

Classroom acoustics and hearing ability as determinants for perceived social climate and intentions to stay at work

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Objective: To investigate how reverberation times (RT), hearing ability in terms of hearing thresholds and distortion product otoacoustic emissions were associated with schoolteachers' perceptions of the social climate at work and their intentions to stay on the job. **Methods:** One-hundred four teachers (77 women) from 10 schools that worked in classrooms classified according to their reverberation times into low, medium and high, were examined. **Results:** There were typically no interaction between reverberation time and hearing ability on any of the self-report measures. Age, gender and hearing adjusted statistical analyses showed that teachers who worked in high RT schools reported that they perceived their social climate to be more competitive, conflict laden, and less relaxing and comfortable as compared with teachers who worked in low RT schools. In addition, they reported less positively about their intentions to stay on the job than teachers who worked in low RT schools. **Conclusion:** Even if the teachers were generally satisfied with their work, room acoustics in terms of reverberation times is related to how teachers perceive the social climate and their outspoken intentions to stay on the job.

1 Introduction

While the most common and immediate reaction to a noisy environment is to feel annoyed background noise and poor room acoustics may also impede social interactions by interfering with oral communication and other cognitive processes. For example, recent research in school environments has showed that social relationships with peers and teachers are described more negatively in rooms with long reverberation times [1, 2]. The fact that 64 % of the schoolteachers that responded to the Danish Work Environment Cohort Study (DWECS) in 2010 reported that they were exposed to disturbing noise in at least one-quarter of their working hours, raises questions to the extent poor acoustics and disturbance are associated with work performance and social relationships at work. However, only a few studies have addressed these questions and those that have, has primarily focused on the consequences for the students [2 - 5].

Since teachers and pupils to a large extent share environments, it appears plausible that a poor acoustic environment and high noise levels via increased cognitive load and general feelings of discomfort also may exert a negative influence on teachers' social relationships and well-being. In addition, teachers hearing ability may vary, and poor hearing may make social exchanges more effortful [6]. For these reasons, it seems not only interesting to examine the potential effects noise and poor acoustics have on social relationships but also the potential interaction between hearing ability and room acoustics. Therefore, as part of a larger project [7, 8], we investigated how the RT in classrooms and hearing ability was associated with schoolteachers' perceptions of the social climate at work. The examination included assessment of hearing thresholds (HT), distortion product oto-acoustic emissions (DPOAE), and questions about the social climate at work and intentions to stay on the job. It was hypothesized that long RT's and a relatively lower hearing ability would be associated with more negative evaluations of the social climate at work and lesser intentions to stay on the job. In the present paper, the methods and results will only be presented in overview, but a full-length paper with all detailed results of the study is under preparation for publication.

2 Methods

2.1 Participants

In total 27 men and 77 women participated in the study (N = 104). The mean age for the men was 43 years (SD = 10 years) and the mean age for the women was 44 years (SD = 10 years). On average the men had 15 years of seniority (SD = 11 years) and the women had 14 years of seniority (SD = 11 years). The teachers were identified from 10 schools in the municipality of Copenhagen. None of the teachers used hearing aids, and only three teachers had a hearing handicap ranging between 0.6 - 8.6 % as calculated according to recommendations by the American Academy of Otolaryngology-Committee on Hearing and Equilibrium and The American Council of Otolaryngological-Committee on the Medical Aspects of Noise [9].

2.2 Identifying and classifying the acoustical environment

Twenty-five schools in the municipality of Copenhagen were initially included and screened for their acoustical environment. The reverberation time was used as the primary determinant. Each of the 25 schools first received an expert made overall classification according to their classroom RT, and was denoted either 'short RT', 'medium RT', or 'long RT'. Ten schools were judged to be acoustically 'homogeneous' across classrooms and were invited to participate in the study. Subsequent measurement confirmed the expert evaluations. These measurements were performed by impulse excitation and reverse integration of the impulse response as described in ISO 3382-2 [10]. Of the 10 included schools, three schools were classified as 'short RT' (mean RT = 0.44 seconds, range 0.41-0.47), three schools as 'medium RT' (mean RT = 0.51 seconds, range 0.50-0.53), and four schools as 'long RT' (mean RT = 0.65 seconds, range 0.59-0.73). The teachers were not informed about the acoustic classifications of the schools during the study and were in effect blinded to this study parameter.

2.3 Assessment of social climate and intentions to stay on the job

Five items from the General Nordic Questionnaire for Psychological and Social Factors at Work (QPS-Nordic) were used to assess various aspects of the social climate at work [11]. The items were preceded by a general statement: 'How would you describe the social climate at your workplace?' and were followed by five descriptive items, 'competitive', 'encouraging and supportive', 'distrustful and suspicious', 'relaxed and comfortable', and 'rigid and rule based'. These five items were supplemented with one additional item, 'conflict laden'. All items were ranked by respondents on a 5-point scale: not at all, to a small degree, partly, to a high degree, and to a very high degree.

2.4 Assessment of hearing ability

Otosopic examinations were performed before the hearing tests, and individuals with excessive ear wax were asked to contact their doctor to remove the ear wax before the hearing test. All hearing tests were performed in a transportable sound booth (IAC 250 Sound Shelter, complying with ISO 6189). Distortion product oto-acoustic emissions (DPOAE) [12] were performed biaurally with two identical DSP systems from Tucker-Davis Technologies (TDT, Alhama, FL), and two Ethymotic Research (ER, Elk Grove Village, IL) microphone probe systems (ER10B+ connected by tubes to ER2 sound transducers) [13]. Before measurements of either hearing thresholds or oto-acoustic emissions, proper earplug fittings were tested by measuring the output from each transducer in situ at 500 Hz. The DPOAE assessments of each ear consisted of two DP-grams with measurements of the cubic distortion product ($CDP = 2f_1 - f_2$) from 33 sets of primary input tones ($f_2/f_1 = 1.23$; f_2 ranging from 707 Hz to 10,374 Hz). The frequencies were grouped in low (f_2 less than 2 kHz), mid (f_2 between 2-4 kHz), and very high (f_2 above 4 kHz). For all frequencies, the results from the best ear were used as an indicator of hearing.

