Discrimination scores used in medico-legal assessment of hearing disabilities

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Objective: Examination of Danish data for medico-legal compensations regarding hearing disabilities. The purposes are: 1) to investigate whether discrimination scores (DSs) relate to patients' subjective experience of their hearing and communication ability, 2) to compare DSs from different discrimination tests (auditory/audio-visual perception and without/with noise), and 3) to discuss the handicap scaling used for compensation purposes in Denmark. *Design:* Data for 466 patients from a 15 year period (1999-2014) were analysed. From the data set 50 patients were omitted due to suspicion of exaggerated hearing disabilities. *Results:* The DSs were found to relate well to the patients' subjective experience of their speech perception ability. As expected the least challenging test condition (highest DSs) was the audio-visual test without an interfering noise signal, whereas the most challenging condition (lowest DSs) was the auditory test with noise. The hearing and communication handicap degrees were found to agree, whereas the measured handicap degree tended to be higher than the self-assessed handicap degree. *Conclusions:* The DSs can be used to assess patients' hearing and communication abilities. In order to get better agreements between the measured and self-assessed handicap degrees it may be considered to revise the handicap scaling.

INTRODUCTION

Even though noise-induced hearing loss is a significant work related injury in many industrialized countries, there is no standard way of assessing a person's hearing disabilities regarding medico-legal compensation purposes across countries. In Denmark an ENT doctor has to fill in a special medical examination form. The form is filled in for all kinds of medico-legal assessments of hearing disabilities regardless of whether the hearing disability is work related, due to an accident, or a treatment

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Proceedings of ISAAR 2015: Individual Hearing Loss – Characterization, Modelling, Compensation Strategies. 5th symposium on Auditory and Audiological Research. August 2015, Nyborg, Denmark. Edited by S. Santurette, T. Dau, J. C. Dalsgaard, L. Tranebjærg, and T. Andersen. ISBN: 978-87-990013-5-4. The Danavox Jubilee Foundation, 2015.

injury. Thus, the form is used by both the Danish National Board of Industrial Injuries and Danish private insurance companies.

In order to assess the patient's hearing disability, and thereby the amount of financial compensation to be paid, the form uses the scaling of the hearing handicap (HH) and the communication handicap (CH) proposed by Salomon and Parving (1985). The HH degree is based on the patient's ability to comprehend speech auditorily without the help from visual cues, whereas the assessment of the CH degree is based on the patient's audio-visual speech comprehension. Both the HH and the CH are determined 'self-assessed' by an interview and 'measured' by results from discrimination tests. For both types of handicaps an overall degree is stated as the mean of the self-as-sessed and the measured degree.

This study analyses data from a large number of patient forms collected over a 15-year period (1999-2014). The research purposes of the study are:

1) to investigate whether discrimination scores (DSs) relate to patients' subjective experience of their hearing and communication ability.
2) to compare DSs from different discrimination tests (auditory/audio-visual perception, and without/with noise).
3) to discuss the handicap scaling used for compensation purposes in Denmark.

METHODS

Patients

The medical examinations for 466 patients form the basis of this study. The patients were referred to medico-legal examinations due to hearing disabilities mainly caused by work related noise exposure. For a minor part of the patients the hearing difficulties were due to an accident or a treatment injury. From the data set 50 patients were omitted due to suspicion of exaggerated hearing disabilities. Thus, the analyses include data for 416 patients (376 men and 40 women, aged 10-80 years with an average age of 54 years).

Interview

In the medical examination form the HH and the CH degrees are determined 'self-assessed' by an interview containing three questions:

QI Are you able to understand speech one-to-one in a quiet environment?

QII Are you able to understand speech one-to-one despite background noise, speech, music or other everyday noises?

QIII Are you able to follow a group conversation at home?

For each patient the three questions were posed twice, first regarding auditory perception and then regarding audio-visual perception. For patients having hearing aids the questions were posed two additional times. The answers regarding hearing aid use are in this study used for the handicap scaling only (i.e., regarding research purpose 3).

The patient answered each question with 'Yes' or 'No'. If the patient answered Yes with a reservation, the answer was recorded as '(Yes)'. Thus, a (Yes)-answer refers to the patients being able to perceive speech but only under certain circumstances, e.g., depending on the character of the voice, the noise type or the placement of the talker. The doctor assesses whether a (Yes)-answer is interpreted as Yes or No.

