

AUDIOMETRIC WEBER AND RINNE TESTS AS COMPARED TO PURE-TONE THRESHOLDS

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SUMMARY

Results of the audiometric Weber and Rinne tests were compared to pure tone thresholds in 185 Bantu patients. The frequency of 1000 Hz was selected as being most suitable for Weber and Rinne testing. The Weber was found to be of limited diagnostic value even with unilateral conductive losses whilst the Rinne displays a fair degree of efficiency and is of value as a routine supplement to audiometric threshold tests.

OPSOMMING

Resultate van die oudiometriese Weber en Rinne toetse is met suiwer toon drempels vergelyk. 185-Bantoe pasiënte is as proefpersone gebruik. Die frekwensie van 1000hz is as die geskikste vir die Weber en Rinne toetse gereken. Die Weber is, selfs met eensydige geleidings verlies, van beperkte diagnostiese waarde gevind, terwyl die Rinne 'n redelike graad van doeltreffendheid getoon het en aanvullend by die oudiometriese drempel toetse gebruik kan word.

At the hearing clinic at Baragwanath Hospital, Johannesburg, routine audiometric Weber and Rinne tests were fairly frequently found to be inconsistent with pure tone thresholds. In the present study, a large number of pure tone audiograms were compared with audiometric Rinne and Weber results.

In recent years, very little has appeared in the literature concerning the Weber and Rinne tests. That which has appeared deals almost exclusively with testing by means of tuning forks. Most authors stress the need to include the Weber and Rinne in a battery of tuning fork tests including the Schwabach and Gellé tests.^{1-3, 6, 8, 11, 12} Reliability of these tests has been questioned by these workers but they are nevertheless considered to be useful in supplementing audiometric results.

Testing by means of the audiometric bone vibrator has certain advantages over testing by means of tuning forks.^{2, 8, 13} The bone vibrator maintains its intensity output at any desired level, whereas the tuning fork fades rapidly in intensity, especially in the high frequencies.¹¹ In addition, the bone vibrator permits a standard presentation which is independent of the ear of the operator.^{5, 13}

MATERIALS AND METHODS

Hearing assessments of 185 South African Bantu of both sexes with an age range of 12 to 75 years were analysed. These were taken randomly from the

records of patients tested at the hearing clinic over an 18 month period. A Maico MA-10 audiometer calibrated to I.S.O. 1964 hearing threshold levels was used for testing. The test room was not ideally soundproofed despite the fact that it was lined with acoustic board.

Conventional pure tone air- and bone-conduction audiograms were obtained for each patient. Both the Weber and Rinne were tested at an intensity of 15 dB above the patient's threshold of audibility (vibrator placed on the midline of the forehead).⁸ This is sufficient intensity for clear audibility yet it minimises cross-hearing by being close to the patient's threshold.

Testing by the Weber and Rinne methods at several frequencies was considered laborious and unnecessary. A test frequency of 1000 Hz was investigated and finally utilised for the following reasons:

- 1) An increase in the force of vibrator application results in an improved threshold. The greatest change in intensity due to differential force occurs at 250 Hz whilst only slight changes occur at 1000 Hz.^{4,9}
- 2) Middle ear lesions influence the vibratory mechanism of the *inner* ear thereby providing an artefact of poorer bone conduction thresholds.¹ Although this phenomenon is not yet fully explained, it appears to occur most frequently in the lower frequencies where the conductive loss is generally at a maximum.⁷
- 3) With lower frequencies the Rinne is more likely to be negative in *normal* ears whereas the reverse is true with higher frequencies.¹¹ The centrally situated 1000 Hz is hypothetically more reliable.
- 4) With frequencies below 1000 Hz there is a possibility of confusion between the tactile sensation and hearing. This is enhanced with presentation at higher intensities.
- 5) A frequency of 1000 Hz is situated at the centre of the critical frequency range, and is likely to reflect most successfully both conductive and sensori-neural losses.
- 6) Tones below 1000 Hz appear to be most affected by ambient noise. This assumes importance when the test environment is not completely soundproof.

In Rinne testing a conductive loss of 15 dB reverses the response at ± 500 Hz (i.e. B-C better than A-C), whilst a 20 dB loss is required to reverse the response at 1000 Hz.¹⁰ The test is thus slightly less sensitive at 1000 Hz. However, as the levels of 0dB to 20 dB are considered to constitute the normal hearing range, the required sensitivity is present.

The audiograms were classified by two audiologists into 11 broad categories of bilateral hearing characteristics. (Refer to categories listed in Tables I and II). Conventional interpretation criteria were applied. Those classified differently were discarded.

