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TEACHERS' VOICE USE AND WELLBEING IN RELATION TO THE CLASSROOM ACOUSTICS AND BACKGROUND NOISE

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ABSTRACT*

Although many studies have shown that teachers' vocal health is challenged by noise and the room acoustics, research on classroom sound environment from the perspective of teachers' well-being is scarce. This study aimed to explore the relationship between teachers' well-being, voice use and classroom acoustics. In this study, well-being refers to self-reported vocal health, self-assessed level of stress, burnout and self-efficacy. Twenty-three primary-school teachers answered questionnaires on well-being. In each teacher's classroom, the acoustical properties were measured with the variables reverberation time, clarity of speech (C50) and ventilation system noise (VSN). A series of non-parametric correlations were run to determine the relationship between teachers' well-being and classroom acoustics. There was a significant bivariate correlation between burnout and VSN, (dBA), that, however, after correction for multiple analyses remained non significant, Voice symptoms correlated with VSN and teaching grade. This study indicates that higher degree of burnout in teachers is associated with higher levels of VSN in classrooms. Moreover, teachers' voice symptoms increase with higher levels of VSN. Teachers teaching lower grades had more voice symptoms than those teaching higher grades.

Keywords: *teachers, voice, ventilation noise, wellbeing, intervention*

1. INTRODUCTION

A variety of studies confirm that teachers remain one of the groups reporting the highest prevalence of voice problems, even in relation to the general population [1]–[3]. One explanation for voice problems can be found in noisy work environments and often poor room acoustics that create a constant need to speak over noise. In Lyberg Åhlander et al., [4], the included teachers reported being disturbed by various noise sources, of which activity noise from students and noise from classroom ventilation were two of the top five. Research shows that voice problems reduce well-being and quality of life. The training of teachers' voice- and interaction techniques during teacher education is limited. Karjalainen and colleagues therefore set out to design an intervention to train teachers' voice technique and interaction skills in the classroom and examine the effects on teachers' ratings of ratings of voice, stress, burnout, and self-efficacy in relation to the classroom. In this paper, special focus is set on the measurement of, the teachers' assessment of and reaction to the classrooms' acoustics and sound environment. Further, effects of the intervention are described.

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2. METHODS

The intervention consisted of five sessions of 1.5 h each. The sessions covered evidence based techniques in voice use, including techniques for adapting voice use to the sound environment; language supporting interactions, including optimising of language learning environments. Assessments were made pre/post intervention and at two follow-ups: after three weeks and five months. Details of the intervention are described in Karjalainen et al., [5]

2.1 Participants

Primary teachers (n=25), teaching grades 3-6 and from seven schools participated. Due to incomplete questionnaires, answers from 23 teachers were submitted for further analysis. Mean age 44 (27-63) years and mean years in occupation was 14.5 (0-31) years. Median number of students in their classes was 22 (17-37). Their hearing was screened (pure-tone, according to ISO 8253-1 at 0.25, 0.5, 1, 2, 4, 6, 8kHz). Impairments were found in two of the teachers but considered minor so they were still included.

2.2 Questionnaires

All included questionnaires were presented in Swedish and were validated either in their original language or in Swedish. Scorings and calculations were made according to the test manuals. Included questionnaire:

- Voice Handicap Index short form (VHI-11) [6]
  Eleven items measuring self-assessments of voice problems on a five point, frequency based scale (0=never, 4= always).
- Assessment of current voice status (VAS), 100 mm VA-scale [7]
- Self efficacy: Teachers' Sense of Efficacy Scale: Classroom management sub scale (TSES) [8], [9]
  Eight items targeting teachers' sense of ability to manage classroom situation despite distracting events. Responses given on a nine-point scale (1=nothing, 9=a great deal).
- Perceived Stress Questionnaire (PSQ) [10]
  Thirty items to assess cognitive perceptions of tress on a four point, frequency based scale (1= almost never, 4= almost always). Time limited version.
- Copenhagen Burnout Inventory (CBI) [11]
  Nineteen items assessing burn-out defined as fatigue and exhaustion in relation to specific domains. Answers are either frequency based ((1=always,5=never/almost never) or to what extent one agrees (1=very high degree, 5=very low degree). The CBI consist of three sub scales measuring different aspects of fatigue (personal, 6 items; work-related, 7 items; client-related 6 items). For the present study the total CBIscore was calculated [11], [12].