Discrimination tests

In the medical examination form the HH and the CH degrees are determined 'measured' by results from discrimination tests. The discrimination tests were performed using the Dantale word lists and Dannoise (Elberling *et al*., 1989). They were performed for two listening conditions:

- Without interfering noise (in analogy with QI), speech level = 65 dB SPL
- With interfering noise (in analogy with QII), signal-to-noise ratio = 0 dB (both the speech signal and the noise signal were 65 dB SPL)

For each patient the two discrimination tests were performed twice, first regarding auditory perception and then regarding audio-visual perception. For patients having hearing aids the two discrimination tests were performed two additional times. The discrimination tests performed using hearing aids are in this study used for the handicap scaling only (i.e., regarding research purpose 3). The result of each test is stated as the discrimination score (DS), i.e., the percentage of correctly answered words.

Handicap scaling

The degrees of the HH and the CH were assessed based on the patient's answers to the questions in the interview as well as on the results from the discrimination tests. Thus, for each person four handicap degrees were determined: HH self-assessed, CH self-assessed, HH measured, and CH measured. The handicap degree classification was: 0 = no handicap, 1 = slight handicap, 2 = mild to medium handicap, 3 = considerable handicap, 4 = severe handicap, and 5 = total handicap.

Table 1 shows how each of the four handicaps were assessed. The answers to the three questions are in the columns marked QI, QII, and QIII, whereas the discrimination scores marked DSI and DSII are for the conditions without and with an interfering noise, respectively. The abbreviation A is for auditory perception (HH), whereas AV is for audio-visual perception (CH). The column "HA use" refers to whether the questions were answered regarding hearing aid/the discrimination tests were performed with hearing aid. Note that setting the handicap degree using the table is not always unambiguous.

RESULTS

Fig. 1 shows for all three questions that the percentages of Yes-answers are larger for the audio-visual than for auditory perception. It also shows that the percentage of Yes-answers is largest for question I representing good listening conditions and smallest for question III representing poor listening conditions.

Degree	HA used	Self-assessed						Measured			
		HH			CH			HH		CH	
		QI A	QII A	QIII A	QI AV	QII AV	QIII AV	DSI A	DSII A	DSI AV	DSII AV
0	No	Yes	Yes	No	Yes	Yes	Yes	Normal	> 80%	Normal	> 80%
1	No	Yes	No	No	Yes	Yes	No	Normal	< 60%	Normal	> 60%
2	Yes	Yes	Yes	No	Yes	Yes	Yes	90-95%	> 60%	Normal	> 90%
3	Yes	Yes	No	No	Yes	Yes	No	> 60%	< 60%	> 90%	> 60%
4	Yes	No	No	No	Yes	No	No	< 60%	→ 0%	> 60%	< 60%
5	Yes	No	No	No	No	No	No	0%	0%	< 60%	0%

Table 1: Hearing handicap and communication handicap scaling; both self-assessed and measured. See the text for details. The table is a merged reproduction of Tables I, V, and VI in Salomon and Parving (1985).

