University of New Mexico
UNM Digital Repository

Speech and Hearing Sciences ETDs | Electronic Theses and Dissertations

7-27-1976

Bekesy Audiometry in the Detection of Nonorganic Hearing Loss

Paula Elizabeth Rotondi

Follow this and additional works at: https://digitalrepository.unm.edu/shs_etds

Part of the Speech and Hearing Science Commons

THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87106

Policy on Use of Theses and Dissertations

Unpublished theses and dissertations accepted for master's and doctor's degrees and deposited in the University of New Mexico Library are open to the public for inspection and reference work. *They are to be used only with due regard to the rights of the authors.* The work of other authors should always be given full credit. Avoid quoting in amounts, over and beyond scholarly needs, such as might impair or destroy the property rights and financial benefits of another author.

To afford reasonable safeguards to authors, and consistent with the above principles, anyone quoting from theses and dissertations must observe the following conditions:

1. Direct quotations during the first two years after completion may be made only with the written permission of the author.
2. After a lapse of two years, theses and dissertations may be quoted without specific prior permission in works of original scholarship provided appropriate credit is given in the case of each quotation.
3. Quotations that are complete units in themselves (e.g., complete chapters or sections) in whatever form they may be reproduced and quotations of whatever length presented as primary material for their own sake (as in anthologies or books of readings) ALWAYS require consent of the authors.
4. The quoting author is responsible for determining "fair use" of material he uses.

This thesis/dissertation by Paula Elizabeth Rotondi has been used by the following persons whose signatures attest their acceptance of the above conditions. (A library which borrows this thesis/dissertation for use by its patrons is expected to secure the signature of each user.)

NAME AND ADDRESS	DATE

3/1/73—1M

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of The University of New Mexico in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

BEKESY AUDIOMETRY IN THE DETECTION OF NONORGANIC HEARING LOSS

Title

PAULA ELIZABETH ROTONDI

Candidate

DEPARTMENT OF COMMUNICATIVE DISORDERS

Department

Bernard Spolsky

Dean

July 27, 1976

Date

Committee

Max E. McClellan

Chairman

Richard B. Hood

Wayne E. Swisher

Michael A. Quinn

BEKESY AUDIOMETRY IN THE
DETECTION OF NONORGANIC HEARING LOSS

BY
Paula Elizabeth Rotondi
B.S., University of Massachusetts, 1972

THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science
in the Graduate School of
The University of New Mexico
Albuquerque, New Mexico
July, 1976

LD
3781
N563R755
cop 2

BEKESY AUDIOMETRY IN THE
DETECTION OF NONORGANIC HEARING LOSS

BY
Paula Elizabeth Rotondi

ABSTRACT OF THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science
in the Graduate School of
The University of New Mexico
Albuquerque, New Mexico
July, 1976

BEKESY AUDIOMETRY IN THE
DETECTION OF NONORGANIC HEARING LOSS

Paula Elizabeth Rotondi
Department of Communicative Disorders
The University of New Mexico, 1976

Numerous investigators have utilized Bekesy audiometry in the detection of nonorganic hearing loss. The efficiency with which Bekesy audiometry detects nonorganicity has varied according to the method of Bekesy test administration and the definition of the Type V nonorganic pattern. Rintelmann and Harford's Type V definition and the LOT- (Lengthened Off-Time) Bekesy test have emerged as valuable nonorganicity detectors. However, more recent research (Citron & Reddell, 1976; Sedge, 1974) has found these methods to be considerably less worthwhile than originally reported.

The first purpose of this study was to devise an efficient means for utilizing Bekesy audiometry in the detection of nonorganicity. Atypical Type V criteria as evidence of nonorganicity were proposed and investigated. Additionally, the atypical Type V definition was compared with LOT-Bekesy audiometry and Rintelmann and Harford's typical Type V definition for frequency of nonorganicity detection and frequency of false-positive findings.

The study was carried out in three parts. In Part I, Bekesy audiograms traced by "known" nonorganics were retrospectively analyzed to discover the percentage which could be classified as atypical and/or typical Type V. Part II compared the atypical Type V definition, Rintelmann and Harford's typical Type V criteria, and

LOT-Bekesy audiometry for frequency of nonorganicity detection among "known" nonorganic subjects. Part III compared the atypical Type V criteria, Rintelmann and Harford's typical Type V criteria, and LOT-Bekesy audiometry for frequency of false-positive findings among subjects with no evidence of nonorganicity on any other audiometric tests.

The results of the study indicated that the atypical Type V definition is an highly efficient detector of nonorganicity which is significantly superior to both Rintelmann and Harford's typical Type V definition and LOT-Bekesy audiometry in frequency of nonorganicity detection. No significant difference was found among the three methods in frequency of false-positive findings. The results also indicated that the reliability and validity of both Rintelmann and Harford's typical Type V definition and the LOT-Bekesy test are suspect.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Controversy exists over the efficiency of Bekesy audiometry in the detection of nonorganic hearing loss (see Appendix A for definition). Both the method of Bekesy test administration and definition of the Bekesy Type V nonorganic pattern can alter the diagnostic value of Bekesy audiometry in detecting nonorganicity.

Rintelmann and Harford (1967) proposed a definition of the Type V Bekesy tracing which identified 75 percent of nonorganic patients and which misclassified only 5 percent of normal and hypoacusic patients. Hattler (1970) showed that with the use of LOT- (Lengthened Off-Time) Bekesy audiometry, the Bekesy's nonorganicity detection rate could be increased to 95 percent. However, more recent research (Citron & Reddell, 1976; Sedge, 1974) has shown that Bekesy audiometry analyzed with Rintelmann and Harford's criteria and LOT-Bekesy audiometry are considerably less efficient than originally proposed.

The first purpose of the present study was to devise a more efficient way of distinguishing, by Bekesy audiometry, between organic and nonorganic hearing loss. A systematic method of administering the conventional Bekesy test has been emphasized. Atypical Type V criteria for evidence of nonorganicity in the Bekesy tracing have been proposed.

The second purpose of this study was to make a comparison between Bekesy audiometry analyzed with atypical Type V criteria, Bekesy audiometry analyzed with Rintelmann and Harford's typical Type V criteria, and LOT-Bekesy audiometry as designed by Hattler for efficiency of nonorganicity detection.

The basic plan of the study was to identify nonorganic subjects on the basis of non-Bekesy measures and then to examine their performance on Bekesy audiometry analyzed with both typical and atypical Type V criteria and on LOT-Bekesy audiometry as designed by Hattler. Also, a group of subjects demonstrating no evidence of nonorganicity on non-Bekesy measures were examined by Bekesy audiometry analyzed with both typical and atypical Type V criteria and by LOT-Bekesy audiometry for the incidence of false-positive findings.

