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The influence of a 'quiet hub' on the acoustic comfort in an open office environment. A case study.

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ABSTRACT

(introduction) The global COVID pandemic ushered in an era of hybrid work. Because of this there is a growing demand for workplace environments with a flexible office design. Research shows from 6 percent in 2020 up to an expected 30 percent in 2030. But how does this influences the indoor acoustic environment? Good acoustic workplace design is crucial. One of the outcomes of a research from 2017 is that 94 percent of the office workers believed they would be more productive in an less noisy environment. Especially people working in an open office complain about lack of privacy or not having a quiet space to work in. **(method)** The purpose of this case study was to investigate the impact of a quiet hub in an open office environment. The hub, as a separate area in the centre of the open-plan office, consists of a free-hanging ceiling section with a highly sound-absorbing top layer and lateral acoustic curtains that serve as screening and act like a visually separated room. The effects of the hub on the acoustic environment were measured using F SPL (Fast Speed Level), reverberation time (T20), speech intelligibility (STI) and level measurements at different distances as acoustic parameters. **(results & conclusions)** Based on the results, an evidence-based design was developed to improve acoustic comfort, speech intelligibility and privacy within the centre of the workspace. Outside the centre it was leading to a reduction in intelligibility by a significant level decrease when the distance is doubled.

Keywords: open-plan office, acoustic comfort, workplace, speech privacy, speech intelligibility, noise annoyance

INTRODUCTION

Activity-based Flexible Offices

Open offices are designed with the goal of promoting collaboration, communication, and teamwork among employees. They typically work in a shared space, often with a large number of desks or workstations arranged in an open layout. This allows employees to see and interact with each other more easily, which can encourage collaboration and increase productivity. Additionally, open offices can be more cost-effective than traditional closed offices, as they require less construction and fewer materials. However, open offices have also been criticized and may have long-term negative effects on privacy and perceived office support in terms of individual work and well-being [1] which can lead to decreased productivity, performance and job satisfaction. [2 -5]

As such, many organizations have implemented hybrid office models, where employees have access to both open and closed spaces, depending on the activity, their needs and their preferences. These Activity-based Flexible Offices (AFOs) are becoming increasingly popular in modern workplaces as they can increase productivity by allowing employees to move around and find the work environment that best suits their needs and preferences. [6] For example, some employees may prefer a quieter space for focused work, while others may prefer a more social environment for brainstorming and collaboration.

But even though employees can choose where to work in the office, acoustic comfort is still the biggest dissatisfaction within todays workspace environments. [7] (Figure 1)

