were found to be reported from a great number of workers spread in several countries [13]-[16].

The Authors recently published results on a study on the effect of irrelevant speech noise in offices of different sizes [12]. Following those outcomes, the intent of the present work is to build a follow-up that focuses on noise annoyance in the environments where remote working is performed, considering consequences on productivity, mental health and well-being as well as associations with subjective and environmental characteristics. The extended paper presenting results on this study has been published recently [17]. Hereby, only a brief introduction to the main outcomes with base statistical analysis is provided.

2 Materials and methods

2.1 Participants

Remote workers were recruited via email in May 2020 and, considering an overall response rate of about 20%, a final sample of 1934 respondents was considered. Overall, 1889 of them (98%) were Italians, whereas 45 (2%) had a different nationality. Table 1 gives a summary of the demographics of the sample, in terms of gender and age range, and of the typology of company they belonged to.

Table 1 – Demographics of the considered sample (n=1934).

Background information		n	%
Gender	Female	1127	58
	Male	807	42
Age range	18-25	74	4
	26-35	509	26
	26-50	534	28
	51-65	783	40
	65+	34	2
Working company	University	1104	57
	Large size company	731	38
	Research and development unit	59	3
	Research centre	10	0.5
	Small size company	30	1.5

In total, 1560 respondents (81%) reported to perform remote working activity in Northern Italy, 122 (6%) in Central Italy, 228 (12%) in Southern Italy. Twenty-four more respondents (1%) performed remote working in countries other than Italy.

2.2 Questionnaire

The questionnaire delivered online was design according to a previous work by the Authors [12], where the effect of irrelevant speech noise (i.e., noise generated by colleagues talking, chatting, laughing and moving in a workplace) was studied considering different office sizes.

Twenty-two questions with close answer were included in the questionnaire. Nine questions of the questionnaire were related to demographic issues (e.g., gender, age range, nationality) and to understand the configuration of the remote working setting (e.g., number of people in the overall living environment and in the working environment, room of the house where the activity typically took place). The other 13 questions were oriented specifically to assess the relationship between noise sensitivity, annoyance, well-being and work productivity:

- Q1 - How much does noise annoy you during your smart working activity?
(Rating: 1 = not at all; 5 = extremely)
- Q2 - What is the main feeling (or symptom) related to noise during your remote working activity?
(Rating: single choice among > stress, negative feeling such as feeling displeased, negative feelings toward other housemates, loss of concentration, anger, loss of motivation, headache, tiredness and overstrain, none, other)
- Q3 - Noise often interrupts me during my smart working activity
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q4 - Noise does not allow me to work as much as I would like during my remote working activity
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q5 - Noise significantly reduces my work performance during my remote working activity
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q6 - Noise during my remote working activity compromises the harmony at home
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q7 - What is the main strategy that you use to reduce the annoyance resulting from noise during your remote working activity?
(Rating: single choice among > take a break, change work task, headphones with music, noise cancelling headphones, open window, close window, change room, close the room door, plan the return to office, ask people to reduce their voice volume, none, other)
- Q8 - I am sensitive to noise
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q9 - I find it hard to relax in a place that is noisy
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q10 - I get mad at people who make noise that keeps me from falling asleep or getting work done
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q11 - I get annoyed when my neighbours are noisy
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q12 - I get used to most noises without much difficulty
(Rating: 1 = strongly disagree; 5 = strongly agree)
- Q13 - What is the main source of noise present during your remote working activity?
(Rating: single choice among > technological noise, traffic, sirens, anthropic noise generated by children under the age of 5 years, anthropic noise generated by children aged 6-13 years, anthropic noise generated by adults, noise from own pets, noise of nature, neighbourhood noise)

2.3 Statistical analyses

SPSS (IBM Statistics20, IBM, Armonk, NY, USA) was used as main tool for the statistical analysis of the acquired data. Because of the non-normal distribution of data, non-parametric tests were applied such as the Kruskal-Wallis (KW) test, which fits the comparison of results for more than two groups of observation (e.g., when comparing answers for different environments), and then the Mann-Whitney U Test (MWU), which is used to compare two groups of independent observations (i.e., to deepen the differences found with KW on pairs) [18].