CHAPTER II

REVIEW OF THE LITERATURE

In 1947 Bekesy introduced a new audiometer in which the intensity of the tone increases continuously as long as a signal button is pressed and decreases automatically when the button is released. The subject controlling the button determines the direction of the change in intensity and is able to let the intensity of the tone fluctuate between just above and just below threshold. A graphic representation or tracing of the subject's successive threshold crossing is automatically recorded.

Bekesy noted different types of audiograms in different pathological cases. To investigate "malingering or dissimulation" he suggested that an extra 10dB of attenuation be periodically inserted into the circuit. Bekesy observed that "In malingering and dissimulation, where the real threshold is not observed, the subject is unable to follow the intensity changes and a typical curve is observed."

Burns and Hinchcliffe (1957) made a comparison of the auditory threshold as measured by individual pure tone and by Bekesy audiometry. They found that the measurement of the threshold of hearing either by Bekesy or pure tone audiometry resulted in essentially similar results, and that the reliability of both audiometric methods was satisfactory at all frequencies.

Jerger (1960) reported that the key to the interpretation of Bekesy audiograms is the relationship between tracings of periodically interrupted and continuous tonal stimuli. Previously reported research had employed only a continuous stimulus. Jerger suggested that the relationship between a subject's continuous tone tracing and interrupted tone tracing corresponds to the site of lesion within the auditory system. He distinguished four basic types of relationships labeled Type I, Type II, Type III, and Type IV, respectively.

Type I is characterized by an interweaving of continuous and interrupted tracings, and by a tracing width which is constant over frequency and averages about 10dB. Normal hearing and lesions of the middle ear are characterized by a Type I tracing.

In Type II tracings the continuous drops below the interrupted tracing at high frequencies but never to a substantial extent. The gap seldom exceeds 20dB and ordinarily does not appear at frequencies below 1000 Hz. Also, the amplitude of the continuous tracing is often quite small in the higher frequencies. Lesions of the cochlea are characterized by a Type II tracing.

The continuous tracing dropping below the interrupted tracing to a considerable degree characterizes the Type III pattern. The two tracings may separate at relatively low frequencies (100 to 500 Hz). The continuous tracing drops very rapidly and ordinarily does not stabilize. The Type III tracing is indicative of a retrocochlear lesion, i.e., eighth nerve or brain stem.

Type IV pattern is characterized by the continuous tracing falling consistently below the interrupted tracing at frequencies below 500 Hz. At higher frequencies the continuous may fall a constant distance below the interrupted. Lesions of the eighth nerve and brain stem are also characterized by a Type IV tracing.

In all of the four types described above, the interrupted tracing is at the same or a lower sound pressure level than the continuous tracing. It was not until 1961 that Jerger and Herer reported three Bekesy audiograms, out of a total of 600 gathered in a three-year period, showing a greater threshold sound pressure level for the periodically interrupted than for the continuous tone. In each of these three cases, all other available evidence was suggestive of functional hearing loss. The continuous tone tracing was as much as 20dB less than the corresponding threshold sound pressure level for the periodically interrupted tone tracing in the range from 250 to 2000 Hz. The authors identified this Type V Bekesy audiogram with the continuous tracing at a lower sound pressure level than the interrupted tracing as indicative of functional hearing loss.

Subsequent research supported the finding of Jerger and Herer that a Type V Bekesy audiogram is consistent with functional hearing loss. In 1962 Resnick and Burke presented three cases in which the threshold for the continuous tonal stimuli was better than the threshold for the periodically interrupted pure tone stimuli. Both sweep-frequency and fixed-frequency Bekesy tracings were employed.

Rintelmann and Harford (1963) reported clinical data obtained by Bekesy audiometry for ten children who showed other evidence of bilateral functional hearing loss. Nine of the ten children demonstrated Type V patterns for at least one ear. There were only two instances in which another pattern, Type I, was found. Rintelmann and Harford's findings suggested that if a subject was attempting to keep the stimuli from the Bekesy audiometer at a relatively low sensation level (10dB or lower), he traced a Type I Bekesy pattern. If the subject was attempting to keep the stimuli at a relatively high sensation level (40dB or higher), he traced a Type V Bekesy pattern.

A study presented by Peterson (1963) also substantiated the finding of Type V Bekesy patterns among children with functional hearing loss. Four cases showing other evidence of functional hearing loss revealed Bekesy patterns demonstrating better hearing for the continuous than for the periodically interrupted tone.

A modified Bekesy audiometry procedure for distinguishing between organic and nonorganic hearing loss was described by Hood, Campbell, and Hutton in 1964. The Bekesy Ascending Descending Gap Evaluation (BADGE) procedure involves a comparison of the differences between the following 1000 Hz fixed-frequency Bekesy tracings: (1) continuous tone with tracing begun well below threshold, (2) pulsed tone with tracing begun well below threshold, and (3) pulsed tone with tracing begun well above threshold. A gap, as defined by the authors, between any of the tracings was found to be about 70 percent efficient in detecting the presence of nonorganicity in the 27 nonorganic subjects.

Rintelmann and Carhart (1964) compared the configurations of continuous and interrupted tonal stimuli traced by twelve normal hearing subjects engaged in loudness tracking. The subjects were given two monaural tracking tasks: maintaining most comfortable loudness, and maintaining the recalled loudness of a 1000 Hz reference tone. They found that the tracking level for the continuous stimulus occurred at a lower sound pressure level than for the interrupted stimulus. The authors concluded that a pulsed stimulus is not as loud as a continuous one at the same sensation level. The discrepancy between the loudness of continuous and interrupted stimuli at the same sensation level accounts for the Type V Bekesy audiogram produced by a person monitoring the loudness of continuous and interrupted tones.

From 1965 to 1966, three studies appeared which questioned the interpretation and clinical utility of Type V Bekesy audiograms. Price, Sheperd, and Goldstein (1965) reported obtaining Type V Bekesy patterns in 6 percent of 256 audiograms traced by normal hearing listeners. The criterion used by the authors for a Type V tracing was, ". . . that the continuous tone threshold tracing be at least 5 dB better than the interrupted tone threshold tracing for any one minute of a two- or three-minute tracing" (p. 140). The 129 listeners had traced fixed-frequency Bekesy audiograms at one or two of the following frequencies: 500, 1000, and 3000 Hz. However, Jerger (1965) stressed that sweep-frequency tracings, not fixed-frequency tracings, should be the basis for Bekesy Type classification. Previous investigators who had substantiated the finding of Type V Bekesy patterns among subjects with nonorganic hearing loss had utilized sweep-frequency Bekesy audiometry, with the exception of Resnick and Burke (1962) who employed both sweep- and fixed-frequency methods.

