THE AURAL-HARMONIC TEST

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The aural-harmonic (aural-overload) test was designed to obtain the lowest sensation level at which the subject begins to detect the presence of harmonics of a fundamental driving frequency. Animal and human experimentation has demonstrated that (1) aural harmonics are generated within the cochlea at intensity levels at which the cochlear structures are overloaded, and (2) the sensation level of aural amplitude distortion is significantly reduced in patients with cochlear pathology. Table I indicates the mean sensation levels found by two groups of investigators in normal and pathological ears, and also demonstrates the clinical application of this technique in audiologic evaluation.

In order for the subject to detect the presence of the first overtone (second harmonic) of the stimulating frequency, this technique employs the classic exploring-tone method in which the beginning of nonlinear distortion is revealed by a "beating" sensation when the frequencies of the second harmonic and the exploring tone are close together. Figure 1 schematically illustrates the equipment arrangement. In order to provide a fundamental and an exploring tone for the aural harmonic, two oscillators with low harmonic distortion, each followed by an output voltmeter and attenuator, are fed to a matched mixing and attenuator circuit, which in turn connects through a switching arrangement to two sets of high-fidelity binaural earphones with ear cushions. With this arrangement the experimenter can test either ear of

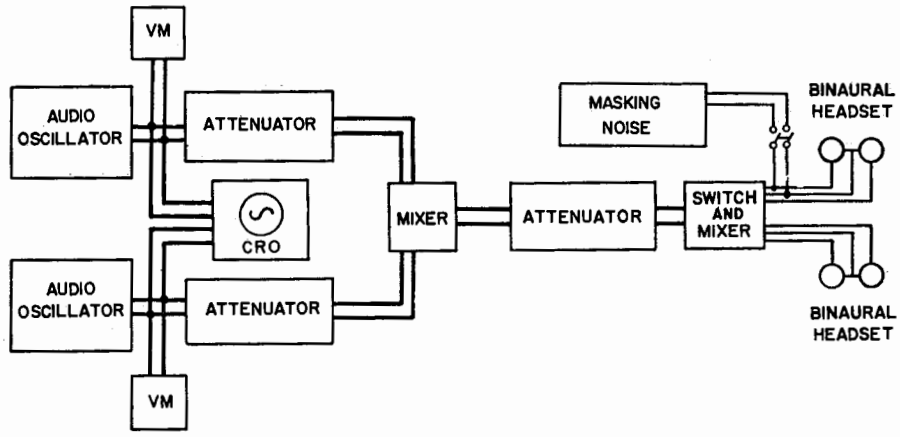

Fig. 1. Arrangement of apparatus for measuring the threshold of aural overload.

TABLE 1

Mean Aural-Harmonic Thresholds Reported by Two Groups of Investigators

Category	Opheim & Flottorp[4]		Lawrence & Yantis[3]	
	250 cps	500 cps	1000 cps	2000 cps
Normal Ears	N-20 M-31 db	N-20 M-42 db	N-145 M-52 db	N-133 M-57 db
Otosclerosis	N-34 M-34 db	N-34 M-42 db		
Conductive			N-5 M-51 db	N-6 M-55 db
Meniere's	N-28 M-8 db	N-28 M-10 db		
Cochlear			N-17 M-12 db*	N-23 M-18 db

* As corrected by Yantis and Magielski. [9]

the subject and listen at the same time. A separate switch provides for the presentation of either oscillator alone or of both together through the mixer. Means for switching in a white noise masker should also be provided, of course. To assure that aural harmonics only are being measured, it is important that the second harmonic from the oscillator must be at least 60 db below the level of the fundamental tone.

The output of each oscillator is also fed into the horizontal and vertical channels, respectively, of a cathode ray oscilloscope, which is used for setting the frequency of the exploring tone oscillator near that of the harmonic so that beats will be produced. This is done by adjusting the frequency of the exploring tone until the Lissajous figure, which is in a two-to-one pattern, is motionless. Then by means of the cycle increment dial on the oscillator the frequency is altered by 4 cps, which seems to give the best beats.