3 Results and discussion

3.1 Noise sources identification and occupants' behaviour

Figure 1 shows the main source of noise that respondents reported to hear in their remote working environment (Q13), and which consisted in “anthropic noise generated by adults” (25% of the overall answers). This answer reflects on the one related to the application of personal strategies to reduce noise annoyance when working (Q7): about 20% of respondents revealed that they do not apply any personal strategy; then the 14% of respondents make use of technological tools to mask or cancel noise (e.g., wearing headphones) and the 12% of respondents actively request to reduce voice levels to other mates in order to keep high focus on the working task. The use of active behaviours to solve a problem and increase the sense of well-being, thus makes it important to think about living spaces that are getting also working spaces more and more in order to provide adequate soundscapes [5] to perform working in a passive but also in an active way, the latter with the direct engagement of the worker.

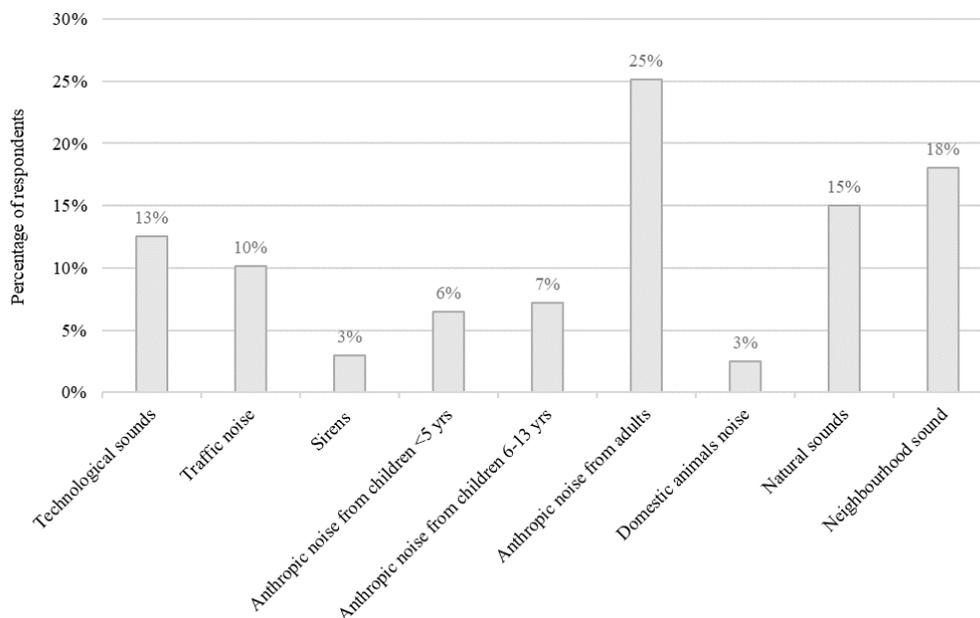


Figure 1 – Percentages related to the main sources of noises heard in the remote working environment, as reported by the respondents.

3.2 The role of noise on the perceived annoyance, productivity, mental health and well-being

For all the questions that investigated noise annoyance (Q1), perception of work productivity (Q3, Q4 and Q5) and perception of mental health and well-being in terms of positive feelings from interpersonal relationships (Q6), the application of the KW test always resulted in statistically significant associations (p -

value = 0.00). With the MWU test, the significant difference (p -value < 0.05) resulted to be among remote workers who performed working activity in a separate or in a shared room of the living environment. In particular, higher ratings (i.e., greater noise annoyance, higher reduction of work productivity and of harmony in the interpersonal relationships at home) were given by respondents who mainly performed their working activity in shared rooms. This outcome is in line, although not perfectly comparable, with other studies that showed a significant relationship between an increase in noise annoyance and the larger size of shared offices [12] [19]. In such working setting, i.e., in shared environments of the house, respondents also reported a greater sense of productivity loss. This is again in line with studies that proved the perceived feeling of wasting time more whenever the working activity is performed in shared or open-plan offices rather than in private ones [12] [13]. A greater perceived noise annoyance also reflected on a greater sense of well-being loss, with a main consequence on the incurring of concentration loss in about 35% of the respondents. This outcome corroborates similar findings in studies by Banbury & Berry [20], Kaarlela-Tuomaala et al. [13], Di Blasio et al. [12], Pejtersen et al. [14].