Hopkinson (1965) questioned the validity of the Type V Bekesy audiogram as a predictor of functional hearing loss on the basis of its incidence in a clinical population having conductive impairment. Twenty-five (48 percent) of the fifty-two audiograms obtained for the conductively impaired ears were classified as Type V. Hopkinson's criteria for a Type V tracing were a minimum separation of 5dB between the mid-points of interrupted and continuous tracings with lower sound pressure levels for continuous tracings, and two requirements regarding frequency: (1) continuous tracing above interrupted at 250, 500 Hz or higher but not lower than 250 Hz; and (2) the average separation at two of the three frequencies, 500, 750, or 1000 Hz equal to at least 5dB. The author concluded that, ". . . the continuous above interrupted tracing has limited clinical utility as an indicator of nonorganic hearing loss, partly because the phenomenon has been inadequately specified and partly because of its high incidence among untrained listeners performing full range Bekesy audiometry" (p. 249). Hopkinson's finding of a high false-positive rate for the Type V Bekesy audiogram largely results from her definition of the Type V pattern which is based on small separations between continuous and interrupted tracings over a short frequency range (as short as one-half octave from 500 to 750 Hz).

In 1966 Locke and Richards explored the direction and extent of separation of continuous and pulsed tone Bekesy tracings in twenty-four normal-hearing adults. A Type V pattern was defined as ". . . more than half the frequencies show less intense continuous than interrupted tone tracings, with an average separation of 5dB or more" (p.394). Forty-two percent of the subjects traced a Type V pattern on the initial test and 38 percent traced a Type V pattern upon retest. Locke and Richards suggest that the Type V tracing is ". . . a fairly common occurrence in normal hearers" (p.394). However, the high incidence of Type V tracings among normal hearers which the authors report appears to stem from a lax definition of the Type V audiogram. A more selective definition would likely have reduced the high false-positive rate as evidenced by the authors' breakdown of the results. "The mean extent of the continuous/pulsed separations for all subjects was 7dB (range for individual subjects of 2-16dB) on test, and 5dB (range of 2-13dB) on retest" (p. 394).

In response to the disagreement concerning the interpretation and clinical utility of the Type V Bekesy pattern, Rintelmann and Harford (1967) proposed a definition of the Type V pattern based on an analysis of Bekesy audiograms traced by thirty-three pseudohypoacusics. Rintelmann and Harford's definition of the Type V Bekesy pattern is:

> . . . the continuous tone tracing occurs at a lower sound pressure level than the interrupted tracing by a minimum of 10dB, measured at the mid-points of the two tracings for a range of at least two octaves. The break (between continuous and interrupted tracings) typically includes the mid-frequency region. Finally, the break should be complete with no overlap in tracings (no more than two excursions) and should reach a peak or maximum separation (between continuous and interrupted tracings) of at least 15dB. (p. 738)

When the authors applied this definition of the Type V pattern to the tracings produced by the thirty-three pseudohypoacusics, Type V Bekesy patterns were found among twenty-five or 76 percent. The authors then applied their definition of the Type V classification to the Bekesy audiograms of both normal hearing subjects and hypoacusics. Type V patterns were found in 2 percent of the 50 conductive cases, in 3 percent of the 150 sensorineural cases, and in none of the normal hearing subjects. Rintelmann and Harford conclude that, ". . . when defined operationally on the basis of documented pseudohypoacusic cases, the Type V Bekesy classification has clinical utility in that it distinguishes persons with pseudohypoacusis from other types of clinical patients about 75 percent of the time" (p.741).

From 1968 to 1971, five studies investigated Bekesy audiometry as a detector of functional hearing loss. Beagley and Knight (1968) reported that in ten out of nineteen functional hearing loss subjects for whom a Bekesy audiogram was completed, the thresholds for continuous tracings were at a lower sound pressure level than those for the interrupted tones.

Istre and Burton (1969) presented eight cases and a discussion to serve as guidelines for the physician in his evaluation of automatic audiometry data for medicolegal cases. The authors reported that in functional hearing loss cases, thresholds for the continuous tones are frequently better than thresholds for the interrupted tones.

Dieroff (1970) conducted experiments with subjects simulating a hearing loss. The author reported that hearing was nearly always worse for pulsed than continuous tones.

Kacker (1971) found that 70 percent of his normal hearing listeners who were simulating a 50dB hearing loss produced a Type V Bekesy audiogram according to Jerger and Herer's criteria (continuous tone thresholds better than interrupted tone thresholds).

Ventry (1971) presented a case study of a twelve-year old girl to illustrate some of the advantages and disadvantages of Bekesy audiometry in functional hearing loss. Ventry reported the major advantage of Bekesy audiometry to be the insights which it provides into the listening strategies of a subject with functional hearing loss.

Stein (1963) has been the only investigator employing Bekesy audiometry to report on evidence of nonorganicity in the Bekesy audiogram other than the relationship of continuous to pulsed tracings. Stein reported on the frequency of occurrence of the Type V Bekesy tracing, and on the existence of other signs of functionality in Bekesy tracings. Of the 100 subjects who traced Bekesy audiograms, thirty showed signs of functional hearing loss on other audiometric tests. Of those thirty, 57 percent recorded Type V patterns according to Jerger and Herer's criteria, and 30 percent recorded patterns that were unclassifiable according to Jerger's criteria for Types I through IV. In total, 87 percent of the nonorganic subjects traced either Type V or unclassifiable Bekesy patterns. The remaining three nonorganic subjects recorded either Type II or Type IV patterns. None of the subjects with organic auditory disturbance traced a Type V pattern and only one traced an unclassifiable pattern.

From 1968 to 1970, Hattler published three experiments on the development of the LOT- (Lengthened Off-Time) Bekesy test. The first experiment (Hattler, 1968) established that the Type V tendency could be enhanced by lengthening the off-time of the Bekesy's pulsed signal. Ten normal hearing subjects were instructed to equate seven 1000 Hz test signals to 50dB SPL and 80dB SPL reference tones of the same frequency. The seven test tones consisted of one continuous and six differentially interrupted pure tones. The tracking levels were found to be inversely related to the signal's duty cycle. Duty cycle is the percentage of time that the signal is on. Hattler attributed the occurrence of the Type V Bekesy pattern to, ". . . the differential effects of memory upon the loudness of sustained and interrupted pure tones" (p.567). Decreasing the duty cycle of the interrupted signal increases the separation between interrupted and continuous loudness tracings without affecting threshold measurements.

The second experiment (Hattler, 1970) presented and evaluated the LOT-Bekesy test, a self-recording screening test for nonorganicity. The LOT-Bekesy test employs a 1000 Hz continuous tone and a 1000 Hz 20 percent duty cycle (200 msec on and 800 msec off) interrupted tone as stimuli. A comparison was made of the tracings produced by twenty organic and twenty nonorganic subjects for the LOT-Bekesy test and for the conventional fixed-frequency (1000 Hz) Bekesy test which employs a continuous tone and an interrupted tone with a 50 percent duty cycle. Using Hopkinson's definition of the Type V, all of the organics and 40 percent of the nonorganics were correctly classified by the conventional fixed-frequency Bekesy test. All of the organics and 95 percent of the nonorganics were correctly classified by the Lot-Bekesy test.

