Calculating the hearing loss in percent based on speech audiograms in German, French and Italian

Berechnung des prozentualen Hörverlusts aus Sprachaudiogrammen in Deutsch, Französisch und Italienisch

Abstract

In Switzerland, speech audiometry in quiet is conducted in German, French, or Italian, depending on the patient's native language. For insurance purposes, a percentage hearing loss is calculated from the speech audiogram based on word recognition scores at three predefined intensity levels, which differ between the three languages. This study aimed to evaluate whether the current intensity levels yield comparable results across all three languages.

We analyzed pure-tone and speech audiograms from 73 patients tested in German, 50 in French, and 121 in Italian. The percentage hearing loss derived from the speech audiogram was compared to that obtained from the pure-tone audiogram, using the internationally used CPT-AMA table.

Our findings indicate that the German and the Italian language tests produce comparable results, whereas the French test requires presentation at nearly 10 dB higher intensity levels to achieve comparable results.

Keywords: speech audiometry, Freiburg monosyllabic words, languages

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Zusammenfassung

Die Sprachaudiometrie in Ruhe wird in Abhängigkeit von der Muttersprache der Patienten in der Schweiz in deutscher, französischer oder italienischer Sprache durchgeführt. Für versicherungstechnische Fragen kann aus dem Sprachaudiogramm ein prozentualer Hörverlust aus dem Wortverstehen bei 3 vorgegebenen Pegeln berechnet werden. Für die drei Sprachen werden unterschiedliche Pegel verwendet. Ziel dieser Studie war es zu überprüfen, ob die heute benutzten Pegel in den drei Sprachen zu vergleichbaren Resultaten führen.

Die Reintonaudiogramme und die Sprachaudiogrammen von 73 Patienten mit deutschen Sprachtests, 50 Patienten mit französischen Sprachtests und 121 Patienten mit italienischen Sprachtests wurden analysiert. Der prozentuale Hörverlust aus dem Sprachaudiogramm wurde jeweils mit dem prozentualen Hörverlust aus dem Reintonaudiogramm gemäß der international gebräuchlichen CPT-AMA Tabelle verglichen.

Es zeigte sich, dass der deutsche und der italienische Sprachtest gut miteinander übereinstimmen, der französische Sprachtest hingegen um knapp 10 dB lauter angeboten werden müsste, um vergleichbare Werte zu ergeben.

Schlüsselwörter: Sprachaudiometrie, Freiburger Einsilbertest, Sprachen

1 Introduction

In order to measure speech comprehension in quiet, in Switzerland, speech tests in German, French, and Italian are used [1]. The test language should correspond to the language best understood by the patient.

From the measurements, a percentage hearing loss, the so-called "social index", can be calculated as follows: 100% minus the averaged speech intelligibility at three specified levels spaced 15 dB apart. Due to differences between the language tests, the three levels have been defined separately for each of the three languages, as shown in Table 1.

The percentage hearing loss is relevant as it determines whether or not an insurance will cover the cost of hearing aids [1]. It is therefore important that the measurements are comparable in all three languages.

Our aim was to assess the comparability of the above levels and to suggest improvements, if necessary.

2 Materials and methods

2.1 Data used and ethics

Data from three different clinics in three different languages were available for the analysis. These included data from 50 patients at the Geneva University Hospital (French), 121 patients at the Lucerne Cantonal Hospital (Italian), and 73 patients at the Inselspital (German). Their mean age was 54.6 years (range 18–97), 83 were female, 161 male.

All patients gave their written consent for the use of their data for scientific purposes in anonymized form on a form approved by the local ethics committee.

For all patients, the hearing loss according to CPT-AMA [2] as well as speech understanding at the 3 levels required for calculating the social index according to Table 1 were available for both ears separately.

The three study groups differ in their size and average hearing loss, which may limit the generalization of the results, as discussed later in section 4.

We hypothesize that one potential reason for the higher average hearing loss observed in the Italian-speaking study group may be the limited availability of specialized tertiary centers in the Italian-speaking part of Switzerland. As a result, individuals from this region must travel to the German- or French-speaking parts of the country to access such care, which may lead them to postpone visits, possibly more so, if they perceive their own hearing loss as mild.

2.2 Analysis of the current situation

All three speech tests are calibrated uniformly across Switzerland. Calibration is based on the maximum peak level of each test word, measured using the 'impulse' time constant and averaged over the test lists [3]. Each center is required to undergo annual verification and certification of these levels by the Swiss Federal Institute of Metrology.