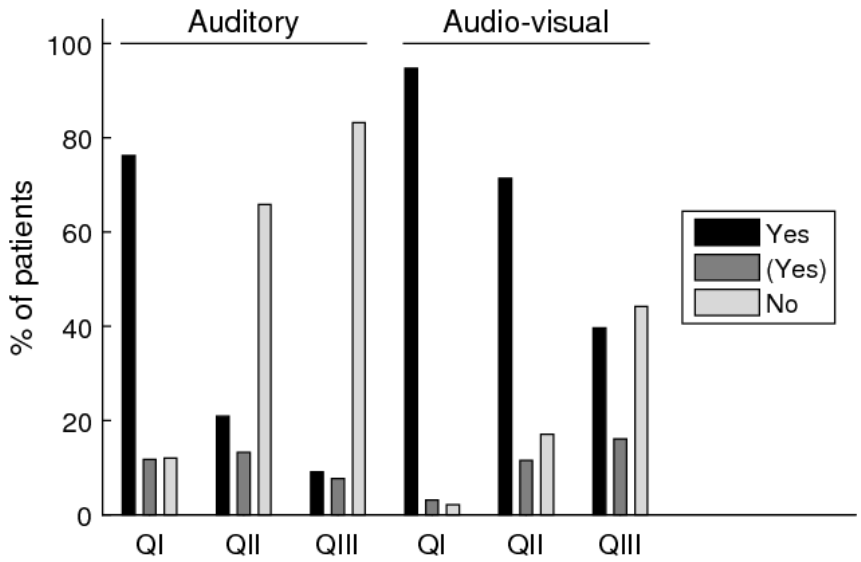

Fig. 1: Percentages of Yes-, (Yes)-, and No-answers to questions I, II, and III. Each question was posed regarding auditory and audio-visual perception, respectively.

Fig. 2 shows the DSs obtained for patients who have answered Yes, (Yes), and No to question I and II, respectively. DSs across the different answers are also shown. The DSs for each of the four conditions are selected as to reflect the listening situation of the question, e.g., for question I auditory the DSs are measured auditory without an interfering noise signal. For all four conditions the medians of DSs are found to be statistically significantly different for all three answers at the five percent level. Additionally, the medians across the different answers (market with squares) are found to be statistically significantly different for all four conditions.

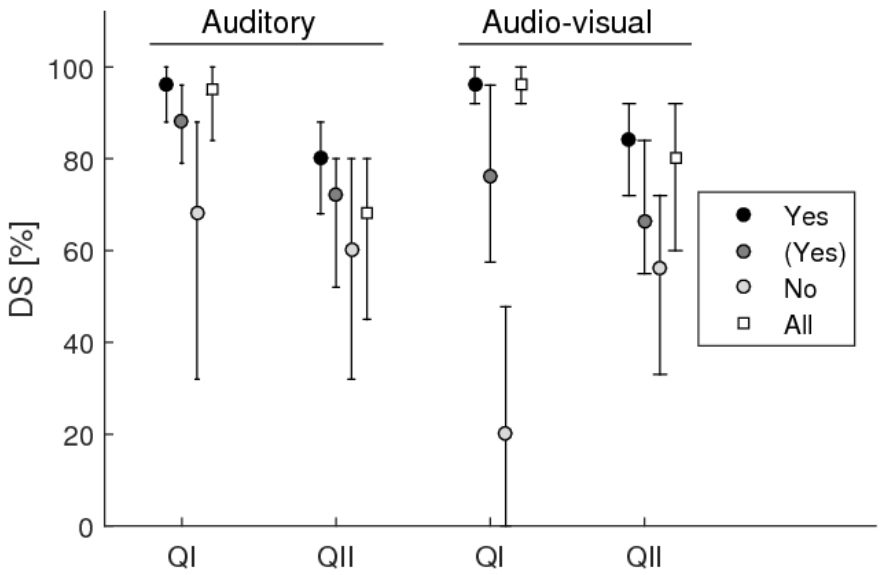

Fig. 2: Medians of the DSs for patients grouped as to their answers to question I and II. Data for the DS across the different answers are marked 'All'. The lower and upper ends of the error bars represent the 25th and 75th percentile, respectively.

Connections between DSs across the different test conditions are shown in Fig. 3. For each subfigure the most challenging test condition (of the two in concern) is on the x-axis, whereas the least challenging test condition is on the y-axis. For the persons obtaining low DSs in the most challenging condition there are relative large individual differences in the DS enhancement as the listening condition improves; especially for the test conditions in Fig. 3, a) and b). Note that, as the DS scale is censored, it is not possible to score below 0% or above 100%, termed the floor effect and the ceiling effect, respectively. Thus, persons obtaining DSs of 100% in the most challenging test condition cannot get higher scores in the least challenging test condition.

Fig. 4 shows the connection between the HH and CH degree as well as the connection between the self-assessed and the measured handicap degree. The handicap degrees were assessed using the scaling reported in Table 1. As seen a large number of the patients are assigned handicap degrees of 0 or 1. For both the self-assessed and the measured handicaps most patients obtain HH and CH degrees which are identical or differ by one degree of handicap from one another, see Fig. 4, a) and b). This agrees with the finding in Salomon and Parving (1985). The agreement between the HH and CH degrees indicates that the handicap scaling compensates for the fact that speech comprehension is easier audio-visual than auditory. For some of the patients the measured handicap degree is higher and even up to four degrees higher than the self-assessed handicap degree, see Fig. 4, c) and d).