2.3 Measurements

As described in [5] the room acoustics of the teachers' respective classrooms were measured for clarity (C_{50}) according to ISO 3382-1, and reverberation time T_{20} (RT) according to ISO 3381-2 by the author JC. The measurements were performed pre-intervention. RT was analyzed in octave bands 125 and 250-4kHz. Twelve measurements were made in each room, with two different loudspeaker positions. The microphones were positioned in the rear of the room at a distance from loudspeakers >5m. The ventilation system noise (VSN) was measured in accordance with ISO 10052, stating that each measurement lasts 30s and the equivalent sound level is given in both dBA ($L_{A,eq}$) and dBC ($L_{C,eq}$) filters. Three consecutive measurements were performed in each room. In accordance with the standards, all measurements were made in unoccupied classrooms.

2.4 Statistical analyses

All statistical analyses were carried out using IBM SPSS Statistics 25 for Windows. Mann-Whitney U-test was used to analyze differences in both teachers' well-being and classrooms acoustics. A series of bivariate correlations were computed with Spearman's rho to determine the relationship between the teachers' self-reported well-being and classrooms acoustical measures. The *teachers' well-being variables* were VHI-11 (both sum of statements and VAS), TSES, PSQ and CBI and the *acoustical variables* being C_{50}, RT (125 Hz and 250-4kHz) and VSN (dBA and dBC). Non-parametric statistics were used as the majority of the questionnaires were on ordinal scale and the sample size was small. Bivariate analyses were made to investigate a possible relationship between the four *demographic variables* teachers' age, experience, teaching grade and class size and the five variables measuring *teachers' well-being*. Calculations to adjust for multiple tests were performed (Benjamini and Hochberg's false discovery rate [33]). Non-parametric partial correlations were performed to determine the relationship between the teachers' well-being measures and classroom acoustical measures, controlling for teachers' age, experience, teaching grade and the number of pupils in class. Since the partial correlations did not yield any significant correlations, no corrections were made. The strength of the correlation coefficient was interpreted using

the guideline by Mukaka: negligible ($|r| < 0.3$), low ($0.3 < |r| < 0.5$), moderate ($0.5 < |r| < 0.7$), high ($0.7 < |r| < 0.9$) and very high ($|r| > 0.9$) [34]. For the intervention effect, six linear mixed-effects regressions were conducted, with (Measure point + Week of training) as fixed factors and (Time | Subject) as random factors. The week of training in the model (reference = 2016 week 38) was included to control for temporal effects of the school semester on the individual measurements as far as possible. For all analysis, the alpha level was set to $p \leq 0.05$.

2.4.1 Ethical approval

This study was approved by the Regional Ethical Review Board in Lund (2016/567). The headmasters of the schools approved the project to be conducted at their schools. Informed, written consent was obtained from each participant.

3. RESULTS

3.1 Teachers' well being

The teachers' responses to questionnaires pre-intervention, measuring well-being are presented in Table 1.

Table 1. Self-report questionnaires targeting teachers' well-being presented with number of responding participants (n), mean (M) and standard deviation (SD), assessments pre-intervention.

Measure	n	M	SD
VHI11-sum	23	1.17	1.72
VAS	21	1.04	1.30
PSQ index	23	0.28	0.13
CBI	22	28.11	12.60
TSES: subscale classroom management	23	7.76	0.70

3.2 Classroom measurements

Descriptive data for the acoustical measures of the 23 classrooms emerge from Table 2. The 23 classrooms had a mean RT 125 Hz of 0.48 s (0.35 – 0.67); a mean RT 250-4 kHz of 0.43 s (0.30 – 0.70); a mean C50 of 6.6 dB (2.7 – 9.2). The mean VSN was 34 dBA (28 - 42) and 56 dBC (47 - 61). Recommended limits for RT in school buildings according to SS 25,268 is 0.60 s for 125 Hz and 0.50 s for 250-4kHz. Since early-reflected sounds increase speech intelligibility, a higher C50 value, approximately > 6 dB, is beneficial for the pupils' perceived clarity of speech. For VSN the recommended limits are 30 dBA and 50 dBC according to SS 25268.