To analyse the current situation regarding the three language tests, hearing loss according to the social index was plotted against the hearing loss according to the CPT-AMA table, and the linear correlation between the two was calculated for each language separately. This allows the language-independent hearing loss according to the CPT-AMA to serve as a comparison.

2.3 Extrapolation

In order to be able to propose new presentation levels that might make the social index more comparable across languages, additional calculations were performed. Ideally, measurements at other levels would be available for this purpose. Since this was not the case, a different approach was chosen. Assuming that only relatively minor shifts in the presentation levels would be necessary, the hypothetical measurement data were estimated from the actual available data, as shown in Figure 1.

If the required hypothetical measurements were between two existing measured values, they were linearly interpolated. If they were outside the measurement range (in the example in Figure 1, the point on the far right), they were extrapolated. Extrapolated values were limited to the range between 0 and 100%.

The tests in German served as a base and the presentation levels in the other two languages were adjusted.

3 Results

3.1 Comparison of the data used

Table 2 shows an overview of the raw data used.

The average hearing loss according to CPT-AMA is roughly comparable for German and French, but is considerably higher for Italian-speaking patients.

Figure 2 shows the distribution of hearing loss according to CPT-AMA for the three languages separately. It again shows that severe hearing loss is more common in the Italian-speaking population than in the other two groups.

3.2 Current state

Figure 2 shows the relationship between hearing losses according to the CPT-AMA table and the social index when the measurement levels used today are applied.

As expected, the hearing loss according to the social index increases in all languages approximately proportionally to the hearing loss according to the CPT-AMA table. However, the variance is considerable. The linear regression lines are close for German and Italian, but further apart for French. When tested in French, for the same hearing loss in the audiogram, the hearing loss according to the social index is on average about 10% higher. For the Italian language tests, the mean difference is only about 1%.

Table 1: Calculation of the social index in 3 different languages (current version)

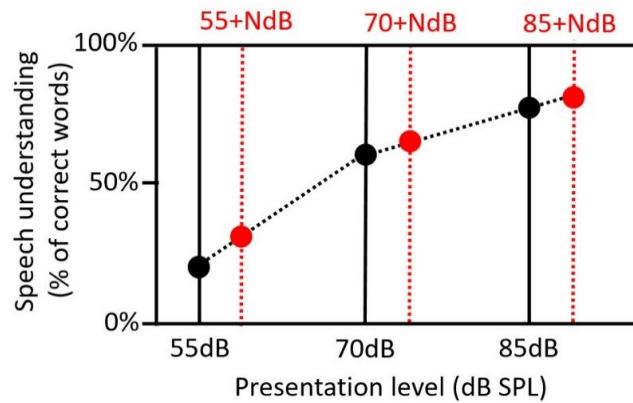| Language	Test	Calculation: 100% minus the mean value of speech intelligibility at these 3 levels
German	Monosyllabic words (Freiburger Einsilber) [8], [9]	60 dB, 75 dB, 90 dB
French	Monosyllabic words (Mots monosyllabique, Fournier test) [10]	55 dB, 70 dB, 85 dB
Italian	Two-syllable words (Bocca e Pellegrini) [11]	55 dB, 70 dB, 85 dB

Figure 1: Principle of the interpolation and extrapolation used (black dots: actual measurements; red dots calculated values)

Table 2: Comparison of mean hearing loss according to CPT-AMA table

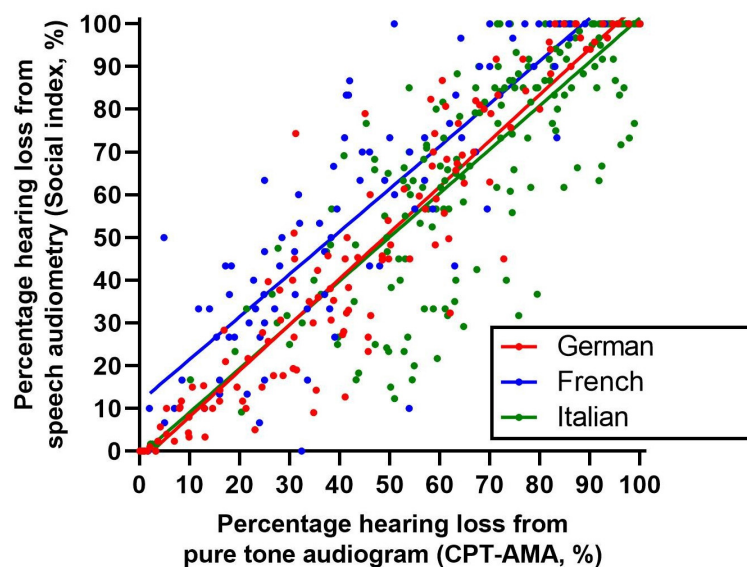| Language	Number of ears	Hearing loss according to the CPT-AMA table		
		Range	Median	Mean (standard deviation)
German	146	0.1 to 100%	46.2%	49.2% (30.4%)
French	100	1.7 to 100%	41.9%	47.6% (27.0%)
Italian	242	0.3 to 100%	77.7%	73.0% (24.2%)