Two assessments were made regarding the Weber and Rinne results in relation to each audiogram:

- 1) Correct/error according to the characteristic of air- and bone-conduction thresholds at 1000 Hz only.

2) Correct/error as to whether the results reflected the *total* loss characteristics of the given ear/s as indicated by thresholds over the range of 250-8 000 Hz.

Criteria for assessment of the Weber test were based on research by Groen.^{1, 3, 7} Lateralisation appears to involve the recognition of interaural phase and time as well as intensity differences. Lateralisation occurs in *normal* ears owing to:

- a) One stronger vibrating cochlea, as a result of better sound conduction to that cochlea.
- b) A phase difference between the two sound waves entering the cochleae, the bone-conducted tone being lateralised in the cochlea with the leading phase.

In normal ears (owing to slight anatomical differences) phase advances may overcome relative amplitude deficiencies of up to 6 dB. Owing to this phenomenon, a 5 dB amplitude difference between bilateral ear thresholds was accepted in the obtaining of a midline response. Lateralisation was expected at differences of 10 dB or above.

Criteria for assessment of the Rinne test were based on the findings of Sheehy.¹⁰ At 1 000 Hz an air-bone gap of less than 20 dB is accompanied by a Rinne positive response. A Rinne negative response occurs with a gap of 20 dB or more. Theoretically, there is a point around 20 dB where both A-C and B-C appear equally loud. This "indifferent" Rinne was accepted as correct with an air-bone gap of 20 dB only.

RESULTS AND DISCUSSION

Tables I and II summarise the results in the present study. These were analysed statistically using the Cochran's Q test, binomial test and Poisson test. The results at 1 000 Hz only were compared with the *total* results for each audiogram in order to determine whether the result at 1 000 Hz only was able to reflect the total loss characteristics of the ear/s. For both the Weber and Rinne tests there was no significant difference between the *total* results and the results at 1 000 Hz only ($p < 0,05$). Testing at 1 000 Hz is therefore suitable as a test frequency although, clearly, it cannot indicate precipitous high or low frequency loss.

The Weber test is generally far less efficient than the Rinne test. This is demonstrated by the finding that in the Weber test, three loss combinations demonstrated highly significant response errors ($p < 0,005$). These were bilateral normal (A), bilateral equal sensori-neural (E) and bilateral conductive ears (C). These findings are interesting in that combinations A (56,3% error*) and E (55,5% error) have bilaterally equal cochlear reserve and the Weber response should therefore be central. That this does not occur indicates that

* All percentages apply to results at 1 000 Hz only.

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Pure Tone Threshold Results (Bilateral Hearing Combination)	Guide to Expected Results for Weber	Number of Patients	% Error of Weber Results When compared to Threshold Results at:		Degree of Significance of Error Results p
			1 000 Hz only	250-8 000 Hz * (Total Results)	
A. Bilateral Normal	Central	32	56,3	46,8	< 0,005
B. Unilateral Conductive	Lateralises to ear with conductive loss	34	23,5	20,5	< 0,01
C. Bilateral Conductive	Lateralises to ear with greater conductive loss	15	60	53,4	< 0,005
D. Unilateral Sensori-neural	Lateralises to ear with normal cochlea	23	13	13	No Significance
E. Bilateral Equal Sensori-neural	Central	18	55,5	50	< 0,005
F. Bilateral Unequal Sensori-neural	Lateralises to better cochlea	8	25	25	No Significance

*.Weber result compared to thresholds over this range to assess agreement with total loss characteristics of the ears.

TABLE I. Comparison of the agreement between the Weber and pure tone threshold results.

Pure Tone Threshold Results (Bilateral Hearing Combination)	Guide to Expected Results for Rinne	Number of Patients	% Error of Weber Results when Compared to Threshold Results at:		Degree of Significance of Error Results P
			1 000 Hz only	250 Hz - 8 000 Hz* (Total Results)	
A. Bilateral Normal	Both +ve	32	3,1	6,3	No Significance
B. One Normal One conductive	+ve -ve	34	11,8 8,8	11,8 17,7	No Significance No Significance
C. Bilateral Conductive	Both -ve	15	10	10	No Significance
D. One Normal One Sensori-neural	+ve False -ve	23	0 8,7	0 8,7	No Significance No Significance
E. Bilateral Equal Sensori-neural	Both +ve	18	11,1	11,1	< 0,05
F. Bilateral Unequal Sensori-neural	One +ve and one False -ve	8	6,3	6,3	No Significance
G. One Normal One Mixed	+ve False -ve	20	0 30	0 25	No Significance < 0,05
H. One Sensori-neural One Mixed		14	35,7 21,4	35,7 28,6	< 0,05 < 0,05
I. One Sensori-neural One Conductive	False -ve -ve	5	20 40	20 40	No Significance No Significance
J. One Conductive One Mixed	-ve False -ve	6	16,7 0	16,7 16,7	No Significance No Significance
K. Bilateral Mixed		10	10	10	< 0,05

* Rinne result compared to thresholds over this range to assess agreement with total loss characteristics of ear.