Table 2. Acoustical measures and respective values for n=23 classrooms. Different letters A to G, represent different schools and numbers the different classrooms within the same school.

Classroom	C_{50}	RT 125 Hz	RT 250-4 kHz	VSN dBA	VSN dBC
A1	8.6	.35	.35	33	56
A2	7.2	.55	.40	31	56
A3	7.9	.48	.36	33	60
A4	7.4	.49	.37	32	61
B1	7.6	.46	.37	40	59
B2	6.6	.64	.39	35	56
C1	4.6	.62	.53	35	55
C2	4.2	.67	.53	33	56
C3	4.7	.61	.50	33	55
C4	4.0	.62	.52	33	57
C5	4.2	.52	.54	36	61
C6	4.9	.49	.48	35	58
D1	9.2	.36	.38		
E1	5.3	.37	.44	36	57
E2	6.7	.38	.42	38	58
E3	4.5	.42	.49	33	53
F1	2.7	.59	.70	29	47
G1	8.9	.44	.31	42	54
G2	9.1	.37	.30	38	53
G3	8.7	.41	.31	39	54
G4	8.0	.44	.40	33	56
G5	8.2	.42	.35	28	54
G7	8.3	.42	.38	31	56

The correlations of teachers' wellbeing measures pre-intervention and the acoustical measurements showed a low, significant correlation between burnout and VSN/dBA, however, after correction for multiple testing it remained without statistical significance. At first, there was a significant relationship with moderate strength, between voice symptoms and VSN (dBA). However., adjusted for

multiple comparisons, the correlation remained not statistically significant. Still more self-reported voice symptoms were associated with higher ventilation noise levels. The correlations emerge from Table 3. Bivariate analyses to investigate whether teachers' well-being was related to teacher demographics (teachers' age, experience, teaching grade) or class size resulted in one significant correlation, between VHIsum and teaching grade and after removal of the outlier the correlation was $r_s(21) = -0.435$, $p = 0.049$.

Table 3. Streamlined correlation matrix for the bivariate correlations computed with Spearman's rho between the well-being measures and acoustical measures.

	VAS	VHI11	PSQ	CBI	TSES:
VSN dBA	0.123	0.507*[1]	0.023	.437*	-0.225
VSN dBC	-0.035	-0.277	-0.111	0.160	0.076
RT 125HZ	-0.150	-0.095	0.217	0.006	-0.253
RT 240-4 KHZ	-0.325	-0.135	0.120	-0.003	-0.197
C50	0.275	0.180	-0.017	0.100	0.110

*Correlation is significant at the 0.05 level (2-tailed).
[1] VHI had an outlier, removed

3.3 Effects of the Intervention

The outcomes of the effects pre- and post intervention are shown in Figure 1. Voice assessments showed significant post-training effects: *VAS*: Perceived voice problems increased significantly after training but had returned to baseline at 3-month follow-up. *VHI11:* A decreasing trend post-treatment. At the three months post-treatment follow-up responses were significantly below baseline ($p < .05$). *CBI*: The observed decrease below baseline was significant at five weeks post-treatment ($p < .05$). At the 3-month follow-up, the results were still but not significantly below baseline. Further statistical analyses on the three separate subscales of CBI with linear mixed-effects regression, showed that the effect was driven almost entirely by the student-related subscale. The degree of burnout had decreased significantly ($p < .05$) at both 5-week follow-up ($B = -6.85$, $CI = [-10.89, -2.81]$), and 3-month follow-up ($B = -4.55$, $CI = [-8.85, -0.25]$), for this subscale, whereas the other two subscales showed only small and non-significant decreases below baseline. *TSES.* Teachers estimated sense of self-efficacy increased post-intervention, but only significantly ($p < .05$) at five weeks post-intervention. *PSQ index*:. Responses showed decrease below baseline post-intervention, significantly so at 5 weeks ($p < .05$).