After thresholds for these two frequencies (the fundamental and exploring tone) are taken, the fundamental frequency is set so that when presented it will be at a sensation level of 70 db for that frequency. The exploring tone is made to differ from the second harmonic of the fundamental by 4 cps and then adjusted so as to be 60 db above the subject's threshold for that tone. The tones are then switched to the subject's ear under test, and in most cases he will hear beats, with only a slight adjustment of the exploring tone level being necessary for him to hear best beats. If beats are not heard the level of both tones is raised until beats are readily perceptible. By means of the common attenuator following the mixer both tones are then reduced together until the subject claims the beats are no longer heard. A slight

reduction in the exploring tone generally makes the beats return, and the level of both is again reduced with the common attenuator. This procedure is followed until the beats have disappeared completely. At this point the intensity level of the fundamental is recorded and considered to be the threshold of aural overload (aural-harmonic threshold).

Although this equipment is not commercially available in one instrument, it can usually be readily assembled from individual components in most laboratories. The major caution is to be sure that the oscillators are relatively free of amplitude distortion.

In addition to the implications of this technique to the differential diagnosis of end-organ pathology, it also appears to have value as a means of measuring the physiologic limits beyond which the auditory system cannot be driven by hearing-aid amplification without the introduction of aural amplitude distortion.

LE TEST HARMONIQUE DE L'OREILLE

Le test harmonique de l'oreille (surcharge de l'ouïe) avait pour but d'obtenir le niveau de sensation le plus bas, pour lequel le sujet examiné commence à déceler la présence d'harmoniques d'une fréquence fondamentale.

L'expérimentation sur les êtres humains et sur les animaux a démontré (1) que les harmoniques de l'oreille se forment à l'intérieur du limaçon à des niveaux d'intensité pour lesquels les structures du limaçon sont surchargées, et (2) que le niveau de sensation de la distorsion d'amplitude dans l'oreille se trouve réduit d'une manière appréciable chez les malades atteints d'une affection du limaçon.

Le tableau (I) indique les niveaux de sensation moyens, que deux groupes d'investigateurs ont trouvés dans des oreilles normales et "pathologiques", et démontre aussi l'application clinique de cette technique dans l'examen audiologique.

La figure 1 illustre schématiquement le dispositif de l'outillage, y compris les oscillateurs pour le son fondamental et pour le son d'exploration: chacun d'eux est suivi d'un "amortisseur" et de "mixing circuits", et est dirigé vers des téléphones destinés au sujet et à l'examinateur.

On utilise un oscilloscope pour régler la fréquence de l'oscillateur du son explorant près de celle de l'harmonique, de sorte qu'il se produira des battements.

La portée linéaire de l'audition est la différence en db entre le seuil pour le son fondamental et le niveau de sensation pour lequel on détecte en premier lieu des battements au moyen du test harmonique de l'oreille.

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Reference:

1. SOKOLOWSKI, S. — Recruitment phenomenon by means af aural harmonics. **Bull. Int. Acad. Cracovie,** Cl. Med., 1951, 21-30.

2. LAWRENCE, M. and BLANCHARD, C. W. — Prediction of susceptibility to acoustic trauma by determination of threshold of distortion. **Indust. Med. and Surg.,** 23, 1954, 193-200.

3. LAWRENCE, M. and YANTIS, P. A. — Threshold of overload in normal and pathological ears. **Arch. Otolaryngol.,** 63, 1956, 67-77.

4. OPHEIM, O. and FLOTTORP, G. — The aural harmonics in normal and pathological hearing. A new method of demonstration of the recruitment phenomenon. **Acta Otolaryngol.,** 45, 1955, 513-531.

5. YANTIS, P. A. — Audiologic examination of the inner ear: The aural-overload test. **J. speech hearing Disorders,** 21, 1956, 303-312.

6. FLOTTORP, G., MORLEY, D. E. and SKATVEDT, M. — The localization of hearing impairment in athetoids. **Acta Otolaryngol.,** 48, 1957, 404-414.

7. OPHEIM, O. and FLOTTORP, G. — Meniere's disease. Some audiological and clinical observations. **Acta Otolaryngol.,** 47, 1957, 202-218.

8. LAWRENCE, M. and YANTIS, P. A. — Overstimulation, fatigue, and onset of overload in the normal human ear. **J. acoust. Soc. Amer.,** 29, 1957, 265-274.

9. YANTIS, P. A. and MAGIELSKI, J. E. — Aural-harmonic and bone-conduction thresholds in the evaluation of cochlear reserve in clinical otoclerosis. **Laryngoscope,** 68, 1958, 159-188.