3.3 The role of subjective and environmental characteristics on noise annoyance

Figure 2 is a clustered summary of the locations reported by the respondents to be the main environments of the house where remote working takes place. The 97.7% of respondents reported to perform remote working activity from a separate environment (54.6%) or in a shared environment (43.1%) of the house. Subsequent results were clustered based on the environment of the house where the working activity was mainly performed. Figure 3 reports the distribution of professional sectors covered by the respondents. When workers performed the remote activity in separate or shared environments of the house, differences could be observed among different sectors. In particular, “researchers” and workers in the field of “creative, design and architecture” were mostly annoyed by noise in separate and shared environments, respectively. Further studies should categorize respondents maybe introducing a clustering related to the predominant cognitive task carried out (e.g., linguistic/humanistic, mathematical, technical) rather than on their specific professional sector to have a more robust clustering of the acquired data.

With respect to the factor “age”, the perception of noise annoyance was different for respondents who worked from a separate or shared environment of the house. In the first case, younger respondents were annoyed more by noise, whereas in the latter case respondents in the 36-50 years of age range were more annoyed. So far, other studies like Pierrette et al. [21] and Di Blasio et al. [12] showed a different trend, that is, with a positive association between years of age and increase in noise annoyance. However, the environmental setting analysed in the present study is still largely unexplored and comparisons cannot be performed that perfectly match. With respect to the factor “location of the cities where remote working is performed”, the perception of noise annoyance was different again for respondents who worked from a separate or shared environment of the house. Respondents from Northern Italy were most annoyed if they worked from a separate environment of the house, the other way around respondents from Southern Italy were most annoyed if they worked in a shared environment of the house.

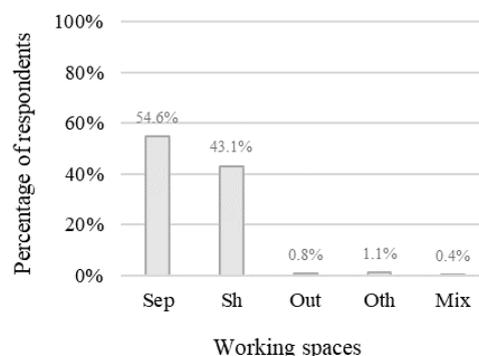


Figure 2 – Percentage of respondents working from a separate environment of the house (Sep), in a shared environment (Sh), outdoor (Out), in other spaces (Oth) or in a mix of the above possibilities (Mix).

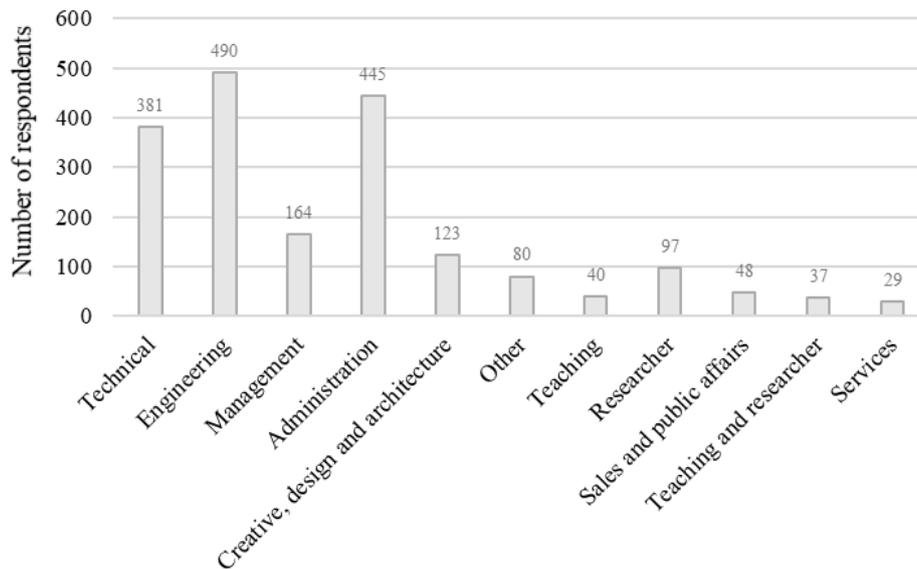


Figure 3 – Professional sectors covered by the respondents.