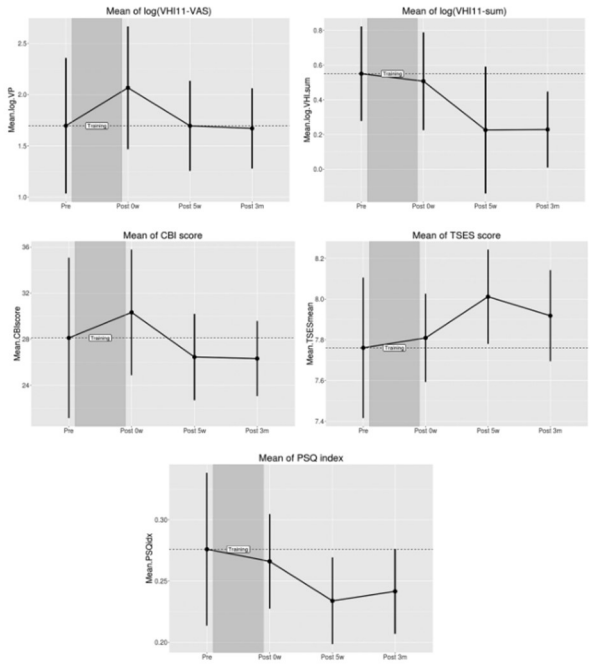

Figure 1. Aggregated data from n=23 teachers. Points correspond to mean values and vertical lines to confidence intervals. The dotted line through the first measure point (Pre-training) indicates the baseline. Note that confidence intervals overlap the baseline for some effects that are nevertheless significant. This is due to small differences between predicted values and calculated means, as the model included covariates.

4. DISCUSSION

This study investigated teachers' well-being in relation to classroom acoustics and background noise. Self-rated symptoms of burnout, as well as voice problems were associated with higher levels of ventilation noise. The connection between voice and burnout symptoms is indicated in previous literature[13]. Also, teachers suffering from voice problems seem to be more sensitive to disturbances in the surrounding environment.,[4] and that the work-ability might be affected [14]. previous research

finding adverse effect of room acoustic conditions on teachers' voices have primarily looked at reverberation time e.g. [15]. In the present study there were no associations found between these parameters. The explanation might be that the RT values differed between our studies with Rantala and Sala [15] reporting values with a mean of 0.55 s, which is about 0.1 s longer than in our study. We expected relationships between clarity (C_{50}) and vocal health and between clarity and burnout since the inherent characteristics of clarity support the voice in getting across to the listeners. It was thus, rather surprising that we did not find any significant correlations between teachers' well-being and clarity. A possible explanation for the scarcity of significant results or strong correlations could be that most of the present classrooms had good C_{50}. Moreover, the lack of significant results may result from the relatively small sample size. Also, the teachers in our study were in general of good vocal health. Sanguinetti et al., [16] discuss that teachers need to be informed about how the ventilation works, especially to be able to take care of the indoor climate during pandemics such as the Covid-19. The authors also deduct that the noise is an inevitable component of an effective ventilation and thus, measures and tools, such as sound field amplification systems and voice amplifiers, must be in place to support both students and teachers in dealing with the increased noise. There is, indeed, a delicate balance between proposed measures to improve physical health conditions and the measures that should be taken to improve the well-being of teachers and students in the classroom. Noise as well as a dysphonic teacher-voice has been shown to affect students' learning [17], [18] and the present study shows that a dysphonic voice might be an unwelcome effect of increased ventilation noise. Much evidence suggests that teachers are left to identify solutions to noise problems as well as their own voices. The intervention tested in the presented project proved effective in providing teachers with strategies to manage their voice and their interaction with the children also in relation to the sound environment. Several studies are currently being presented on continuous professional development (CPD) for teachers, led by speech and language therapists [19], [20]. Primarily, these aim to support teachers' language learning techniques, but the results from this present study indicate that it would be valuable to also include training and awareness of strategies for dealing with the voice and sound environment *i.e.* an increased speakers' comfort [21].

5. CONCLUSION

This study indicates that higher degree of burnout in teachers is associated with higher levels of VSN in classrooms. Teachers teaching lower grades had more voice symptoms than those teaching higher grades. The intervention tested in the presented project proved effective in providing teachers with strategies to manage their voice and their interaction with the children also in relation to the sound environment. The intervention resulted in reduced self-reports of burnout. Thus, teachers benefit from learning supportive strategies that can prevent reduced well-being as an effect of the noise environment.

6. ACKNOWLEDGMENTS

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