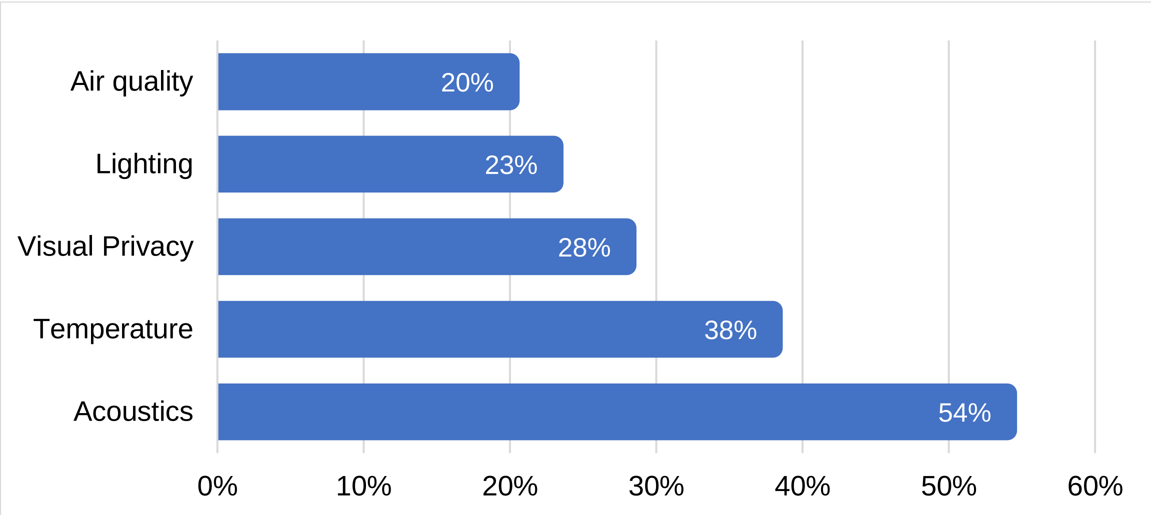

Figure 1: Common sources of occupant dissatisfaction

In the past a lot of research has been done on the biggest sources of distraction within an office environment. [8 – 11] The outcome is not really surprising: the most annoying sound source is irrelevant speech. According to a research from 2023 on the indoor acoustic environment in 600 office buildings, the top 3 is; people talking (78 percent), speech privacy (74 percent) and people talking on the phone (72 percent). [11]

The balance between speech privacy and speech intelligibility.

The need for privacy has been shown to play an important role in users' satisfaction in AFO environments [12], therefore one of the main challenges is achieving a balance between speech privacy and speech intelligibility.

Speech intelligibility refers to the ability to understand speech clearly. When sound levels are too high or there is excessive reverberation, it can be difficult to understand speech. This can lead to a perception of a noisy and chaotic office space. On the other hand, when sound levels are appropriate and reverberation is controlled, speech intelligibility is improved, leading to a perception of a calm and organized office space. A good estimation of speech intelligibility can be made by measuring the Speech Transmission Index, STI, between the speaker and listener.

Speech privacy refers to the ability to have a private conversation without being overheard by others. When sound levels are too low or there is not enough background noise, conversations can be easily overheard, leading to a perception of a lack of privacy. On the other hand, when appropriate sound masking is used, conversations are less likely to be overheard, leading to a perception of increased privacy. Speech privacy is related to the speech-to-noise ratio and is more or less the opposite of speech intelligibility.

Different research shows a clear correlation between the STI and Speech privacy. [13,14] Table 1 (Hongisto V, 2008) and Figure 2 (Pop C, 2005)

STI	Speech intelligibility	Speech privacy
0,00 – 0,05	very bad	confidential
0,05 – 0,20	bad	good
0,20 – 0,40	poor	reasonable
0,40 – 0,60	fair	poor
0,60 – 0,75	good	very poor
0,75 – 1,00	excellent	none