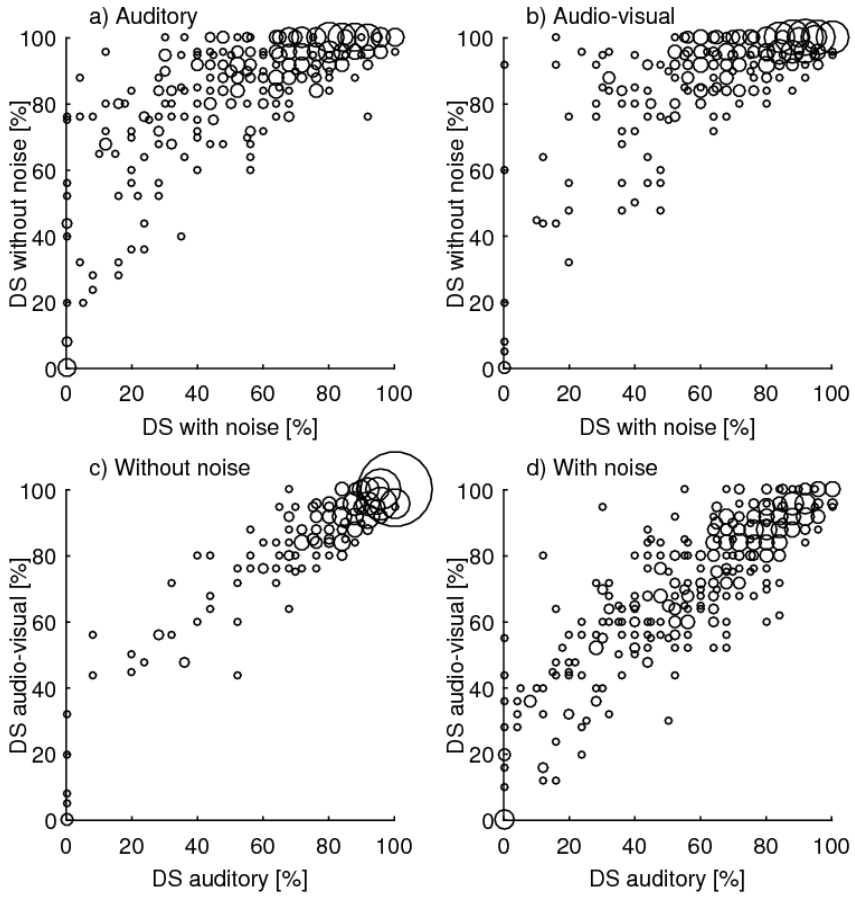

Fig. 3: Combinations of the DSs for the different discrimination test setups. The connection between the DSs with and without noise is in a) for the auditory perception and in b) for the audio-visual perception. The connection between the DSs auditorily and audio-visually is in c) for the test setup without noise and in d) for the test setup with noise. The bigger the dot (defined by the area), the more patients have obtained the same DS in the two tests in concern.

DISCUSSION

For all four test setups the patients who had answered Yes obtained the highest DSs (Fig. 2). The small variations in the DSs for the Yes-answers to question I for DS without noise can be explained by the ceiling effect, i.e., scores cannot go higher than 100%. However, lower scores can be achieved by changing the test setup, e.g., by lowering the level at which the words are played. For the discrimination tests performed with noise the DSs can be lowered by either lowering the SNR or by changing the interfering noise signal to one which is more difficult to distinguish from the speech signal.

