International Tinnitus Journal 2, 83-89 (1996)

Tinnitus - Hyperacusis and the Loudness Discomfort Level Test - A Preliminary Report

Barbara Goldstein, Ph.D., Abraham Shulman, M.D.
Martha Entenmann Tinnitus Center, Health Science Center at Brooklyn, State University of New York, Brooklyn, New York, USA

Abstract: This paper is a preliminary report from the Tinnitus Center, HSCB-SUNY, of hyperacusis in a patient population who request consultation for tinnitus of the severe disabling type. Forty-two consecutive patients seen from January to August 1995 were reviewed for this preliminary report.
There is a positive correlation between tinnitus and hyperacusis as well as a positive correlation between hyperacusis and the loudness discomfort level test (LDL).
Hyperacusis is an increased sensitivity to sound that occurs with/without a hearing loss in individuals with tinnitus of the severe disabling type.
The present method of assessment for hyperacusis includes pure tone audiometry, LDL's, Feldmann Masking Curves and the Metz test for recruitment.
A classification system exists for hearing loss and a similar system is suggested for hyperacusis.

INTRODUCTION

Tinnitus patients frequently complain of "sensitivity to sound/hyperacusis". The incidence of hyperacusis in individuals with tinnitus has been reported as high as 40-45%.[1,2] Clinical experience based on 4000 patients seen for the primary complaint of subjective idiopathic tinnitus (SIT) of the severe disabling type indicates that not every patient with tinnitus has hyperacusis and not every patient with hyperacusis has tinnitus. There does not appear to be consistency between the two symptoms. This led us to explore whether or not there was any correlation or statistical verification between the two phenomena.
A review of the literature reflects the difficulty encountered clinically in attempting to diagnose and treat the subjective complaint of hyperacusis. Do different types of hyperacusis exist? There is an absence of attempting to identify types of hyperacusis and few attempts to establish its clinical significance.
Hyperacusis is an auditory symptom that has not been well defined. This paper is a preliminary report from the Tinnitus Center, HSCB-SUNY, of hyperacusis in a patient population who request consultation for tinnitus of the severe disabling type. Forty-two consecutive patients seen from January to August 1995 were reviewed for this preliminary report. This paper will address the incidence of hyperacusis in patients with SIT of the severe disabling type; examine the relationship between hyperacusis and the presence/absence of hearing loss; hyperacusis and the Feldmann Masking Curve Type and hyperacusis and recruitment. The present method of assessment and a classification system for hyperacusis will be presented.

Reprint requests: Barbara Goldstein, Ph.D., Martha Entenmann Tinnitus Research Center., Health Science Center at Brooklyn - SUNY, Box 1239, 450 Clarkson Avenue, Brooklyn, New York 11203, USA

Literature Review - Definitions/Method

There is no universally accepted definition of hyperacusis. The American Tinnitus Association defines hyperacusis as an unusual condition in which an individual's ears are unable to tolerate ordinary environmental sounds. The ears have lost most of their normal dynamic loudness range.[3]
Vernon suggests that hyperacusis is a collapsed tolerance to sound which requires special tolerance testing for quantification; it can and often occurs in hearing damaged ears although some hyperacusic patients have normal hearing.[4,5]
Preves defines hyperacusis as an unusual intolerance to

the loudness of ordinary environmental sounds that can occur in persons with normal or elevated hearing thresholds and is usually accompanied by tinnitus.[6]

Jastreboff and Hazell define hyperacusis as a manifestation of increased central gain evaluated by direct frequency measurements of loudness discomfort levels (LDLs). They regard hyperacusis as a pre-tinnitus state.[7]

Reich and Griest define hyperacusis as a painful sensitiveness to sound with no necessary relationship between the threshold of hearing and that of discomfort.[8]

Shulman considers hyperacusis as an increased sensitivity to sound perception - a subjective complaint and recruitment as an electrophysiologic correlate of a subjective perception of increased sensitivity to sound.[9]

Miller considers hyperacusis as a hypersensitivity to sound expressed subjectively that may or may not be accompanied by audiologic correlates.[10]

Brandy and Lynn consider hyperacusis as an oversensitivity to everyday environmental sounds with no measurable loss of hearing sensitivity.[11]

Test methodology for the assessment of hyperacusis varies and is not standardized. There is significant variability in the interpretation of test data recommended for its identification.