Table 1: Correlation between the Speech intelligibility and Speech privacy

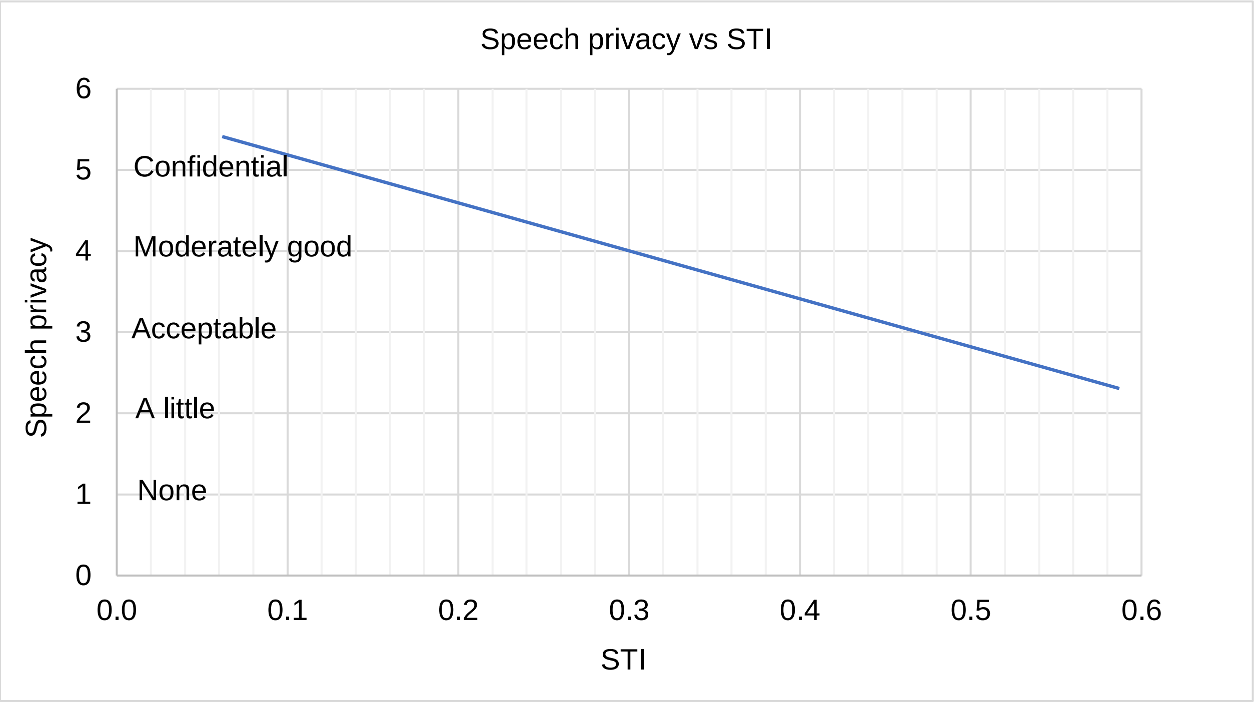

Figure 2: Subjective rating of speech privacy versus Speech Transmission Index (STI)

The need for quiet spaces

A survey among 5151 office workers worldwide shows that, if employees want to flee or hide from distractions, the first thing they do is try to find a quieter space in the office. Quiet spaces allow employees to concentrate on their work without being distracted by noise or interruptions from co-workers. This can lead to improved focus, increased productivity, and higher-quality work. [15]

Office furniture manufacturer, Steelcase, claims that 95 percent of today's workers need quiet, private spaces but 40 percent say their workplaces don't provide them. [16]

A study from Interface, a global manufacturer of commercial flooring, reports that 28 percent do not have a quiet space to work in their office. [17]

Creating effective quiet zones is not as simple as cordoning off a corner of the office and adding in a couple of extra desks. Quiet zones should be an area or space that people will go when they need to sit down and concentrate, probably using a laptop for an extended period of time. People using this section don't want to be distracted, but they also need to be seated in an area which is comfortable, supportive, and pleasant. Introducing a "quiet hub" can be the ideal answer to this issue and create quiet, compact surroundings within the larger office environment.

MATERIALS AND METHODS

The purpose of this case study was to investigate the impact of a quiet hub in an open office environment. It concerns an office in Munich, Germany which is used by a management consultancy company. One of the open office spaces is being used for internal and external communication, concentration and collaboration with a coffee corner and 10 workstations in total (Figure 2). The dimension is 19,5m x 6,3m (avg.) and 3,2m high. The construction consists of a concrete floor, plastered walls and a concrete ceiling. The is no meeting room in the office, so there was a clear demand for adding a flexible space where employees could collaborate or focus. This was met by adding a hub in the middle of the open office.