Although Hattler suggests using the fixed-frequency Bekesy test to reduce the number of false-positive findings, a more realistic picture of the conventional Bekesy's diagnostic ability might be obtained by using sweep-frequency Bekesy tracings as emphasized by Jerger (1965), and by using Rintelmann and Harford's definition of the Type V tracing. Since the LOT-Bekesy and conventional Bekesy tests are essentially two different tests, they need not be administered and analyzed by the same methods in order to make test result comparisons. When each test is administered and analyzed in the classical manner, inter-test comparisons are most meaningful.

The third experiment (Hattler and Schuchman, 1970) examined the clinical efficiency of the LOT-Bekesy test. Of the 340 hearing impaired subjects to whom the LOT-Bekesy test was given, 99.6 percent of the organically impaired subjects and 95.5 percent of the nonorganic subjects were correctly identified by the LOT-Bekesy test. In addition to the high clinical efficiency of the LOT-Bekesy test, its advantages are that it can be administered and interpreted without extensive training, and that it can be employed in all cases except when the subject refuses to respond to pure tones at maximum audiometric levels.

A disadvantage of the LOT-Bekesy test is the additional switching and timing equipment necessary for administration of the test.

In 1974 Sedge compared conventional sweep-frequency Bekesy audiometry and LOT-Bekesy audiometry for efficiency of identification of functional hearing loss. In his comparison of LOT-Bekesy and conventional Bekesy audiometry, Sedge reduced the differences between the test procedures by administering the LOT-Bekesy as a sweep-frequency test. LOT-Bekesy and conventional Bekesy sweep-frequency tracings were obtained for fifty pseudohypoacusics. Using Rintelmann and Harford's criteria, conventional Bekesy audiometry identified 58 percent of the pseudohypoacusics and sweep-frequency LOT-Bekesy audiometry identified 66 percent of the pseudohypoacusics. Using Hattler's Type V criteria, conventional sweep-frequency Bekesy audiometry identified 70 percent of the nonorganics and sweep-frequency LOT-Bekesy audiometry identified 88 percent of the nonorganics. This study may have found the LOT-Bekesy test to be less efficient in identifying functional hearing loss than originally reported by Hattler because the LOT-Bekesy test was not administered as a fixed-frequency test. As was previously noted, the LOT-Bekesy test and conventional sweep-frequency Bekesy test are essentially two different tests which need not be administered and analyzed by the same methods in order to make test result comparisons.

More recently, Citron and Reddell (1976) investigated the use of the LOT-Bekesy test for medical-legal audiological assessment. The investigators employed the LOT-Bekesy test as designed by Hattler.

Of the 14 nonorganic subjects, only 7 (50 percent) were so identified by the LOT-Bekesy test. Citron and Reddell also compared each subject's voluntary discrete frequency test threshold and LOT-Bekesy test threshold. Four additional subjects demonstrated LOT-Bekesy tracings that were 15 to 40dB better than their discrete frequency thresholds. In total, 11 (79 percent) of the subjects were classified as nonorganic on the basis of either Hattler's criteria or threshold discrepancies.

Summary

The Type V Bekesy pattern has been shown to be indicative of functional hearing loss. Method of Bekesy test administration and criteria for classification influence the incidence of the Type V pattern among nonorganic and organic subjects.

The application of Rintelmann and Harford's Type V criteria to sweep-frequency Bekesy tracings was originally shown to be an efficient indicator of nonorganicity and to have a low incidence of false-positive findings. In 1970 Hattler introduced the LOT-Bekesy test as an exceedingly efficient detector of nonorganicity.

Subsequent research by Sedge (1974) and Citron and Reddell (1976) has not confirmed either Rintelmann and Harford's Type V definition or the LOT-Bekesy test as an efficient indicator of nonorganicity. Hattler reported that the LOT-Bekesy test detected 95 percent of nonorganics; Citron and Reddell reported that the LOT-Bekesy test detected 50 percent of nonorganics. By modifying the LOT-Bekesy test, Citron and Reddell increased its efficiency to 79 percent. With Sedge's modification of employing the LOT-Bekesy test as a sweep-frequency test, 88 percent of nonorganics were detected. Rintelmann and Harford reported that the use of their Type V definition identified 76 percent of nonorganics; Sedge reported that the use of Rintelmann and Harford's definition identified 58 percent of nonorganics. Thus, these more recent studies have shown that with the use of Rintelmann and Harford's Type V definition or the LOT-Bekesy test there is approximately a 50 percent chance of detecting nonorganicity.

It is possible that the conventional sweep-frequency Bekesy audiograms of nonorganics contain evidence of nonorganicity other than the continuous tone tracing at a lower sound pressure level than the pulsed tone tracing. Stein (1963) reported on the incidence of Bekesy audiograms traced by nonorganics which were unclassifiable according to Jerger's (1960) and Jerger and Herer's (1961) definitions.

Statement of the Problem

Neither Rintelmann and Harford's Type V definition nor the LOT-Bekesy test has been confirmed by recent research (Citron & Reddell, 1976; Sedge, 1974) as an efficient indicator of nonorganicity. The studies by Sedge (1974) and Citron and Reddell (1976) indicate that with the use of Rintelmann and Harford's Type V definition or the LOT-Bekesy test there is approximately a 50 percent chance of detecting nonorganicity. It was proposed that the identification of nonorganicity by conventional sweep-frequency Bekesy audiometry could be increased by the application of "atypical" Type V criteria to Bekesy audiograms.

The first objective of this study was to define and report on the incidence of "atypical" Type V Bekesy tracings among subjects showing evidence of functional hearing loss on other audiometric tests. Increased efficiency of nonorganicity detection by the application of "atypical" Type V criteria would enhance the overall diagnostic precision of conventional Bekesy audiometry.

The "atypical" Type V tracing was defined as a sweep-frequency Bekesy audiogram which was not in agreement with conventional pure tone test results and/or Speech Reception Threshold (SRT) test results.

A Bekesy audiogram was considered not to be in agreement with the SRT if the average of the two lowest thresholds of the speech frequencies (500, 1000, 2000 Hz) for the Bekesy interrupted tone trace disagreed with the SRT by $\pm$ 9dB or more.

A Bekesy audiogram was considered not to be in agreement with the conventional pure tone threshold test results if the average of the two lowest thresholds of the speech frequencies for the Bekesy interrupted tone trace disagreed with the average of the two lowest thresholds of the speech frequencies for the conventional pure tone threshold test by $\pm$ 15dB or more.

