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CLASS A BOOTH REDUCES STRESS DUE TO OFFICE NOISE

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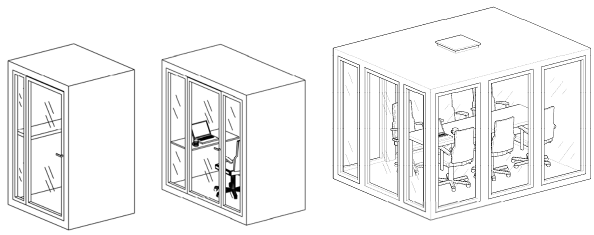
ABSTRACT

Booths are increasingly used in offices and schools to improve noise control and speech privacy. Their acoustic performance (speech level reduction in decibels) shall be measured by ISO 23351-1 standard. The results are classified to speech level reduction classes A–D to facilitate design and trade. We investigated the benefits that an office worker might get from booths with different classes against unnecessary speech. We conducted two psychological laboratory experiments. Experiment 1 investigated how speech affects a worker when the speaker is not in the booth ($D_{S,A}$ = 0 dB) or when the speaker is inside class A booth ($D_{S,A}$ = 30 dB). In experiment 2, class A and C ($D_{S,A}$ = 23 dB) booths were compared. If the class is A, the worker's benefits are large and versatile compared to a condition without the booth: improved cognitive performance, improved subjective experiences, and reduced physiological stress. Comparison of Class A and Class B booths indicated that Class A booth is better with respect of cognitive performance and subjective perception. The results support the choice of Class A office booths where the aim is to minimize the disadvantages of irrelevant speech.

Keywords: *booth, pod, experience, performance, stress.*

1. INTRODUCTION

In open-plan offices, irrelevant speech is the most disturbing source of noise. Irrelevant speech causes stress [2]. The adverse effect of irrelevant speech on cognitive performance increases with increasing speech transmission index, STI [1]. Haapakangas et al. [8] and Radun et al. [3] found that noise problem can be reduced by investing in the room's acoustic properties as much as possible (ceiling absorbers, absorbing screens, sound masking). However, even room acoustic conditions surpassing the strict Finnish regulatory level cannot entirely remove the distraction due to irrelevant speech [8].



$D_{S,A}$ [dB]	Class
>33	A+
30-33	A
25-30	B
20-25	C
15-20	D
<15	unclassified

Fig. 1. Top: Examples of a phone booth, a single person working booth, and a six-person meeting booth. Bottom: Classification scheme of ISO 23351-1 [5].

There is also another acoustic problem in open-plan offices: insufficient speech privacy. Some of the conversations shall not be heard by outsiders. To ensure sufficient speech privacy, standard room, with full-height walls and a door, is the most usual solution. Rooms with sufficient sound isolation reduce the STI of speech from nearby rooms so low that the cognitive performance of people working outside these spaces is improved [7]. However, the trend in the building sector is to maximize the flexibility of space

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and build standard rooms as little as possible. Therefore, mobile booths began to appear on the market after 2000. At first, they were mainly one-person "phone booths". Nowadays, various sizes and furnishings are available. Examples are shown in **Fig. 1**. The speech level difference, $D_{S,A}$ [dB], is determined for booths in accordance with the ISO 23351-1 standard [5]. The method is based on Hongisto et al. [4]. $D_{S,A}$ value expresses how many decibels the booth attenuates the sound pressure level (SPL) of speech. The limits of $D_{S,A}$ classes A, B, C and D are 30, 25, 20, and 15 dB, respectively. Hongisto & Keränen [6] measured the $D_{S,A}$ of 11 commercial phone booths. The value range was surprisingly large: 15–30 dB. This raised the question about the significance of $D_{S,A}$ on office workers. This has not been studied before. The closest research touching on this topic was related to the sound insulation between adjacent rooms [7]. However, they studied rooms where the sound insulation was 5–10 dB larger than with any commercial booth.

Our purpose was to answer two research questions. How irrelevant speech affects an office worker when

1. the speaker is not in a booth, or the speaker is in a class A booth.
2. the speaker is in a class C booth, or the speaker is in a class A booth.

2. MATERIALS AND METHODS

The research questions were responded by conducting two independent psychological experiments in the psychophysics laboratory of Turku University of Applied Sciences.

Experiment 1 involved two *conditions* (Table 1). Forty people participated in the experiment. Each participant was tested in both *conditions* in counterbalanced order one after the other (repeated measures design). The whole experiment lasted 1.5 hours. The duration of each *condition* was 30 min. In both *conditions* 1a and 1b, the speaker was 2 m away from the participant. The speech arrived from a loudspeaker. In *condition* 1a, the speech perceived by the participant corresponded to the situation where no obstacles were between the speaker and the participant (no booth). In *condition* 1b, the speech perceived by the participant corresponded to the situation where the speaker was inside class A booth (Fig. 2). The level reduction produced by a booth always depends on frequency. The frequency-dependent values were obtained from Hongisto & Keränen [6]. In both *conditions*, the background noise of ventilation was constantly 34 dB L_{Aeq}. During both *conditions*, two working memory tasks (visual serial recall and n-back) were performed and questionnaires were answered. Throughout the experiment, physiological stress was monitored with a chest belt measuring electrocardiogram. This data was used to determine heart rate variability.