Figure 2: Analysis of the current state. Dots represent data of individual ears, lines represent the linear regressions for each language separately.
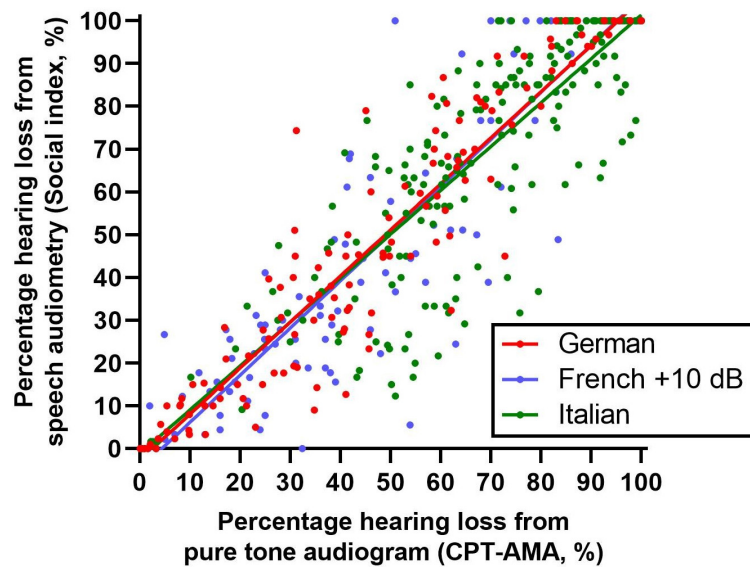
Figure 3: Comparability of the social index with optimized choice of speech levels (step size 5 dB)

Table 3: Comparability with optimized choice of speech levels using a step size of 5 dB

Language	Presentation levels shifted by	New presentation level	Mean difference between social index and German language test at 50% hearing loss according to CPT-AMA
French	+10 dB	65 dB, 80 dB, 95 dB	−0.98%
Italian	±0 dB	55 dB, 70 dB, 85 dB	−1.02%

3.3 Extrapolation to align the social index in the three languages

The extrapolation shown in Figure 1 was used to test the best possible alignment of the three speech tests. Figure 3 shows the best possible alignment of the data when level shifts in steps of 5 dB were allowed. Table 3 summarizes the resulting differences.

It turns out that the apparently more difficult French language test would have to be conducted at significantly higher presentation levels (+10 dB) than today to become comparable with the other two languages.

A step size of 5 dB was chosen, as it is frequently used in practice in speech audiometry. If a smaller step size of 1 dB is allowed, a slightly better agreement can be achieved with a correction of +9 dB (instead of +10 dB) for the French language test and −1 dB (instead of 0 dB) for the Italian test. However, the improvement is small. The mean difference between the social index and the CPT-AMA is then 0.12% for French and +0.44% for Italian.

4 Discussion and conclusions

4.1 Limitations

The study has several limitations. The data were collected at three different centers. If there are systematic differences between the centers, such as slightly different patient instructions, this could result in a systematic error. In addition, the values in the second part of the study were inter- and extrapolated rather than actually measured, which could result in deviations that might not fully reflect reality.

The three study groups differ in their size. In principle, this can lead to different degrees of statistically stability of the derived parameters. In this preliminary study, we decided to use all the data readily available at the time but is clear that further studies are needed for confirmation, also to address the issue of the higher average hearing loss of the Italian speaking group.

We are using the CPT-AMA-table [2] to calculate percentage hearing loss from the pure tone audiogram thresholds. While this makes sense in the current context (this method is used throughout Switzerland and in many other countries), there are different methods of calculations, such as the four-frequency table by Röser [4], which is widely used in Germany.