A pilot study (Appendix B) indicated that the use of atypical Type V criteria markedly increased the efficiency of nonorganicity detection by Bekesy audiometry. The pilot study evaluated the Bekesy audiograms of twenty-five "known" nonorganic patients retrospectively. The study showed that only 12 percent of the Bekesy tracings could be classified as demonstrating nonorganicity when the typical Type V criteria were applied. The "typical" Type V pattern was defined as a sweep-frequency Bekesy audiogram meeting the criteria of Rintelmann and Harford (1967) for classification as Type V. However, when the atypical Type V criteria were used, 93 percent of the Bekesy tracings were correctly identified as nonorganic. Thus, the pilot study showed this to be a promising method worthy of more intensive study.

A second objective of this study was to compare the atypical Type V definition, the typical Type V definition, and the LOT-Bekesy test for efficiency of identification of functional hearing loss. Although both Hattler (1970) and Sedge (1974) had compared the efficiency of LOT-Bekesy audiometry to the efficiency of conventional Bekesy audiometry in identification of functional hearing loss, neither study employed the classical test administration procedure for both tests. A comparison of the clinical efficiency of these two tests can best be made if each test is optimally administered and analyzed.

A third objective of this study was to compare the atypical Type V definition, the typical Type V definition and the LOT-Bekesy test for incidence of false-positive findings among subjects not demonstrating functional hearing loss.

More specifically, the following questions were asked:
(1) What percentage of "known" nonorganic subjects produced patterns by Bekesy audiometry which could be classified retrospectively as typical Type V?

(2) What percentage of "known" nonorganic subjects produced patterns by Bekesy audiometry which could be classified retrospectively as atypical Type V?

(3) How do the atypical Type V definition, the typical Type V definition, and the LOT-Bekesy test compare in frequency of detection of functional hearing loss?

(4) How do the atypical Type V definition, the typical Type V definition, and the LOT-Bekesy test compare in frequency of false-positive findings among subjects not demonstrating functional hearing loss?

CHAPTER III

PROCEDURE

This chapter explains the methods and procedures used in this study. The chapter consists of three main sections. Each section represents a separate part of the study. Part I was a retrospective study designed to investigate the percentage of Bekesy audiograms traced by "known" nonorganics which were classifiable as typical or atypical Type V. Part II was designed to compare the atypical Type V definition, the typical Type V definition, and the LOT-Bekesy test for the frequency of identification of functional hearing loss. Part III was designed to compare the atypical Type V definition, the typical Type V definition, and the LOT-Bekesy test for the incidence of false-positive findings among subjects not demonstrating a functional hearing loss. The methods and procedures used for each of the aforementioned parts is explained separately in the appropriate section.

Part I

Subjects

The files of all functional hearing loss cases tested at the Albuquerque Veterans Administration Hospital, Speech Pathology and Audiology Clinic were screened. Two criteria were used for inclusion of subjects in Part I of the study. First, the subject must have traced a conventional sweep-frequency Bekesy audiogram. Second, for the same ear on which the Bekesy audiogram was available, the subject must have met at least one of the following criteria:

(1) A Speech Reception Threshold (SRT) - pure tone average (PTA) discrepancy of ± 9dB or more. Chaiklin and Ventry (1965) found the most efficient measure for identifying nonorganicity to be the SRT-PTA discrepancy which correctly identified 70 percent of functional subjects. They report that the more a difference exceeds ± 8dB, the more likely it is that one is dealing with a functional hearing problem.

(2) A discrepancy of ± 15dB or more (at 500, 1000 and 2000 Hz average) between conventional pure tone or SRT and Galvanic Skin Response (GSR) audiometry. Burk (1958) found that GSR thresholds are usually within ± 5dB of voluntary thresholds for non-functional listeners.

(3) A discrepancy of ± 15dB or more (at 500, 1000, and 2000 Hz average) between two conventional air conduction pure tone tests administered on the same day. Chaiklin and Ventry (1964) found that a pure tone test-retest discrepancy of ± 15dB or more correctly identified 66 percent of functional subjects.

(4) A positive pure tone or speech Stenger test (see Appendix C for description).

(5) A discrepancy of ± 9dB or more between two Speech Reception Threshold test results administered on the same day.

(6) Inappropriate lateralization (see Appendix D for description).

For the purposes of this study, a subject qualifying for Part I of the study was considered to be a "known" nonorganic.

Method

If a subject had traced a Bekesy audiogram on more than one day, each Bekesy audiogram was compared to the conventional pure tone test and Speech Reception Threshold test of the same day. If a subject had traced Bekesy audiograms for both ears, each Bekesy audiogram was compared to the results of the conventional pure tone test and Speech Reception Threshold test for the same ear.

The sweep-frequency Bekesy tracings were analyzed for: (1) the magnitude of the difference between the continuous and interrupted tracings in decibels, (2) the width of the difference as a function of the frequency range, and (3) the threshold of the interrupted trace measured at the mid-points of the trace at 500, 1000, and 2000 Hz.

To the information obtained from analyzing the sweep-frequency audiograms Rintelmann and Harford's definition of the Type V pattern was applied. An audiogram meeting Rintelmann's and Harford's definition was classified as typical Type V.

The atypical Type V criteria were also applied to all of the Bekesy audiograms. Bekesy audiograms meeting the atypical Type V criteria were classified as atypical Type V.

Data Analysis

The percentages of Bekesy audiograms classified as typical and/or atypical Type V were calculated.

Part II

Subjects

The subjects were adult male patients seen at the Albuquerque Veterans Administration Hospital, Speech Pathology and Audiology Clinic who met at least one of the following criteria:

(1) A discrepancy of ± 9dB or more between a Speech Reception Threshold Test Result and a conventional air conduction pure tone threshold test result administered on the same day. The two best pure tone thresholds of the speech frequency range (500, 1000, 2000 Hz) were compared to the Speech Reception Threshold.

(2) A discrepancy of ± 15dB or more (at 500, 1000, and 2000 Hz average) between two conventional air conduction pure tone threshold tests administered on the same day.

(3) A discrepancy of ± 9dB or more between two Speech Reception Threshold test results administered on the same day.

(4) A positive Stenger test (see Appendix B for description).

(5) Inappropriate lateralization (see Appendix C for description).

The data were based on subjects who appeared for audiological services consisting of routine audiometric examinations, hearing aid evaluations, compensation ratings, and/or special diagnostic testing.

Instrumentation and Calibration

Data were collected in two double-walled Industrial Acoustic Company sound treated hearing test suites. Two Grason-Stadler 1701 and one Grason-Stadler 1704 automatic audiometers equipped with Telephonics TDH-49 earphones in either MX-41/AR cushions or NAF cushions were used for all threshold measurements. Two Sony Model TC-366 and a Sony Model TC-850 two channel tape decks were used as speech signal inputs. The Bekesy capability of the 1701 audiometer was used for both conventional Bekesy testing and LOT-Bekesy testing. For LOT-Bekesy testing the output of the audiometer was controlled by a Grason-Stadler Model 1208 electronic switch triggered by two Grason-Stadler Model 1208 Interval Timers.