The procedure of Experiment 2 was like in Experiment 1, but the *conditions* were different (Table 2). The participants (N=42) had not participated in Experiment 1.

Conditions 1b (Expt. 1) and 2b (Expt. 2) were identical. The statistical analysis was conducted independently for both experiments using ANOVA.

Table 1. The acoustic properties of the experimental conditions of Experiments 1 and 2. These values were measured in the participant's position in the laboratory. L_{Aeq} is A-weighted equivalent SPL.

	Experiment 1		**Experiment 2**	
Condition	1a	1b	2a	2b
Booth performance	-	Class A	Class C	Class A
L_{Aeq} of speech	54	24	31	24
L_{Aeq} of ventilation	34	34	34	34
L_{Aeq} in overall	54	34	36	34
STI	0.84	0.14	0.32	0.14

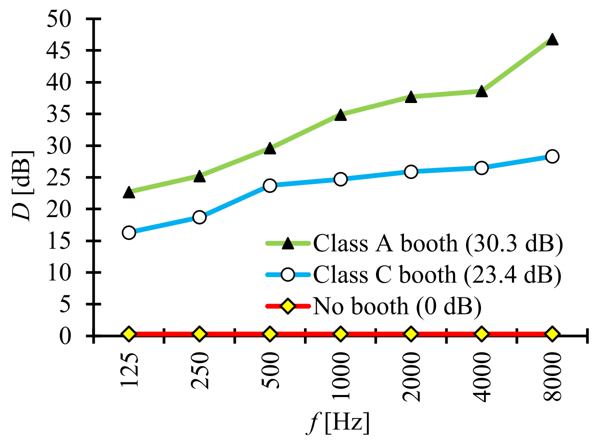

Figure 2. The level reduction, *D*, of the investigated booths as a function of frequency, *f*. The speech level reductions, $D_{S,A}$, are shown in bracket.

3. RESULTS

The results are summarized in Table 2. All the significant differences between the conditions in both experiments were in favor of Class A booth.

4. DISCUSSION

Based on Experiment 1, the class A booth was advantageous in terms of work performance, most subjective experiences and physiological stress compared to the condition without a booth.

Experiment 2 shows that class A booth is advantageous compared to class C booth based on both work performance and most subjective experiences.

Our results can be applied to both directions of noise:

- Speaker (noise) is inside the booth, and the office workers outside the booth benefit.
- Speaker (noise) is outside the booth and the office worker is inside the booth benefit.

Our study studied the worst case where the speaker is very close (2 m away) to the distracted worker and the worker's tasks are cognitively demanding. In practical work environments, the sound environments and the nature of the work vary greatly, which means that the results can be different in real workplaces and in the long term.

Our study is limited to the chosen SPL of steady-state masking sound (34 dB L_{Aeq}). This choice was justified since it is a typical level of mechanical ventilation.

Noise control is not the only benefit of booths. Another, even more important, function of booths is to provide high speech privacy during confidential conversations. This aspect was not examined in our experiment. However, STI-value of 0.14 indicates that speech is not intelligible.

The influence of booths on office occupants is more complex than described in our study, which only focused on sound. A longitudinal field experiment has been conducted recently, which further improves our understanding of the effects of booths on office workers [9].

5. CONCLUSIONS

If irrelevant speech is attenuated by the amount that Class A booths can provide, the benefits to a worker on the other side of the booth are large and versatile: improved cognitive performance, improved subjective experiences, and reduced physiological stress.

Comparison of Class A and Class C booths indicated that when speech comes from Class A booth the worker on the other side of the booth has an improved cognitive performance and subjective experience compared to a speech coming from a Class C booth. The results support the choice of Class A office booths where the aim is to minimize the disadvantages of irrelevant speech.

Our results may also be applicable for other working environments such as hospitals and schools.

6. ACKNOWLEDGMENTS

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Table 2. *Main results from Experiment 1 (Class A booth vs. no booth) and Experiment 2 (Class A booth vs. Class C booth). X means that there was a statistically significant difference ($p<0.05$) between the sound conditions in favor of the Class A booth.*

	Expt 1	Expt 2
OBJECTIVE WORK PERFORMANCE		
Visual serial recall accuracy	X	
3-back accuracy		X
SUBJECTIVE EXPERIENCE		
Task-related experiences		
Workload	X	X
Tiredness		
Lack of motivation	X	
Lack of energy		
Acoustic experiences		
Annoyance of speech	X	X
Pleasantness of sound environment	X	X
Influence on work performance	X	X
Influence on attention	X	X
OBJECTIVE PHYSIOLOGICAL STRESS		
Heart rate variability - LF	X	
Heart rate variability - HF	X	
Heart rate variability - LF/HF		

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