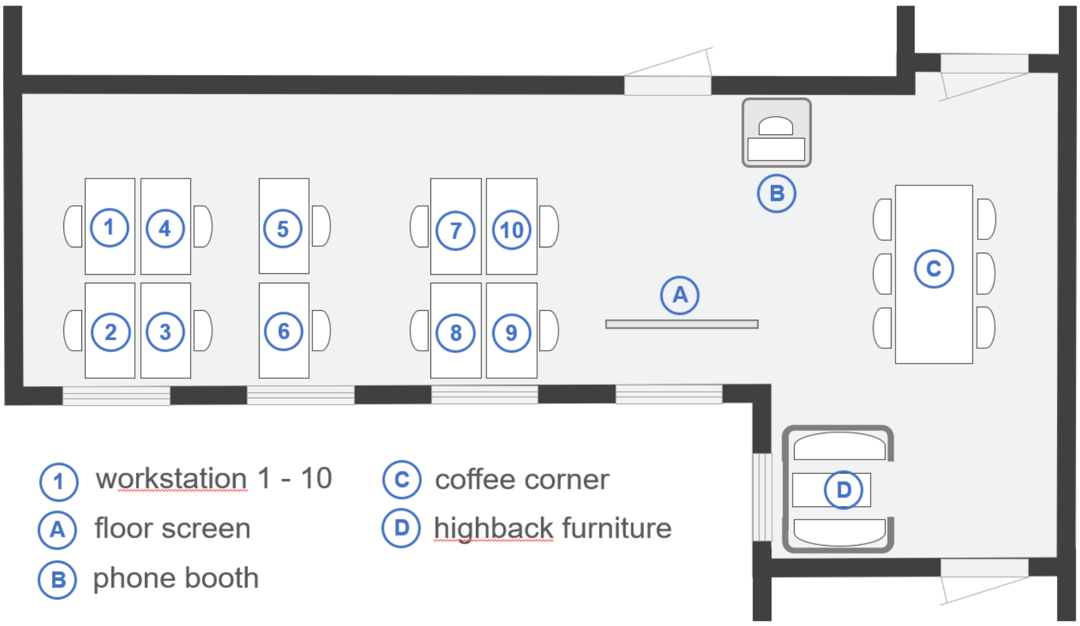

Figure 2: layout of open office

The hub, as a separate area in the centre of the open-plan office, consists of a free-hanging ceiling section (3,6m x 4,2m) with a highly sound-absorbing top layer and lateral acoustic curtains that serve as screening and act like a visually separated room (Figure 3). The curtains are not fitted all around, only on three sides. The facade side has not been applied due to daylight entry. The ceiling section with attached closed curtains are mentioned in the paper as the “hub”.

Figure 3: overview of the room including the hub with half open curtains.

The ceiling element contains a concealed ceiling system with 20mm stone wool ceiling panels mounted within a frame. The curtains are attached to the frame and are build up in three layers. They feature an acoustic fabric on its front and back and a Molton coated layer in between. The sound reduction index (Rw) of both are shown in Figure 4.

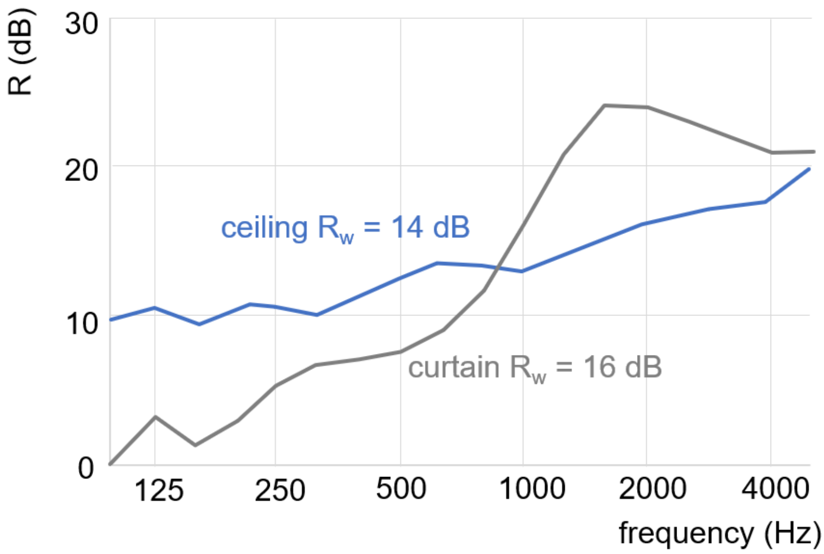

Figure 4: sound reduction index

The measurements

The effects of the hub on the acoustic environment were measured using sound levels (Leq), reverberation time (T20) and speech intelligibility (STI) as acoustic parameters. They were measured with the use of a sound level meter (Norsonic, type 118, class 1) and a sound source (Fostex speaker, type 6301B). For the T20 measurements an impulse sound source was used (Geco alarm pistol 6mm, mod. 7762). The sound levels and speech intelligibility were measured on different distances (m) left and right from the centre of the hub (Figure 5).