Loudness discomfort levels are most frequently used in the assessment of hyperacusis.[12] What frequencies to use for the assessment and how many repetitions per judgement are not universally agreed upon. The difference between the pure tone threshold and the LDL at the frequency being tested is the dynamic range (DR). Whether to use the LDL threshold or the dynamic range to support the presence/absence of hyperacusis is not agreed upon. More questions remain. What frequencies should be tested? What is the normal dynamic range? What is considered a reduced dynamic range? When is a reduced dynamic range interpreted as positive for hyperacusis? Is hyperacusis a unitary symptom or are there different types of hyperacusis as there are different types of tinnitus?

Kotsanis and Harjes consider uncomfortable loudness level thresholds (UCLs) under 90 dB HL at 500 - 8000 Hz and 70 dB at 250 Hz as abnormal. When thresholds are equal to or above 90 dB HL at 500 - 8000 Hz and 70 dB at 250 Hz they are considered as normal. Any frequency with a UCL below 90 dB was labeled as hyperacusis.[13]

Jastreboff considers LDLs of 100 dB as normal and states that the normal hearing ear can tolerate 100 dB of sound.[14]

Jastreboff and Hazell define "sensitivity to sound/hyperacusis" as a reduced dynamic range of less than 60 dB between threshold and LDL.[7]

Brandy considers severe hyperacusis as having a dynamic range between 25 - 40 dB.[11]

What is the relationship between hyperacusis and recruitment? Do the terms hyperacusis and recruitment refer to the same physiologic phenomena? Is hyperacusis in one patient the same as in another? Hyperacusis is a perceptual disorder with different grades or degrees. It is a subjective description by the patient of increased sensitivity to sound. Recruitment is an abnormal physiologic response to sound that can be demonstrated with electrophysiologic recording; it is a finding in patients who report increased sensitivity to sound, that supports their subjective complaint.[15] Vernon defines recruitment as an abnormally rapid growth of loudness when sound intensity is increased in damaged ears. He states that recruitment is not hyperacusis, nor will it become so.[16]

Are hyperacusis and recruitment mutually exclusive? Is sensitivity to sound always recruitment? There is no universally agreed upon answer to this question. With recruitment, only loud sounds are uncomfortable; with hyperacusis, all sounds are uncomfortable.[4] Kotsanis feels hyperacusis can occur with little or no measurable hearing loss, while recruitment is an abnormal growth in the perception of loudness and is not uncommon with hearing loss.[13] Brandy believes that an individual with hyperacusis is highly sensitive to sound but has no hearing loss; a person with recruitment is highly sensitive to sound but also has a hearing loss.[11]

METHOD

Based on past experience the following method was used:

Subjects

Forty-two consecutive cases, 29 males and 13 females, ranging in age between 20-75 years with a mean of 51.9 years with the primary complaint of subjective idiopathic tinnitus (SIT) of the severe disabling type were included in this study. To the limits of neurotologic physical examination no positive findings were reported for any of the subjects.

Procedure

All subjects completed a tinnitus questionnaire and a medical/audiologic history interview. In the questionnaire, the patient was asked whether they find loud sounds to be unpleasant both prior to or following the onset of tinnitus. In the history interview, the patient is asked several questions related to sensitivity to sound i.e., hyperacusis. The answers are considered a self-report, that is a subjective report of the presence/absence of hypersensitivity to sound.

Pure tone audiograms were obtained at the discrete frequencies of 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz for the right and left ears for each individual. Tympanometry and acoustic reflex thresholds were obtained for those individuals who could tolerate the procedures. Acoustic reflexes were obtained at 500, 1000, 2000, and 4000 Hz when possible. If the acoustic reflex level is less than 60 dB above threshold of hearing at a given frequency recruitment is considered positive. This is called the Metz test.[17]

The pitch of the tinnitus was matched to frequency using a two alternative forced choice procedure.[18] The ear with the tinnitus is used as the reference for the match. When the patient reported binaural tinnitus, pitch was matched for each ear individually.

Feldmann masking curves were established using narrow band noises and white noise. For the purposes of this study only ipsilateral masking curves were obtained. The curves are plotted and classified according to Feldmann's procedure.[19] Minimal masking levels were obtained at each of the discrete frequencies tested on the classic audiogram: 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz; at the frequency of the pitch match; and with white noise. Masking curves were classified by Type: Type I - convergence; Type II - divergence; type III - congruence; Type IV - distance; Type IV A; and Type V - persistence.