The calibration of the speech and pure tone circuits was checked with a Bruel and Kjaer Model 158 audiometer calibrator before, during, and immediately after completion of the study. The stability of the timing network for LOT-Bekesy was periodically checked by a Hewlett-Packard Model 522B electronic counter.

Method

The conventional pure tone test employed an ascending technique (Hughson and Westlake, 1944) and a signal interruption rate of 2.5 ips.

The Speech Reception Threshold test employed a live voice ascending technique (Chaiklin et al, 1967) and CID Auditory Test W-1.

All conventional sweep-frequency Bekesy audiograms were obtained with an attenuation rate of 2.5dB per second and a signal interruption rate of 2.5 ips for the pulsed tone. The duty cycle was 50 percent;

this means the tone was alternately on and off for 200 msec. The tracings swept from 125 Hz through 8000 Hz. The rate of frequency change was 1 octave per minute. The LOT-Bekesy test employed the method parameters specified by Hattler, 1971. For the LOT-Bekesy, the pulsed tone condition was set for 200 msec on-duration and 800 msec off-duration (20 percent duty cycle) with 10 msec rise-decay times. The Bekesy was set to attenuate the intensity of the signal at a rate of 2.5 dB/sec. The LOT-Bekesy test was given at 1000 Hz.

Test Procedure

Patients seen at the Albuquerque Veterans Administration Hospital for audiological services first were tested bilaterally for Speech Reception Threshold followed by conventional air conduction pure tone testing.

To insure uniformity of test administration procedures among the five audiologists at the Albuquerque Veterans Administration Hospital, all test instructions were read to each subject (see Appendix E).

Patients demonstrating a ± 9dB or more SRT-PTA (two best thresholds of the speech range) discrepancy was tested with conventional sweep-frequency Bekesy audiometry and with LOT-Bekesy audiometry. Patients not demonstrating a discrepancy of ± 9dB or more on the initial SRT-PTA measurements but who on subsequent audiometric testing met one of the criteria for inclusion in Part II of the study were then tested with conventional sweep-frequency Bekesy audiometry and with LOT-Bekesy audiometry. Both ear order and presentation order of the conventional Bekesy and LOT-Bekesy tests were randomized.

For conventional Bekesy audiometry the pulsed signal always was presented first followed by the continuous signal in the same ear. The signals were presented at 0 dB HL and allowed to ascend. The same procedure was then undertaken in the opposite ear.

LOT-Bekesy audiometry was employed as described by Hattler, 1971.

> The LOT-Bekesy test procedure followed four steps designed to provide maximum clinical ease and standardization: (1) the Lengthened Off-Time pulsed signal was presented in either ear at OdB HL and allowed to ascend at a rate of either 2.5 or 5dB/sec. The patient was allowed at least one minute for tracking. (2) The LOT signal was removed, applied to the contralateral ear and again allowed to ascend from OdB HL. (3) The LOT signal was removed and a continuous tone was applied to the same earphone at OdB HL and allowed to ascend. (4) The continuous signal was then removed and applied to the contralateral ear as in Step 3. The LOT test can be given at any frequency, however, 1000 Hz was generally employed for clinical convenience. (p. 614)

The conventional sweep-frequency Bekesy tracings were analyzed as reported in Part I. The LOT-Bekesy tracings were analyzed as described by Hattler, 1971, who specified that "the LOT test results were considered positive for nonorganicity if the pulsed tone tracing suggested at least 5.5dB poorer hearing than the continuous tone tracing" (p. 611).

Data Analysis

The statistical test applied to the data was the sign test. Table 1 denotes the arbitrarily assigned direction of the difference (positive or negative) for the two test conditions Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry.

Table 1

Sign Test Table Denoting the Direction of the Difference for Comparison of Nonorganicity Detection by Bekesy Audiometry Analyzed with Atypical Type V Criteria and LOT-Bekesy Audiometry

		Bekesy Audiometry Analyzed with Atypical Type V Criteria: Not identified	Bekesy Audiometry Analyzed with Atypical Type V Criteria: Identified
LOT-Bekesy Audiometry	Not Identified	A 0	B +
	Identified	C -	D 0

The data gathered were used to test null hypothesis Ho_1 at the .05 level of significance.

Ho_1 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry in the frequency of identification of functional hearing loss.

The null hypothesis Ho_1 tested by the sign test is that

$$P(B > C/\neq 0) = P(B < C/\neq 0) = \frac{1}{2}$$

In other words, the number of Bekesy audiograms in cell B is expected to be the same as the number of Bekesy audiograms in cell C.

Experimental hypothesis H_1 was as follows:

H_1 = The frequency of positive signs is significantly greater than ½. That is, the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with atypical Type V criteria is significantly greater than the frequency of identification of functional hearing loss by LOT-Bekesy audiometry.

Table 2 denotes the arbitrarily assigned direction of the difference (positive or negative) for the two test conditions Bekesy audiometry analyzed with atypical Type V criteria and Bekesy audiometry analyzed with typical Type V criteria.

Table 2

Sign Test Table Denoting the Direction of the Difference for Comparison of Nonorganicity Detection by Bekesy Audiometry Analyzed with Atypical Type V Criteria and with Typical Type V Criteria

		Bekesy Audiometry Analyzed with Atypical Type V Criteria: Not Identified	
		Not Identified	Identified
Bekesy Audiometry Analyzed with Typical Type V Criteria	Not Identified	A 0	B +
	Identified	C -	D 0

The data gathered were used to test null hypothesis Ho_2 at the .05 level of significance.

Ho_2 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and Bekesy audiometry analyzed with typical Type V criteria in the frequency of identification of functional hearing loss.

Null hypothesis Ho_2 tested by the sign test is that

$$P(B > C/\neq 0) = P(B < C/\neq 0) = \frac{1}{2}$$

Experimental hypothesis H_2 was as follows:

H_2 = The frequency of positive signs is significantly greater than ½. That is, the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with atypical Type V criteria is significantly greater than the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with typical Type V criteria.

Table 3 denotes the arbitrarily assigned direction of the difference (positive or negative) for the two test conditions Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry.

Table 3

Sign Test Table Denoting the Direction of the Difference for Comparison of Nonorganicity Detection by Bekesy Audiometry Analyzed with Typical Type V Criteria and LOT-Bekesy Audiometry

		Bekesy Audiometry Analyzed with Typical Type V Criteria: Not Identified	Bekesy Audiometry Analyzed with Typical Type V Criteria: Identified
LOT-Bekesy Audiometry	Not Identified	A 0	B +
	Identified	C -	D 0

The data gathered were used to test null hypothesis Ho_3 at the .05 level of significance.