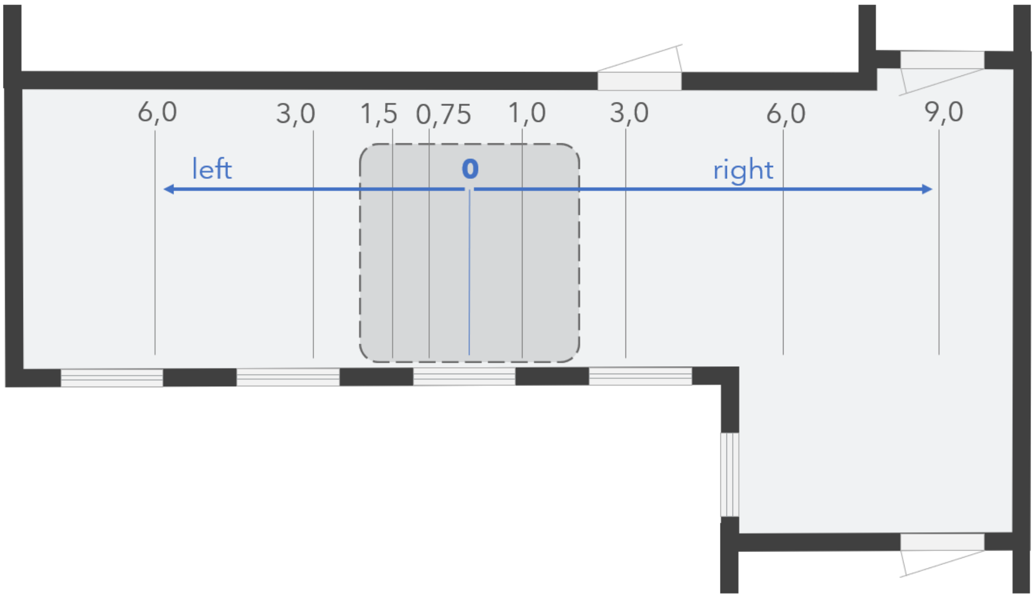

Figure 5: measured distances (meters)

RESULTS

The measurements were performed in three different situations: 1. without the installation of the ceiling element and curtains, 2. with the installation of the ceiling element, 3. with the installation of the ceiling element and curtains (Figure 6).

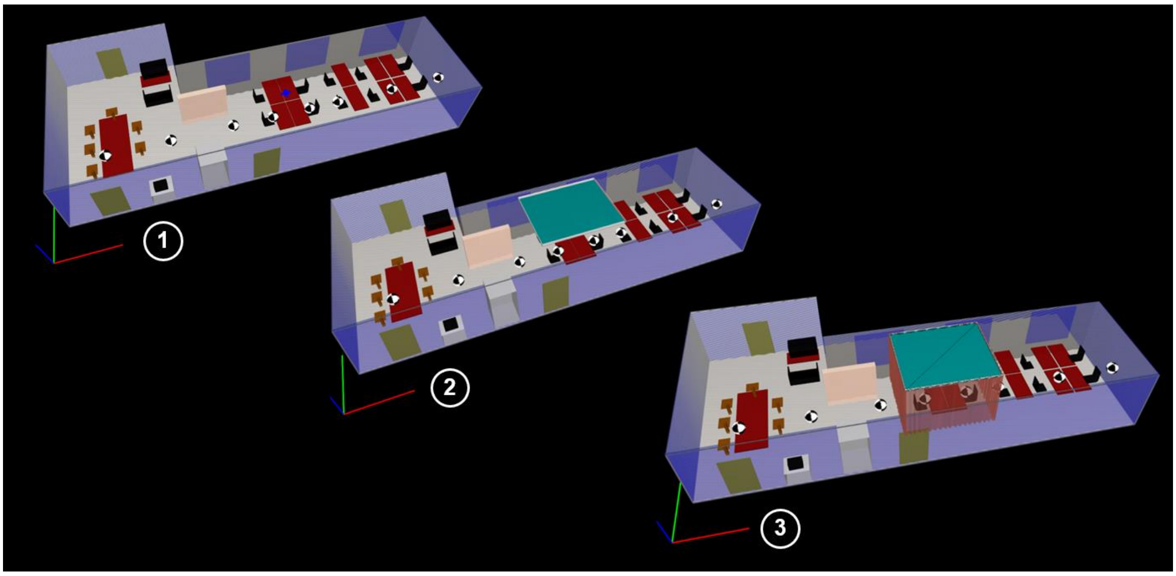

Figure 6: different situations measured

Sound pressure levels

The results of the measurements show that adding sound-absorbing materials has a clear influence on the reduction of the sound levels over different distances (Table 2.). The biggest differences are visible in situation #3, from the position inside the hub to the first position outside the hub (Table 3.). To the left the difference from measurement position 1,5m to 3,0m is 7 dB(A) and to the right from 1,0 m to 3,0m is 10 dB(A).