Loudness discomfort levels (LDLs) were obtained for each ear individually at the discrete frequencies tested on the audiogram; 250, 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz and at the frequency of the tinnitus pitch match. The patient was instructed to indicate when the sound delivered through the earphone from the audiometer became uncomfortable to the ear - not just loud, but uncomfortable. Loudness discomfort level judgements were made based on an ascending presentation method. Three trials were used for each loudness measure to ensure reliability.

The difference between the pure tone threshold and the loudness discomfort level is considered the dynamic range (DR). The dynamic range for each of the discrete frequencies tests was calculated.

Interpretation of Data

For this study LDLs of 95 dB or greater at all frequencies are considered negative for hyperacusis.

LDLs considered as positive for hyperacusis were defined in two different ways: 90 dB or less at any frequency; or 90 dB or under at two or more frequencies.

Dynamic range was considered satisfactory or negative for hyperacusis if it was 60 dB or greater at all frequencies. If the DR was 55 dB or less at any frequency, hyperacusis was considered positive.

Proposed Method of Assessment and Classification of Hyperacusis

Based on the results of this preliminary study, a methodology for hyperacusis assessment is proposed.

1. Pure tone audiometry, Feldmann masking curves and the Metz test should be performed.
2. LDLs should be established at 250 - 8000 Hz, and at the pitch match of the tinnitus. Three trials should be used to reach LDL determination.
3. The dynamic range should be calculated for each frequency.

Interpretation of test results suggested:

1. Hyperacusis should be considered positive if the LDL is 90 dB or less at two or more frequencies or if the dynamic range is 55 dB or less at any frequency.
2. Hyperacusis should be considered negative when LDLs are 95 dB or greater at all frequencies and if the dynamic range is 60 dB or greater at all frequencies.

A classification system exists for hearing loss [20] and a similar one for hyperacusis is suggested in Table 1.

Table 1. Classification of Hyperacusis

Hyperacusis	Dynamic Range	Loudness Discomfort Level
None/Negative	60 dB or greater all frequencies	95 dB or greater all frequencies
Mild	50-55 dB at any frequency	80-90 dB at 2 or more frequencies
Moderate	40-45 dB at any frequency	65-75 dB at 2 or more frequencies
Severe	35 dB or less at any frequency	60 dB or lower at 2 or more frequencies

RESULTS

Thirty (71%) of the 42 patients gave a self-report of hyperacusis while 12 (29%) denied any such complaint. Pure tone thresholds indicated hearing to be within the limits of normal in 6/42 (14%) of the individuals. Criteria for normal hearing were strict and for the purposes of this study normal hearing was considered to be thresholds of 25 dB or better at all frequencies.

Tinnitus was unilateral in 22/42 (52%) of the subjects and bilateral in the remaining 20 (48%). The frequency of the tinnitus pitch match is shown in Table 2. Over 50% of the subjects had tinnitus in the 6000-8000 Hz frequency range. Eighty-four percent of the subjects had tinnitus ranging from 3000 - 18,000 Hz.

Table 2. Frequency of Tinnitus Pitch Match

Frequency	Number of Subjects (N=42)
100 - 250 Hz	4 (10%)
2 kHz	1 (4%)
3-4 kHz	6 (14%)
6-8 kHz	22 (52%)
9-12 kHz	5 (12%)
15-18 kHz	4 (10%)

Acoustic reflex thresholds could be obtained for 37/42 (88%) of the subjects. The Metz test indicated a difference between acoustic reflex threshold and pure tone threshold of 60 dB or less, positive for end organ lesion/recruitment in 29 (78%) of the individuals.[20] The Metz test was negative for the other 8 (22%). Of the 29 with recruitment, 20 had a self report of hyperacusis; 9 did not. Feldmann masking curves for the 42 subjects were classified as Type I, convergence for 22 (52%); Type III, congruence for 3 (7%); and Type IV, distance 12 (34%); incomplete 3 (7%). Loudness discomfort levels were recorded for each of the discrete frequencies. 5/42 (12%) had levels of 95 dB or greater at all frequencies; 37/42 (88%) had LDLs of 90 dB or less at any frequency; 35/42 (83%) had LDLs of 90 dB or less at 2 or more frequencies (Table 3).