3.4 The role of the number of people in the environment on noise annoyance

Figure 4 refers to the number of people that were present in the working environment (i.e., Fig. 4a) and in the overall living environment (i.e., Fig. 4b), excluding the respondent her/himself from the count. The density of people that was present either in the working environment or in the overall living environment brought to a same significant trend, as expected: the more the people were present, the more the respondents were annoyed by noise. Such trend was confirmed by the application of the KW and then of the MWU tests, which revealed a statistically significant difference in the mean ratings for the perceived noise annoyance (Q1) under the condition of increasing number of people in the overall living environment and in the specific remote working environment.

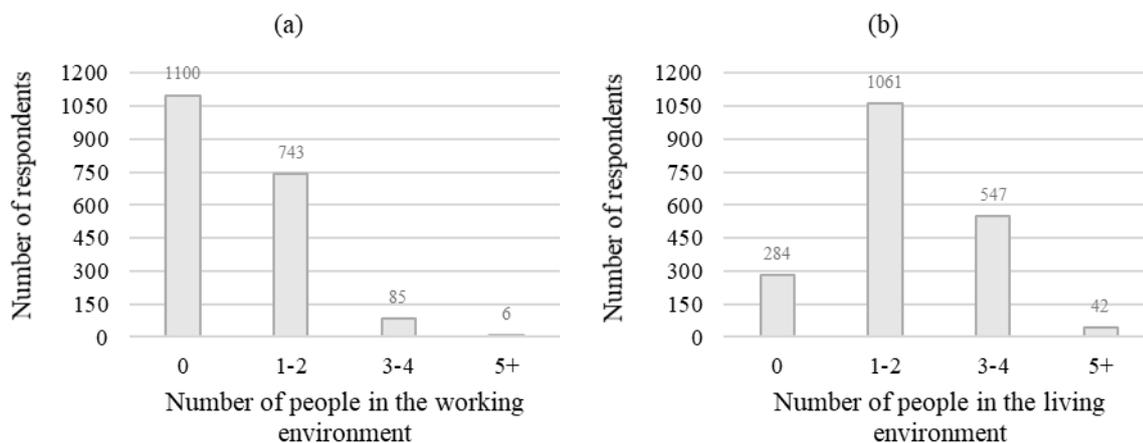


Figure 4 – Number of people in the working environment (a) and in the overall living environment (b). The count excludes the respondent from the answer.

4 Conclusions

The present study investigated on the extent to which productivity, mental health and well-being are affected by the sound environment in the remote working setting, in particular focusing on the induced noise annoyance. A further objective consisted in the investigation on the possible effects of subjective and environmental characteristics on noise annoyance in the remote working setting. To these aims an online questionnaire has been administered and 1934 people responded overall.

The main conclusions of the present study, which can be summarised as follows, will contribute to understand the extent to which working from home can be supported by the indoor soundscape, as remote working seems to persist in time:

1. Noise annoyance affects work productivity, mental health and well-being when workers perform their activity from home. In particular, sharing a room brings to a higher degree of perceived noise annoyance with respect to working from a separate environment in the house;
2. Subjective characteristics such as the location of the city of remote working and the age of the respondents, must be considered to assess the relationship between indoor soundscape, in terms of noise annoyance, and the practice of working from home.

As a consequence of these findings, the proper design of home environment that includes well-equipped and distributed workspaces is needed. Both research and architectural practice should then focus on human centred premises for living and for working at the same time. To reach this objective, a more inclusive design that considers the occupant's behaviour too would be a key strategy to be applied.

Acknowledgements

The work has been made possible thanks to the kind collaboration of the management area of each company and the participation of the workers, to whom the Authors are grateful.

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