TABLE II. Comparison of the agreement between the Rinne and pure tone threshold results.

either the patient resists believing he can hear the tone centrally (in spite of being prepared for this possibility during testing) or that the test is more sensitive than desired in that a slight deficit in the conductive mechanism results in lateralisation in normal ears. No definite trend was found as to the ear selected for response; neither the ear where pathology or loss was judged present nor the better functioning ear was selected.

In the bilateral conductive combination (60% error) similar factors are present in that frequently the degree of loss is practically equal in both ears. A central Weber was expected, but seldom occurred.

Although the Weber is considered to be primarily a test for determining presence of unilateral conductive loss, results did not support this very well (23,5% error; significant at $p < 0,01$).

The Weber appears to be reliable in two combinations only i.e. bilateral unequal sensori-neural hearing loss (25% error) and unilateral sensori-neural hearing loss (13% error). However, in the former case there was only a small group of eight patients and thus these results are questionable. The trend indicates that the Weber is more efficient where cochlear reserve is not equal in both ears.

An inherent limitation of the Weber is that it is not possible to interpret responses obtained when a mixed loss is present, or when there is a combination of sensori-neural loss in one ear and conductive loss in the other. The response obtained from the patient may thus prove misleading.

On considering the results for the Rinne, all results for similar categories i.e. normal, conductive, etc, were compared to assess whether results for any given category were comparable irrespective of the hearing characteristics of the contralateral ear. On analysis, results within each category did not differ significantly (all at $p < 0,05$) thus confirming test consistency.

The Rinne is generally efficient in depicting normal hearing and conductive losses. (An arbitrary response was usually given with a conductive loss around 20 dB, thus reducing efficiency in this region). Ears with a sensori-neural loss demonstrated a significant incidence of errors ($p < 0,05$) in only two combinations i.e. with a mixed loss (35,7%) and in the bilateral equal sensori-neural group (11,1%). The latter is of borderline significance only. Sensori-neural loss is therefore depicted less efficiently but results are still of value in diagnosis. Mixed losses give the least reliable results.

The use of masking to prevent the false-negative response in unilateral severe sensori-neural loss has long been a problem. The general difficulties in establishing effective masking levels are equally relevant here. The writer suggests that the false-negative response be accepted as it stands. In the present study, masking was not used. However, on analysis of results, the false-negative appears consistently where one would expect it to occur. The history, plus Weber and Schwabach tests, can be employed to provide further information (the present study found the Weber to be reliable in this category). There is, nevertheless, no totally satisfactory solution to this problem.

The greatest limitation of the Weber and Rinne tests is that inconsistencies may occur in any patient's responses for a variety of psycho-acoustic, ana-

tomical and physical reasons. As with any test requiring a subjective response, these tests are only as efficient as the patients' preparedness and ability to judge what is presented to him. Unsophisticated patients may be more suggestible and erratic in this regard.

Although findings based on the audiometric Weber and Rinne cannot be directly compared to those obtained with tuning forks, owing to the slight differences in frequency levels and presentation, trends of test efficiency can be extracted.

Neither of these tests are sufficiently reliable to substitute for threshold tests. However, the findings of this study suggest that the Rinne is of value as a supplement to threshold testing. A result at variance with the threshold levels alerts the tester to the need for closer investigation. The Weber can be used reliably to help identify a unilateral sensori-neural loss but, clearly, its general inefficiency makes it of little diagnostic value.

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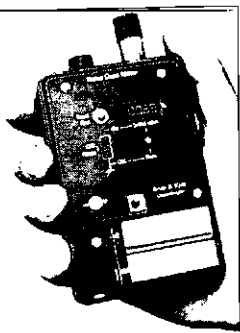
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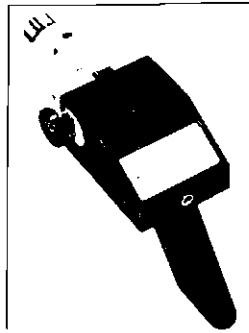
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