Table 3. Loudness Discomfort Levels (N=42)

	N	%
95dB or greater all frequencies	5	12%
90dB or less at any frequency	37	88%
90dB or less: 2 or more frequencies	35	83%

A dynamic range of 60 dB or greater at all frequencies was found in 7/42 (17%). A dynamic range of 55 dB or less at any frequency was found in 35/42 (83%) (Table 4).

Table 4. Dynamic Range (N=42)

	N	%
60dB or greater all frequencies	7	17%
55dB or less at any frequency	35	83%

If we examine the dynamic range at the frequency of the tinnitus pitch match, 25/31 (81%) had a range of less than 60 dB while 6/31 (19%) had a range of 60 dB or greater. There was a positive self-report of hyperacusis in 26/36 individuals with hearing loss and tinnitus. In 25/26 subjects both the LDLs and DR substantiated the self-report of hyperacusis. In the remaining subject, the LDL was negative but the DR was positive. There was a negative self-report of hyperacusis in 10/36 individuals with hearing loss and tinnitus. In 4/10 both the LDLs and DR supported the self-report. In 4/10 both the LDLs and DR were positive for hyperacusis (Table 5).

Table 5. Hyperacusis Self-Report: LDL and DR Results/Hearing Loss and Tinnitus (N=36)

Self Report	LCL/DR Pos	LDL/DR Neg	LDL Pos	DR Pos
Positive N=26	25	0	0	1
Negative N=10	4	4	1	1

In 2/10 either the LDL or DR was positive for hyperacusis. There was a positive self-report of hyperacusis in 4/6 individuals with normal hearing and tinnitus. In 3/4 both the LDLs and DR substantiated the self-report. In the remaining subject the LDL was positive and the DR negative. There was a negative self-report of hyperacusis in 2/6 individuals with hearing loss and tinnitus. In 2/2 both the LDLs and DR were positive for hyperacusis. In 28/30 individuals reporting hyperacusis, both the LDL and DR substantiated the self-report. In the other two cases, one of the tests was positive. Of the 12 individuals not complaining of hyperacusis, four had LDLs and DRs substantiating the absence of hyperacusis. Six/12 were positive for hyperacusis on the LDL and DR. The remaining two had a positive result on either the LDL or DR (Table 6).

Table 6. Hyperacusis Self-Report: LDL and DR Results/Normal Hearing and Tinnitus (N=6)

Self Report	LCL/DR Pos	LDL/DR Neg	LDL Pos	DR Pos
Positive N=4	3	0	1	0
Negative N=2	2	0	0	0

DISCUSSION

The incidence of hyperacusis in individuals with tinnitus has been reported as high as 40-45%.[1,2] The type and severity of the tinnitus from which this figure was derived have not been specified.

In this preliminary study of the Tinnitus Center of the HSCB-SUNY there was an incidence of 71% (N=30/42) by self-report from the patient of hyperacusis in individuals with SIT of the severe type. The difference may be due to the definition of hyperacusis; type and severity of tinnitus; and/or factors not identified or known to be significant at this time.

The LDL test indicates a higher incidence of hyperacusis than the self-report by the patient. If we use the criteria of 90 dB or less at any frequency the incidence is 86% for the right ear and 83% for the left ear. Using a one-tailed binomial test, these rates are significantly different from the rate of 71% for self report (right ear p=.009; left ear p=.0245). If we use the criteria of 90 dB or less at two or more frequencies, the incidence is 83% for the right ear and 79% for the left ear. Only the right ear shows a difference from a rate of 71% for self report (right ear p=.0245; left ear p=.1126) (Table 7).

Table 7. LDL Test and Incidence of Hyperacusis N = 42

Incidence		Significance/One-Tailed Binomial Test
Criterion:		
LDL 90dB or less at any frequency		
Right	86%	*p=.0090
Left	83%	*p=.0245
LDL 90dB or less 2 or more frequencies		
Right	83%	*p=.0245
Left	79%	p=.1126

*Significant

The reason for the left ear results is not known at this time. Additional numbers of patients are being evaluated to explore this finding and to examine its significance. The difference in incidence is significant compared to the 71% by self-report.