Ho_3 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry in frequency of identification of functional hearing loss.

Null hypothesis Ho_3 tested by the sign test is that

$$P(B > C/\neq 0) = P(B < C/\neq 0) = \frac{1}{2}$$

Experimental hypothesis H_3 was as follows:

H_3 = The frequency of negative signs is significantly greater than ½. That is, the frequency of identification of functional hearing loss by LOT-Bekesy audiometry is significantly greater than the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with typical Type V criteria.

Part III

Subjects

The subjects were adult male patients seen at the Albuquerque Veterans Administration Hospital who gave no indication of nonorganicity on any audiometric tests. The subjects had appeared for routine audiological services.

Instrumentation and Calibration

The instrumentation and calibration were the same as for Part II of the study.

Methods

The methods were the same as for Part II of the study.

Test Procedure

Patients who gave no indication of nonorganicity on any audiometric test were administered the conventional sweep-frequency Bekesy test and the LOT-Bekesy test. Both ear order and presentation order of the two tests were randomized.

The tests were administered and analyzed as in Part II.

Data Analysis

The sign test was applied to the data to test for significant differences in frequency of false-positive findings among the three methods. The data analysis involved the same comparisons as in Part II, namely, Bekesy audiometry analyzed with atypical Type V criteria compared to LOT-Bekesy audiometry, Bekesy audiometry analyzed with atypical Type V criteria compared to Bekesy audiometry analyzed with typical Type V criteria, and Bekesy audiometry analyzed with typical Type V criteria compared to LOT-Bekesy audiometry. The sign test tables for the comparisons were set up the same as in Part II. The only difference was that Part II investigated frequency of nonorganicity detection whereas Part III investigated frequency of false-positive findings.

The null hypotheses of Part III were as follows:

Ho_4 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry in the frequency of false-positive findings.

Ho_5 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and Bekesy audiometry analyzed with typical Type V criteria ia the frequency of false-positive findings.

Ho_6 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry in the frequency of false-positive findings.

The experimental hypotheses of Part III were as follows:

H_4 = The frequency of positive signs is significantly greater than ½. That is, the frequency of false-positive findings by Bekesy audiometry analyzed with atypical Type V criteria is significantly greater than the frequency of false-positive findings by LOT-Bekesy audiometry.

H_5 = The frequency of negative signs is significantly greater than ½. That is, the frequency of false-positive findings by Bekesy audiometry analyzed with typical Type V criteria is significantly greater than the frequency of false-positive findings by Bekesy audiometry analyzed with atypical Type V criteria.

H_6 = The frequency of positive signs is significantly greater than ½. That is, the frequency of false-positive findings by Bekesy audiometry analyzed with typical Type V criteria is significantly greater than the frequency of false-positive findings by LOT-Bekesy audiometry.

CHAPTER IV

RESULTS

Part I

The following results were obtained when the typical and atypical Type V criteria were applied retrospectively to the 156 Bekesy audiograms traced by the 89 "known" nonorganic subjects of Part I. As is indicated in Table 4, 34 (21.8 percent) of the Bekesy audiograms met the typical Type V criteria; 137 (87.8 percent) of the Bekesy audiograms met the atypical Type V criteria; 16 (10.3 percent) did not meet either the typical or atypical Type V criteria. Because of overlap these percentages are not expected to total 100 percent.

Table 4

Number and Percentage Comparison of Bekesy Audiograms Traced by Nonorganics which were Classified Retrospectively as Typical and/or Atypical Type V

	Typical Type V	Atypical Type V	Typical and Atypical Type V Inclusive
Exclusive Identification	3 (1.9%)	106 (67.9%)	
Mutual Identification	31 (19.9%)	31 (19.9%)	
Total Identification	34 (21.8%)	137 (87.8%)	140 (89.7%)
Unidentified	122 (78.2%)	19 (12.2%)	16 (10.3%)

As can be derived from the results in Table 4, 103 (66 percent) more of the tracings were identified as nonorganic with the atypical Type V definition than with the typical Type V definition. The combined usage of the typical and atypical Type V definitions resulted in the highest overall nonorganicity detection, 140 (89.7 percent).

Part II

Part II of this study investigated the following null hypothesis:

Ho_1 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry in the frequency of identification of functional hearing loss.

Ho_2 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and Bekesy audiometry analyzed with typical Type V criteria in the frequency of identification of functional hearing loss.

Ho_3 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry in frequency of identification of functional hearing loss.

The hypotheses were tested for significance at the .05 level by the sign test. Appendixes F, G, and H indicate the direction of the difference and the sign for each subject for the three comparisons.

The summary of the data used for the sign test comparison of Bekesy audiometry analyzed with atypical Type V criteria to LOT-Bekesy audiometry is in Table 5.

Table 5

Sign Test Comparison of Nonorganicity Detection by Bekesy Audiometry Analyzed with Atypical Type V Criteria and LOT-Bekesy Audiometry (44 Audiograms Total)

		Bekesy Audiometry Analyzed with Atypical Type V Criteria	
		Not Identified	Identified
LOT-Bekesy Audiometry	Not Identified	A 1	B 24
	Identified	C 1	D 18

$*P < .001$

$*P < .05$

The sign test indicated that the probability of the recorded distribution was less than .001. Thus the statistical analysis indicated that there was a significantly greater incidence of non-organicity detection by Bekesy audiometry analyzed with atypical

Type V criteria than by LOT-Bekesy audiometry. Null hypothesis Ho_1 was rejected and experimental hypothesis H_1 was accepted.

H_1 = The frequency of positive signs is significantly greater than ½. That is, the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with atypical Type V criteria is significantly greater than the frequency of identification of functional hearing loss by LOT-Bekesy audiometry.

The summary of the data used for the sign test comparison of conventional Bekesy audiometry analyzed with atypical Type V criteria to conventional Bekesy audiometry analyzed with typical Type V criteria is in Table 6.

Table 6

Sign Test Comparison of Nonorganicity Detection by Bekesy Audiometry Analyzed with Atypical Type V Criteria and Typical Type V Criteria (44 Audiograms Total)

		Bekesy Audiometry Analyzed with Atypical Type V Criteria: Not Identified	Bekesy Audiometry Analyzed with Atypical Type V Criteria: Identified
Bekesy Audiometry Analyzed with Typical Type V Criteria	Not Identified	A 2	B 31
	Identified	C 0	D 11

$z = 5.39$ $*P < .00003$

$*P < .05$

The sign test indicated that the probability of the recorded distribution was less than .00003. Thus, the statistical analysis indicated that there was a significantly greater incidence of nonorganicity detection by Bekesy audiometry analyzed with atypical Type V criteria than by Bekesy audiometry analyzed with typical Type V criteria. Null hypothesis Ho_2 was rejected and experimental hypothesis H_2 was accepted.

