Perception of classroom acoustics and listening tests – a web-based survey

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INTRODUCTION

Poor listening conditions in classrooms impair speech comprehension, (Klatte et al. 2010) memory (Kjellberg et al. 2008; Ljung et al. 2009; Ljung & Kjellberg 2009) and increase annoyance and the mental effort needed to listen (Shield & Dockrell 2003). Listening conditions are determined by a number of factors but can mainly be attributed to room acoustic qualities, and the background sound determined by outdoor or indoor noise sources. In assessing listening conditions there are several indexes based on room acoustic measures, however, these require measurements on site and are hence expensive and time consuming to carry out. Furthermore a good rating alone may not sufficiently quantify a favorable communication according to Morimoto et al. (2004), that introduced the subjective rating of listening difficulty.

This study was carried out to see whether poor listening conditions could be assessed on a large scale using speech in sound tests, subjective ratings of the classroom acoustics and and/or the teachers' description of the physical room, all administered on the net. We also wanted to find out more on how the pupils experienced their sound environment and whether poor listening conditions could be predicted by their perception of the classroom acoustic and/or the teachers' description of the physical room.

METHOD

The instructions, questionnaires, and listening test were administered via the internet.

Listening tests

The pupils listened to sentences with low semantic redundancy (Hagerman 1982) in two signal-to-noise ratios, -3 dB and -6 dB and at two distances.

The choice of signal to noise ratios were selected on the basis of a pilot study carried out in two classes not taking part but of the same age group to get a response around 50 % of the psychometric response scale.

The sentences were played back though loudspeakers connected to a computer or MP3 player, using the schools own playback systems. The loudspeakers were placed at a position where the teacher usually stands when she/he teaches the class. The volume was chosen beforehand to give a comfortable listening level. Before the tests the students were given information and the opportunity to hear one set of the sentences without noise.

Four wave files each with 10 sentences were played back, two had a signal to noise ratio of -3, and two a signal to noise ratio of -6 dB. For the test, the class was divided

into two groups, one positioned *close* to the loudspeakers and one *far away* from the loudspeaker. After half of the listening test the groups changed places. Each group hence heard the two conditions in the order of -3 dB and -6 dB twice, one in the position *close* and one in the position far away. In all, there were 4 listening conditions *10 sentences and as every sentence had 5 words the pupils could have 0 to 50 (5*10) correct answers in each listening condition.

Questionnaire

A questionnaire was distributed after the listening test where the pupils were asked to rate the interference of the sound environment with their ability to: speech, listen and concentrate. They were further asked to describe their perception of the classroom sound environment using the adjectives quiet, clattering, and noisy. The teacher was asked to give a description of the size of the room, the type walls and ceiling, the type of sound absorbents in the ceiling if any, and number of larger scattering objects, such as shelves.

Participants

Classes at junior high school and grammar schools were invited and 59 classes from 38 schools in Sweden took part. The total numbers of pupils were 1,135 with 49.6 % girls and 49.4 % boys. Of the pupils, 179 (15.8 %) did not have Swedish as their native language, 48 (4 %) had impaired hearing and 4 pupils had hearing aid.

Analyses

The results from each class were reported as percentages of answers in the various categories, hence no individual analyses of relations etc. could be carried out. Statistical analyses of the data was done using ANOVA when data was numerical and approximately normally distributed, and with Mann Whitney U-test when data was ordinal and/or could not be assumed to be normally distributed.

RESULTS

Perception of speech

The average percentages of correct answers for the four conditions are given in Table 1. The results showed that there was a slight effect of distance and that this was not affected by the S/N ratio. The reduction of signal to noise ratio of 3 dB gave a reduction of correct answers with about 25 %. The results also showed that there was a large variation between classes in percentage correct heard words, with one standard deviation ranging from 15 to 20 %.

Table 1: Average percentage of correct answers and standard deviation per class and conditions

Conditions	- 3 dB	- 6 dB
Close	66 % (18.7)	40 % (16.5)
Far away	59 % (20.2)	34 % (15.4)

Factors that marginally predicted the speech perception were if the classroom ceiling had hanging absorbent panels, and the pupils descriptions of the classroom as clattering or noisy while the number of children speaking Swedish as their native language, the size of the room, or the number of hard walls did not have a statistically significant influence.

Figure 1 shows the results of the speech perception for the four listening conditions for the classrooms with hanging absorbent panels (n=13) and for the classrooms with absorbent panels directly mounted on the ceilings (n= 31) and the rest (n=5). For the conditions with -6 dB S/N, the classes in rooms with hanging absorbing panels generally performed somewhat better, and a significant difference was seen for the condition close ($Z=-2.067$, $p<0.05$).

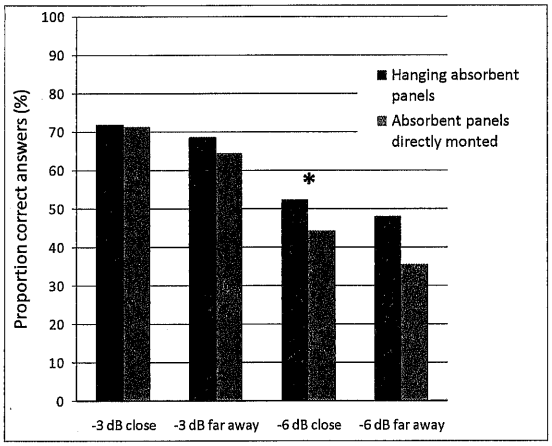

Figure 1: The median value of proportion of correct answers for the classroom with hanging absorbent panels and for those mounted directly on the ceiling and the rest

Subjective reaction of noise interference

In 40 % of the classes there was at least one pupil and in 19 % of the classes there were two or more pupils that *often* had difficulties hearing what the teacher said. Furthermore, nearly all classes or 81 % had one or more student that had difficulties concentrating due to noise.