In addition, chi square tests indicated significant associations between self report of hyperacusis and an LDL of 90dB for at least one frequency in both ears. For the right ear, 97% (29/30) patients who self report tinnitus also showed an LDL of 90dB for at least one frequency. For patients who did not report tinnitus, 58% (7/12) showed an LDL of 90dB for at least one frequency (p=.0047). For the left ear, 93% (28/30) self report patients qualified according to the LDL of 90dB for at least one frequency criterion versus 58% of the non self-report patients (p=.0138).

For the criterion of 90dB at two or more frequencies, only the right ear showed a significant association with hyperacusis self report. For the right ear, 93% (28/30) patients qualified according to this criterion versus 58% of the non-report patients (p=.0138). For the left ear, 87% (26/30) self-report patients qualified versus 58% (p=.09). It may be that the non-self-report patients who qualify according to the 90 dB criteria are at risk of hyperacusis, despite the fact that they do not report any symptoms of it. In no case of self-report of hyperacusis (N=30), did both the LDL and DR indicate negative results. In 28/30 both tests substantiated the self-report. In the other two cases, either the LDL or DR was positive. Of the 29% (N=12/42) cases not reporting hyperacusis, six had positive results for both the LDLs and dynamic range and two had a positive result on one of the two tests. This suggests that hyperacusis may be present in individuals with tinnitus before they become symptomatic. The value of this test would be to identify such individuals and provide treatment before they become symptomatic for hyperacusis.

Jastreboff considers hyperacusis as a pre-tinnitus state.[7] However, there are many tinnitus patients who do not report hyperacusis and who exhibit a satisfactory dynamic range on test. Will these patients eventually develop an increasing sensitivity to sound i.e., hyperacusis? What are the results of long term follow-up of tinnitus of patients who were negative by self-report for hyperacusis but demonstrate positive LDL and positive DR? Will medical or audiologic intervention prevent them from becoming hyperacusic and, if so, what modalities are to be considered? Such information is required to determine the medical/audiologic significance of the LDL/DR issue. Generalizations of hyperacusis and tinnitus are not recommended at this time.

If hyperacusis is a central phenomena, then the Feldmann masking curves may reflect this by classification as Type IV or Type V. Our data demonstrates an overall incidence of 59%. Of the 59%, 52% were Type I and 7% Type III curves. Both results are considered clinically to represent peripheral problems. There was an incidence of 34%, Type IV curves, considered clinically to represent central problems. This correlation may support the concept of different types of hyperacusis and could explain why some individuals respond to treatment and others do not.

If one accepts the thought for discussion that tinnitus is a pre-condition for hyperacusis, does this not suggest that there are different types of hyperacusis reflecting a difference in clinical types of tinnitus with the same or different site(s) of lesion?

If hyperacusis is a pre-tinnitus state, then all hyperacusic patients should develop tinnitus and all tinnitus patients should have hyperacusis. Clinical experience with over 4000 tinnitus patients does not support this statement.

Our results at this time in 42 patients suggest that hyperacusis and recruitment may occur either alone and/or in combination with each other. Of the 29 subjects who had recruitment on test, 20 reported hyperacusis while 9 did not. LDLs and DR results supported the presence of hyperacusis in 19/20 and the remaining subject had a positive DR. Of the nine who did not report hyperacusis, only two were substantiated by test results while the other seven had one or both tests positive. Perhaps, individuals with recruitment who are not complaining of hyperacusis but test positive with LDLs and/or DR will become symptomatic for hyperacusis. Also to be considered is the factor of malingering.

SUMMARY

It is proposed that hyperacusis be addressed by the disciplines of audiology/otology/and hearing sciences. Larger numbers of subjects are needed 1) to establish statistical significance for the correlation of hyperacusis/tinnitus, hyperacusis/LDLs, hyperacusis/dynamic range; hyperacusis/hearing level; 2) to determine whether the LDL thresholds or the dynamic range is more sensitive for the identification of hyperacusis; and 3) for the monitoring of the condition as well as for measuring efficacy of treatment.

The question which still remains unanswered is what is the significance of positive LDL and positive DR and the subjective difference. Clinically this may reflect and support the concept of different types of hyperacusis - central/peripheral or both at this time.