The same setup and probe systems were used for assessments of pure-tone hearing thresholds (HT: 125.2 Hz, 250.3 Hz, 500.7 Hz, 1001 Hz, 1541 Hz, 2000 Hz, 3085 Hz, 3999 Hz, 6169 Hz, and 7999 Hz) by an experienced technician in 5 dB steps.

3 Results

Unadjusted univariate analyses of variance showed that there was typically no statistically significant interaction between hearing ability (i.e. DPOAE, HT) and the room RT on the ratings of social climate and intentions to stay on the job. Only for the very high frequency band there was one statistically significant interaction between RT and HT. This concerned the distrustful and suspicious score (Interaction: $F [2, 88] = 3.40, p = 0.038, \eta^2 = 0.07$). Posthoc analysis revealed that teachers who taught in classrooms with short RT and who had poorer hearing in the very high frequency reported the social climate to be more distrustful and suspicious. However, since there typically was no interaction between any of the hearing measures and RT, the results were calculated as main effects models.

Unadjusted univariate analyses of variance showed that teachers who worked in classrooms with long reverberations were less positive about the social climate at work than teachers who worked in classrooms with short or medium RTs. Specifically, the teachers who worked in classrooms with long RTs reported that they perceived their social climate to be more competitive ($F [2, 101] = 6.23, p = 0.003, \eta^2 = 0.11$), more rigid and rule based ($F [2, 101] = 3.47, p = 0.035, \eta^2 = 0.06$), and conflict laden ($F [2, 101] = 7.59, p = 0.001, \eta^2 = 0.13$), and less relaxing and comfortable ($F [2, 104] = 7.04, p = 0.001, \eta^2 = 0.12$).

Unadjusted univariate analyses of variance showed that teachers who worked in classrooms with long reverberations were less positive about their intentions to stay on the job than teachers who worked in classrooms with short or medium RTs ($F [2, 104] = 8.43, p < 0.001, \eta^2 = 0.14$) (Table 1).

Table 1. Unadjusted mean scores for teachers grouped according to reverberation time (RT).

	Short RT (<i>n</i> = 28)		Medium RT (<i>n</i> = 34)		Long RT (<i>n</i> = 42)		Univariate ANOVA F-test	
	Mean	SD	Mean	SD	Mean	SD	P-value	Partial-eta square
Social climate at work (1-5)								
Competitive	1.68*	0.55	2.03	0.76	2.24	0.62	0.003	0.11
Encouraging and supportive	3.72	0.65	3.71	0.84	3.49	0.83	0.350	--
Distrustful and suspicious	1.54	0.74	1.68	0.73	1.93	0.78	0.090	--
Relaxed and comfortable	3.76*	0.69	3.46	0.82	3.07	0.80	0.001	0.12
Rigid and rule based	1.75*	0.70	2.15	0.99	2.29	0.81	0.035	0.06
Conflict laden	2.18*	0.86	2.29	0.68	2.93	1.05	0.003	0.13
Intentions to stay (1-5)								
Wish to remain during next three years	3.69*	0.93	3.86	0.97	2.98	1.08	<0.001	0.14

Note: * posthoc t-test $p < 0.05$, short RT versus long RT; Δ posthoc t-test $p < 0.05$, medium RT versus long RT. All questionnaire scales range from 1 = Not at all to 5 = To a very high degree.

Subsequent age, gender, and hearing-adjusted univariate analyses essentially confirmed this pattern of results. Only rigid and rule based lost the statistical significance and there were only minor alterations in the F-values and the estimated effect sizes.

4 Discussion

Even if the schoolteachers described their social climate positively, we observed that schoolteachers who worked in the classrooms with the longest RTs described the social climate less positively than teachers who worked in the classrooms with the shortest RTs. As verified by assessments of hearing thresholds (HT) and distortion product otoacoustic emissions (DPOAE), we observed that the absolute majority of the teachers had relatively good hearing in relation to their age. Since neither HT or DPOAE independently, or in interaction with RT, correlated with reports of the social climate at work or intentions to stay on the job, it seems unlikely that normal variations in teachers' hearing is

a substantial contributor to the perception of the social climate or intentions to stay on the job. To what extent the good hearing ability reflect a healthy worker effect is unknown.

All in all our results agree fairly well with previous findings that noise in classrooms with reverberation times in the range between 0.7-0.9 seconds obstructed students' conversational interactions and collaborative learning [1] as well as long reverberation times (1.0 second or more) were associated with less positive student evaluations of social relationships with peers and teachers [2]. It should, however, be noted that our long RTs were in the range of 0.6 seconds to 0.7 seconds and thus somewhat lower than in previous studies. This circumstance may lead to a relative underestimation of the effect on the social climate. However, since the RTs agree with the new Danish building regulations from 2008, demanding that the RT must not exceed 0.6 seconds in new or renovated classrooms, our result appear to be both realistic and practically relevant.

5 Conclusion

The teachers described the social climate in positive terms. However, teachers who work in classrooms with long RTs perceived their social climate less favourably and reported having weaker intentions to stay on the job as compared with teachers who worked in classrooms with shorter RTs. Even if the teachers were generally satisfied with their work, the presented results suggest that teachers' comfort at work may be further improved by acoustical interventions that focus on reducing sound reflections.

6 Funding

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