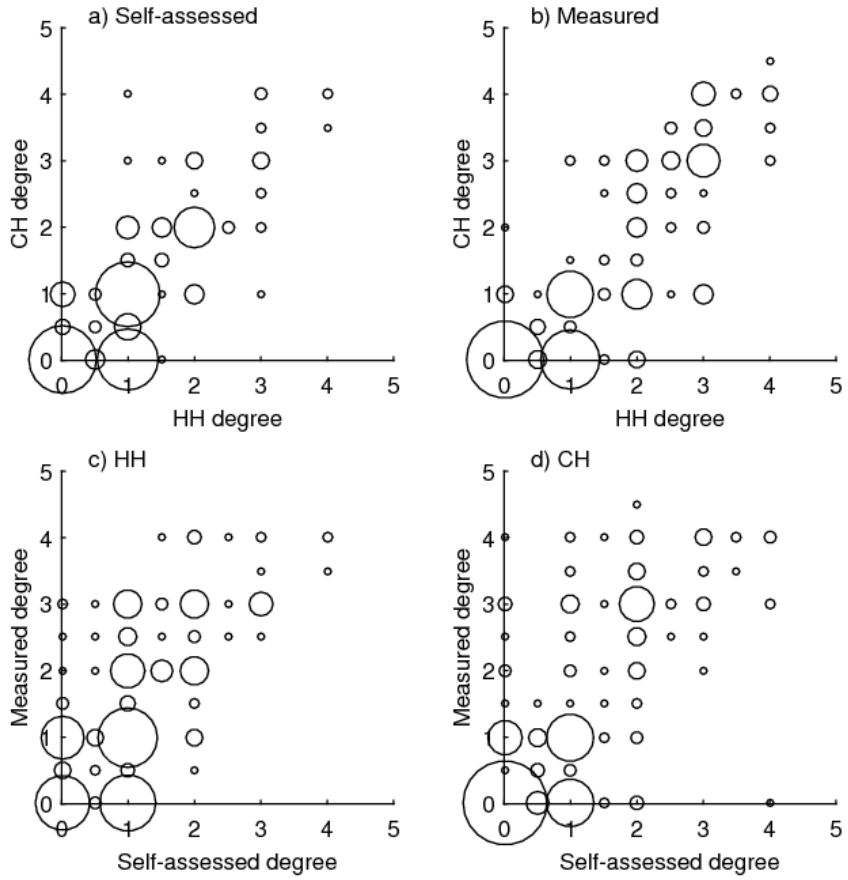

Fig. 4: Connections of the different handicap degrees (ordinal scaled values). The connection between the hearing handicap (HH) and the communication handicap (CH) is in a) self-assessed based on the patient's answer to the three questions and in b) assessed based on the DSs. The connection between the self-assessed and the measured handicap degrees is in c) for the HH, i.e., related to auditory perception and in d) for the CH, i.e., related to audio-visual perception. The bigger the dots (defined by the area), the more patients have obtained the same handicap degree.

If the handicap scaling is to be revised this should be adjusted, so that the measured and self-assessed handicap degrees are more consistent, i.e., either the self-assessed scale should be changed so a high self-assessed degree is easier to obtain or the measured scale should be changed so a high measured degree is harder to obtain. Since the HH and CH degrees correlate well, the adjustment should be made so that the proportion between the HH and CH degrees is kept fixed, for instance by applying the same adjustment to the measured degrees of both the HH and CH.

Furthermore, if the handicap scaling is to be altered, it should be framed unambiguously so that determination of the handicap degrees are uninfluenced by the experi-

menter's subjective evaluation, i.e., not as today where the measured handicap degree can fall outside a degree or into two degrees.

CONCLUSIONS

Data for the medical examination form filled in over a 15-year period were analysed. The data set includes data for 466 patients, from which 50 were omitted due to suspicion of having exaggerated their hearing disabilities. Analysing the data for the remaining 416 patients gave the following answers to the three research purposes listed in the introduction:

1) The DSs relate well to the patients' subjective experience of their speech perception ability. This was found for all four investigated test conditions.
2) The patients obtained higher DSs when the discrimination tests were performed without noise than with noise, and slightly higher when performed audio-visually than auditorily.
3) In order to get better agreements between the measured and self-assessed handicap degrees it may be considered to revise the scaling for either the HH or the CH. The handicap scaling should be framed unambiguously.

ACKNOWLEDGEMENTS

The authors thank Hilde Christin Wangen, Department of Audiology, Aarhus University Hospital for carrying out the majority of the audiological tests. The authors also thank Torben Poulsen, Centre for Applied Hearing Research, Technical University of Denmark for valuable discussions. This study was supported by the Oticon Foundation, grant number 12-1361.

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