Leq, dB(A)	left					right			
distance (m)	6,0	3,0	1,5	0,75	0	1,0	3,0	6,0	9,0
1. without ceiling and curtains	83	84	84	86		86	83	80	80
2. with ceiling	76	77	79	83		82	76	73	73
3. with ceiling and curtains	72	72	79*	84*		81*	71	69	68

* values measured inside the hub.

Table 2: Sound level measurements

Δ Leq, dB(A)	left				right		
between distance (m)	3,0 - 6,0	1,5 - 3,0	0,75 - 1,5	0	1,0 - 3,0	3,0 - 6,0	6,0 - 9,0
1. without ceiling and curtains	1	0	2		3	3	0
2. with ceiling	1	2	4		6	3	0
3. with ceiling and curtains	1	7	5		10	2	1

Table 3: Sound level differences between distances

Speech Transmission Index

The results of the STI measurements towards left side (Figure 7.) and right side (Figure 8.) show that adding sound absorption slightly improves the speech intelligibility from situation #1 to situation #2. In situation #3 there is clear reduction of the speech intelligibility from the measurements inside the hub compared with the measurements outside the hub.

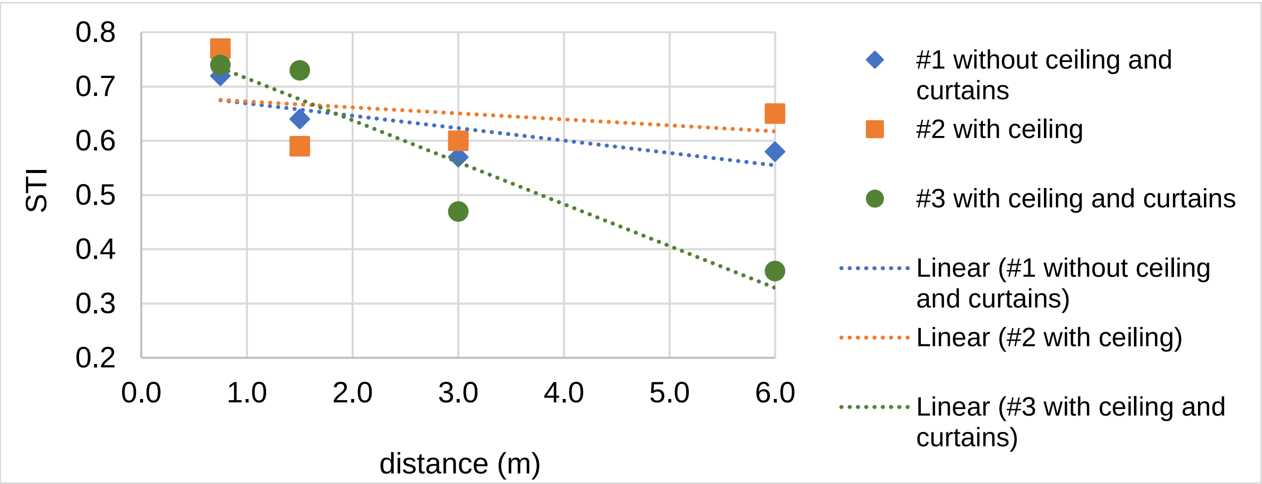

Figure 7: STI measurements left side

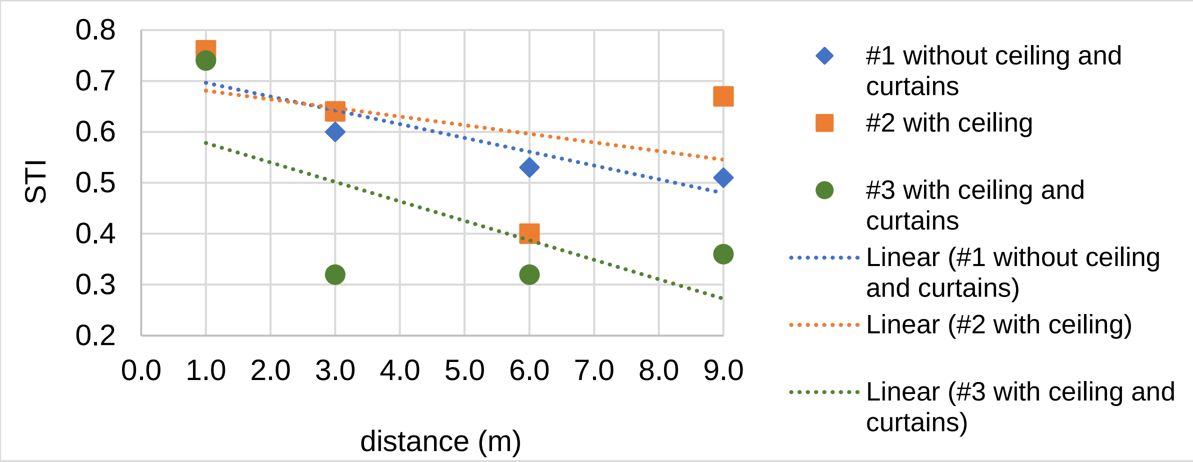

Figure 8: STI measurements right side

Speech privacy