Figure 4 shows a comparison of the percentage hearing loss values for the German speaking group, where this methodical choice may be most relevant. It can be seen, that the two methods lead to similar, but not to identical estimates of the percentage hearing loss from the same data. Generally, the percentage hearing loss is higher when calculated according to the methods of Röser (mean difference +4.1%, range −5.8% to +13.7%). Differences tend to be larger around the 20 to 40% hearing loss range.

For an ideal data set, i.e. if all 3 study groups contained subjects with exactly the same pure tone threshold, the choice of the method of calculation would not have any impact at all. Individual data points in Figure 2 and
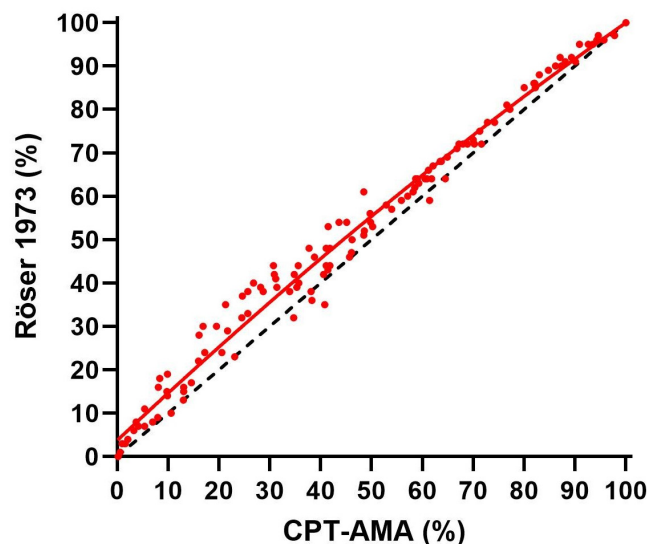
Figure 4: Comparison of percentage hearing loss values calculated according to CPT-AMA [2] and to Röser 1973 [4]. Red dots denote individual ears group, the dashed black line identity and the red line a second order polynomial (quadratic) fit to the data.

Table 4: Proposed measurement levels with improved comparability between languages

Language	Test	Calculation: 100% minus the mean value of speech intelligibility at these 3 levels
German	Monosyllabic words (Freiburger Einsilber) [8], [9]	60 dB, 75 dB, 90 dB
French	Monosyllabic words (Mots monosyllabique, Fournier test) [10]	65 dB, 80 dB, 95 dB
Italian	Two-syllable words (Bocca e Pellegrini) [11]	55 dB, 70 dB, 85 dB

Figure 3 would shift slightly to the left or to the right, but by the exact same amount for all 3 languages. In a real-world data set such as ours, differences must be expected. However, we would not expect a systematic bias between languages, if the same method of calculation is used for all data points.

4.2 A tentative explanation for the higher levels in French

It was not a primary aim of this study to investigate why differences between the test in the different languages occur. There is a number of possible reasons, such as e.g. the selection of words for a given test or how fast or how clearly they are spoken. However, we find hints in the literature and in our study, which suggest another intriguing reason, why higher levels should be used specifically in the French test.

We hypothesize that French as a language might be slightly more difficult to understand even for native speakers than e.g. German for German native speakers. We can find this tendency also in other test for speech understanding, such as the French matrix test, with a speech reception threshold of (-6.0 ± 0.6) dB [5], whereas a similar test in German requires by lower speech reception threshold of (-7.1 ± 1.1) dB [6]. Please note however, that this explanation is currently very much hypothetical.

4.3 Conclusions and recommendations

Based on the above analysis, the following levels listed in Table 4 should be used for better comparability.

The levels for the German and Italian language tests would remain unchanged, while those for the French language test would be increased by 10 dB, as our study suggests that the French language test has a higher level of difficulty than previously assumed.

We would like to point out that this is not the only possible approach. Alternatively, for example, the minimum percentage hearing loss threshold above which individuals become eligible for insurance benefits could be defined differently depending on the language of the test used.

An increase of 10 dB is a significant step and would have insurance implications. French-speaking patients would be more likely to be denied reimbursement for hearing aids than today. On the other hand, comparability with patients of other languages would be improved, and patients from all three language groups would be treated more similarly than today.

In case of introduction of new levels, the authors recommend re-examining the comparability between languages with actual measurements using the new presentation levels, rather than interpolations.

Notes

Conference presentation

This contribution was presented at the 27th Annual Conference of the German Society of Audiology and published as an abstract [7].

Competing interests

The authors declare that they have no competing interests.

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