As a loss of hearing does not reflect the severity of tinnitus, so the severity of hyperacusis does not reflect itself in loss of hearing, recruitment, or Feldmann Masking Curve type. This is important with respect to diagnostics and may explain why treatment results are positive with some hyperacusic patients and not with others.

CONCLUSIONS

1. There is a positive correlation between tinnitus and hyperacusis as well as a positive correlation between hyperacusis and the loudness discomfort level test.
2. Hyperacusis occurs with normal hearing as well as with hearing loss in individuals with tinnitus of the severe disabling type.
3. Hyperacusis is an increased sensitivity to sound that occurs with/without a hearing loss. At present, it is being identified by the LDL test and the dynamic range.
4. A standardized new methodology for assessment of hyperacusis is recommended to include a battery of tests: Pure tone audiometry, LDLs, Feldmann Masking Curves, and the Metz test for recruitment.
5. A classification system exists for hearing loss and a similar system for hyperacusis is suggested.

REFERENCES

1. Coles RRA: Epidemiology, Etiology and Classification of Tinnitus. Presentation Fifth International Tinnitus Seminar, Portland, Oregon, July 1995.

2. Coles RRA, Sood SK: Hyperacusis and phonophobia in tinnitus patients. *Br. J. Audiol.* 22:228, 1988.

3. American Tinnitus Association: Hyperacusis: a life altering supersensitivity to sound (brochure).

4. Vernon J: Hyperacusis Network Newsletter. June 1992. ATA, Hyperacusis. Hyperacusis Network Newsletter, March 1993.

5. Vernon J. Questions and Answers. *Tinnitus Today*, Vol. 20, 3:21, 1995.

6. Preves D, et al: Experimental hearing device for hyperacusis. *Hearing Instruments*, 34-40, 1995.

7. Jastreboff PJ, Hazell JWP: A neurophysiological approach to tinnitus: clinical implications. *Br. J. Audiol* 27:7-17, 1993.

8. Reich GE, Griest SE: A survey of hyperacusis patients. In: Tinnitus 91, Proceedings of the Fourth International Tinnitus Seminar. Edited by JM Aran and R. Dauman, Amsterdam, Kugler Publications, 249-253, 1992.

9. Shulman A. Medical evaluation. In: Tinnitus Diagnosis/Treatment. Edited by A. Shulman, et al. Malvern, PA, Lea and Febiger, 253-291, 1991.

10. Miller, M: Personal Communication, March 1996.

11. Brandy W, Lynn J: Audiologic findings in hyperacusis and non-hyperacusis subjects. *Amer. J. of Audiol* 4:46-91, 1995.

12. Hazell JWP, Sheldrake JB: Hyperacusis and Tinnitus. In: Tinnitus 91, Proceedings of the Fourth International Tinnitus Seminar, Edited by JM Aran and R. Dauman. Amsterdam, Kugler Publications, 245-248, 1992.

13. Kotsanis C, Harjes C: Pilot study - effects of auditory enhancement training on speech, language, hyperacusis and behavior. In Press, Grapevine, TX, 1995.

14. Jastreboff PJ: Presentation Fifth International Tinnitus Seminar, Portland, Oregon, July 1995.

15. Tonndorf J: Personal Communication, 1985.

16. Vernon J: Recruitment/when noise spells pain. The Voice, 12, 37, June/July 1991.

17. Jepsen O: Middle ear muscle reflexes in man. In: Modern Developments in Audiology. Edited by J. Jerger, New York, Academic Press, 226-234, 1963.

18. Goldstein B, Shulman A: Tinnitus Evaluation. In: Tinnitus Diagnosis/Treatment. Edited by A. Shulman et al. Malvern, Pa., Lea and Febiger, 293-318, 1991.

19. Feldmann H: Homolateral and contralateral masking of tinnitus by noise bands and by pure tones. *Audiology*, 10:128-144, 1971.

20. Green DS: Pure tone air conduction testing. In: Handbook of Clinical Audiology, Edited by J. Katz, Baltimore, Williams and Wilkins, 98-109, 1978.

ACKNOWLEDGMENTS

Appreciation is extended to the Martha Entenmann Tinnitus Research Foundation and the Lionel Hampton Ear Research Foundation for its support of this effort.
Presentation/Invitation Neurootologic and Equilibriometric Society (NES), Bad Kissingen, Germany, on March 23, 1996.