The degree of speech privacy is derived from the measured STI values. The correlation between the speech intelligibility and speech privacy (Table 1.) shows in general a *reasonable* speech privacy (STI is between 0,20 - 0,40) in situation #3 when working in the office space outside the hub. (Table 4.).

Speech privacy	left					right			
distance (m)	6,0	3,0	1,5	0,75	0	1,0	3,0	6,0	9,0
1. without ceiling and curtains	0,58	0,57	0,64	0,72		0,74	0,60	0,53	0,51
2. with ceiling	0,65	0,60	0,59	0,77		0,76	0,64	0,40	0,67
3. with ceiling and curtains	0,36	0,47	0,73	0,74		0,74	0,32	0,32	0,36

Table 4: color coding Speech privacy

Reverberation time

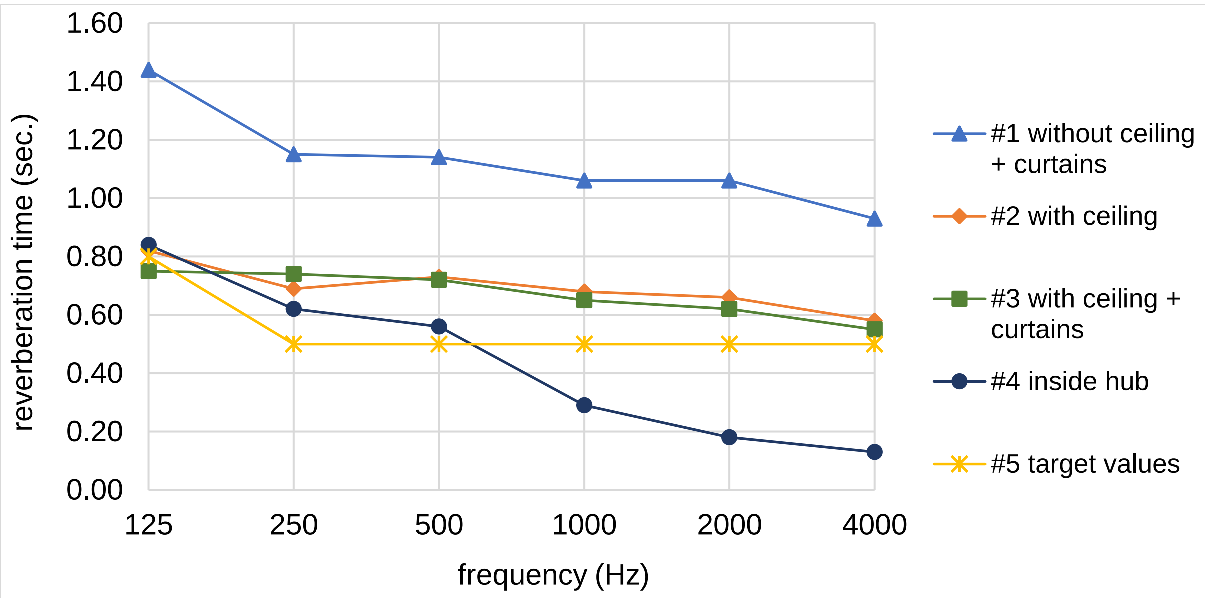

Figure 9: overview of reverberation times

The results of the measured reverberation times (Figure 9.) show that adding sound-absorbing materials in situation #2 an #3 have a clear influence on the room acoustics with a 40% reduction of the reverberation times. The avg. T20 in situation #1 is 1,13 sec. in situation #2, 0,69 sec., in situation #3, 0,67 sec. and in situation #4 it is 0,44 seconds. The target values are taken from the ISO 22955 – Acoustic quality of open office spaces. [18]