Subjective perception of the sound environment in the classroom

In 33 % of the classrooms there were 3 to 6 pupils rating the classroom as very clattering, and only 14 % of the classrooms had no pupil rating the classroom as very clattering.

In 37 % of the classrooms there were 3-18 pupils rating the classroom as very noisy, and only 19 % of the classrooms had no pupil rating the classroom as very noisy.

Relation between subjective perception and speech perception

Figure 2 shows the results of the speech perception for the four listening conditions for classes where two or more pupils had reported the classroom as being very clattering (n=19) respectively very noisy (n=21) as compared to classes where less than two pupils had reported the classroom as being very clattering (n=38) respective noisy (n=36).

It can be seen that classes where more than two pupils rated the classroom as clattering and noisy, also generally have a somewhat poorer result on the listening test. Significant differences were found for the conditions with -6 dB S/N, at close distance for both descriptions ($F=4.93$; $p<0.05$; $F=4.40$ $p<0.05$) and for noisy also for far away ($F=4.93$; $p<0.05$).

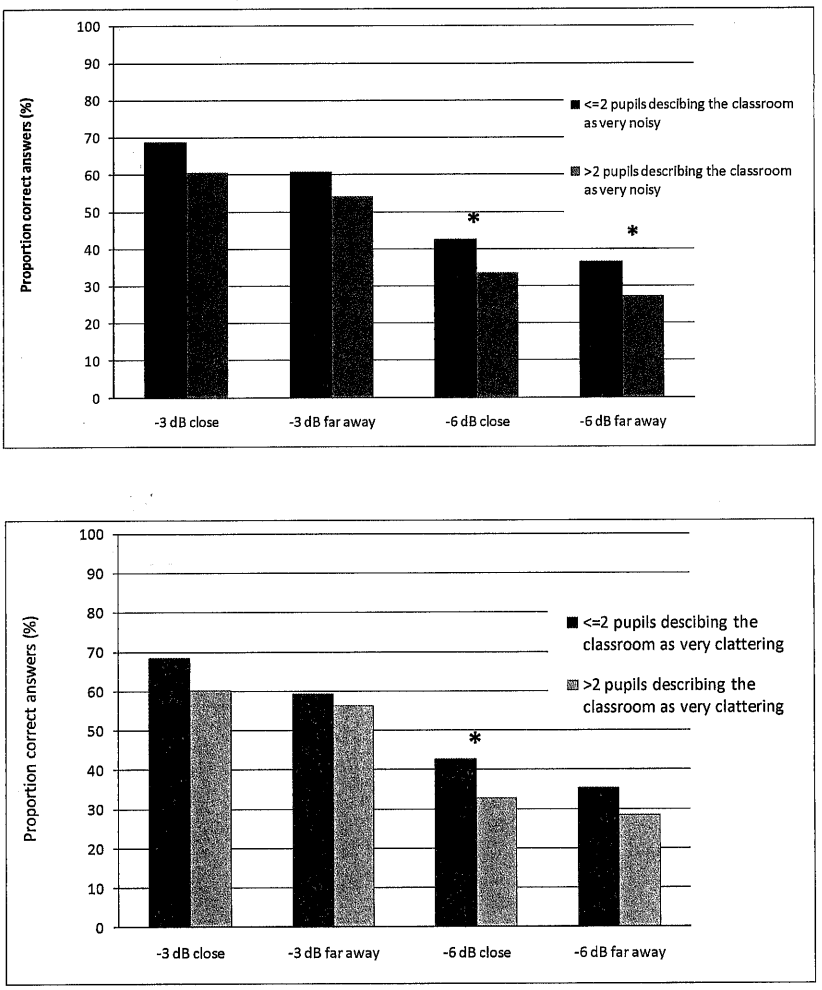

Figure 2: Average percentage of correct answers for classes divided into those with more than two respective two or less pupils describing the classroom as very clattering (top figure) and as very noisy (bottom figure)

CONCLUSION

The study was carried out via the web with for us limited possibilities to control for errors that may occur in performing the study. The way of distribution also means that we have little knowledge on the participating schools and those who chose not to participate, hence general conclusions cannot be drawn. The conclusions are also hampered by the fact that we only got summaries of the results per class, making it impossible to for instance relate individual reactions and perceptions to the results of the listening test.

Nevertheless, the results are from more than 1,000 pupils and give some interesting results on factors that could predict perception of speech in the classroom, such as type of absorbent panels. It is also noteworthy to see that about one fifth of the classes had two or more pupils that *often* had difficulties hearing what the teacher said, and that in nearly all classrooms one or more pupils *often* had difficulties concentrating due to noise. Worth following up in further studies is also the finding that the pupils' own perception of the sound environment was the best prediction of the results of the listening test.

If the method can be validated it opens up for interesting possibilities to screen via the web.

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