DISCUSSION AND CONCLUSION

This study aimed to investigate the impact of the hub on the indoor acoustic environment and the acoustic comfort in the open office. Can you reduce noise annoyance and improve acoustic privacy in an AFO with simply adding a sound absorbing ceiling element/island with attached acoustic dividing curtains?

Some results and outcomes are not surprising, if you add highly sound absorbing materials in a space where none is present, it is generally known that it will reduce the reverberation times and the sound pressure levels when the distance is doubled. It is clearly noticeable however that at the location of the ceiling element (without curtains) the sound pressure levels are reduced 4 - 6 dB(A) which gives an improved speech intelligibility.

The reverberation time is reduced more than calculated/expected with only the ceiling element (without curtains) as shown in Figure 10. knowing that it only contains 12% of the floor surface. The calculations are performed with using CadnaR software.

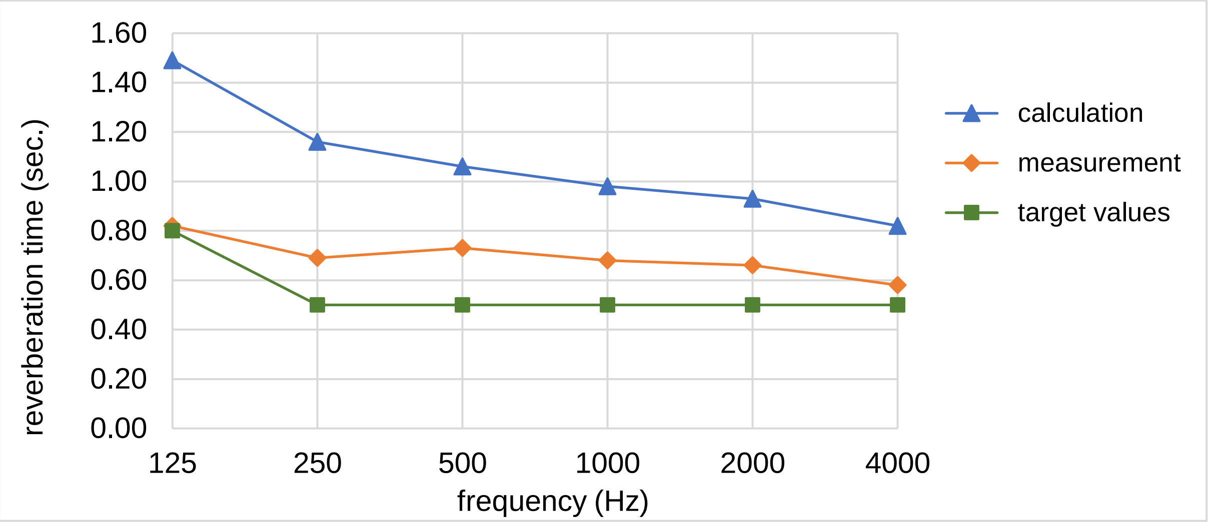

Figure 10: reverberation time calculated vs. measured in the situation with ceiling element (without curtains)

A *reasonable* speech privacy was achieved on the left position from measurement point 1,5m to 3,0m with a difference of 7 dB(A) and on the right side from 1,0 m to 3,0m with a 10 dB(A) difference (Table 4). When looking at the subjective rating of speech privacy versus Speech Transmission Index in Figure 2., the outcome from these positions give an *acceptable* speech privacy. Future research is needed to see how much the speech privacy can be improved when installing curtains fully closed around the hub instead of only three sides as in this case study.

The first reactions of the employees is that they mention an improved acoustic comfort. A detailed survey is being conducted and the outcomes will be shared when ready.

Disclosure statement

The authors of this paper, whose names are listed, declare a conflict of interest as the ceiling element discussed in this paper is an acoustic solution from the company they work for.

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