H_2 = The frequency of positive signs is significantly greater than ½. That is, the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with atypical Type V criteria is significantly greater than the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with typical Type V criteria.

The summary of the data used for the sign test comparison of Bekesy audiometry analyzed with typical Type V criteria to LOT-Bekesy audiometry is in Table 7.

Table 7

Sign Test Comparison of Nonorganicity Detection by Bekesy Audiometry Analyzed with Typical Type V Criteria and LOT-Bekesy Audiometry (44 Audiograms Total)

		Bekesy Audiometry Analyzed with Typical Type V Criteria: Not Identified	Bekesy Audiometry Analyzed with Typical Type V Criteria: Identified
LOT-Bekesy Audiometry	Not Identified	A 21	B 4
	Identified	C 12	D 7

*P < .038

*P < .05

The sign test indicated that the probability of the recorded distribution was less than .038. Thus, the statistical analysis showed that there was a significantly greater incidence of nonorganicity detection by LOT-Bekesy audiometry than by Bekesy audiometry analyzed with typical Type V criteria. Null hypothesis Ho_3 was rejected and experimental hypothesis H_3 was accepted.

H_3 = The frequency of negative signs is significantly greater than ½. That is, the frequency of identification of functional hearing loss by LOT-Bekesy audiometry is significantly greater than the frequency of identification of functional hearing loss by Bekesy audiometry analyzed with typical Type V criteria.

Table 8 presents a comparison of the number and percentage of atypical Type V audiograms, typical Type V audiograms, and positive LOT-Bekesy audiograms which were traced by the nonorganic subjects of Part II.

Table 8

A Comparison of the Number and Percentage of Atypical Type V Audiograms, Typical Type V Audiograms, and Positive LOT-Bekesy Audiograms which were Traced by Nonorganics (44 Audiograms Total)

	Atypical Type V Audiograms	Typical Type V Audiograms	Positive LOT-Bekesy Audiograms
Number of Audiograms	42	11	19
Percentage of Audiograms	95%	25%	43%

As can be seen in Table 8, 95 percent of the Bekesy audiograms traced by the nonorganic subjects could be classified as atypical Type V whereas only 25 percent could be classified as typical Type V. Only 43 percent of the LOT-Bekesy audiograms traced by the nonorganic subjects were positive for nonorganicity.

Part III

Part III of this study investigated the following null hypotheses:

Ho_4 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry in the frequency of false-positive findings.

Ho_5 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and Bekesy audiometry analyzed with typical Type V criteria in the frequency of false-positive findings.

Ho_6 = The median of the differences is zero. That is, there is no significant difference between Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry in the frequency of false-positive findings.

The hypotheses were tested for significance at the .05 level by the sign test. Appendixes I, J, and K indicate the direction of the difference and the sign for each subject for the three comparisons.

The summary of the data used for the sign test comparison of Bekesy audiometry analyzed with atypical Type V criteria to LOT-Bekesy audiometry is in Table 9.

Table 9

Sign Test Comparison of Bekesy Audiometry Analyzed with Atypical Type V Criteria and LOT-Bekesy Audiometry for Frequency of False-Positive Findings

		Bekesy Audiometry Analyzed with Atypical Type V Criteria: True-Negative	Bekesy Audiometry Analyzed with Atypical Type V Criteria: False-Positive
LOT-Bekesy Audiometry	True-Negative	A 20	B 0
	False-Positive	C 0	D 0

$P > .05$

The sign test indicated that the probability of the recorded distribution was greater than .05. Thus the statistical analysis showed that there was no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry in frequency of false-positive findings. Null hypothesis Ho_4 was not rejected.

The summary of the data used for the sign test comparison of Bekesy audiometry analyzed with atypical Type V criteria to Bekesy audiometry analyzed with typical Type V criteria is in Table 10.

Table 10

Sign Test Comparison of Bekesy Audiometry Analyzed with Atypical Type V Criteria and Typical Type V Criteria for Frequency of False-Positive Findings

		Bekesy Audiometry Analyzed with Atypical Type V Criteria: True-Negative	Bekesy Audiometry Analyzed with Atypical Type V Criteria: False-Positive
Bekesy Audiometry Analyzed with Typical Type V Criteria	True-Negative	A 19	B 0
	False-Positive	C 1	D 0

$P > .05$

The sign test indicated that the probability of the recorded distribution was greater than .05. Thus the statistical analysis showed that there was no significant difference between Bekesy audiometry analyzed with atypical Type V criteria and Bekesy audiometry analyzed typical Type V criteria in frequency of false-positive findings. Null hypothesis Ho_5 was not rejected.

The summary of the data used for the sign test comparison of Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry is in Table 11.

Table 11

Sign Test Comparison of Bekesy Audiometry Analyzed with Typical Type V Criteria and LOT-Bekesy Audiometry for Frequency of False-Positive Findings

		Bekesy Audiometry Analyzed with Typical Type V Criteria: True-Negative	Bekesy Audiometry Analyzed with Typical Type V Criteria: False-Positive
LOT-Bekesy Audiometry	True-Negative	A 19	B 1
	False-Positive	C 0	D 0

$P > .05$

The sign test indicated that the probability of the recorded distribution was greater than .05. Thus the statistical analysis showed that there was no significant difference between Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry in frequency of false-positive findings. Null hypothesis Ho_6 was not rejected.

CHAPTER V

DISCUSSION AND IMPLICATIONS

The first purpose of this study was to define and report on the incidence of atypical Type V Bekesy audiograms among "known" nonorganic subjects. A second purpose of this study was to compare Bekesy audiometry analyzed with atypical Type V criteria, Bekesy audiometry analyzed with typical Type V criteria, and LOT-Bekesy audiometry for efficiency of nonorganicity detection. This chapter discusses the results of the study in three main sections. Each section corresponds to a separate part of the study. The chapter concludes with implications and suggestions for future research.

Discussion

Part I

Part I of the study investigated retrospectively the number and percentage of atypical Type V Bekesy audiograms which had been traced by "known" nonorganics. The results of Part I show that the atypical Type V criteria correctly identified 137 (87.8 percent) of the nonorganics. Of these 137, 31 (19.8 percent) also met the typical Type V criteria, 106 (67.9 percent) met the atypical Type V criteria but not the typical Type V criteria. These results indicate that the atypical Type V definition is a viable detector of nonorganicity.

Part I also investigated retrospectively the number and percentage of typical Type V Bekesy audiograms traced by "known" nonorganics. The results of Part I show that the typical Type V definition correctly identified only 34 (21.8 percent) of the nonorganics. 31 (19.8 percent) of the typical Type V audiograms also met the atypical Type V criteria. However, 3 (1.9 percent) of the nonorganics traced Bekesy audiograms which met the typical Type V criteria but not the atypical Type V criteria.

The results of Part I show the atypical Type V definition to be superior to the typical Type V definition in percentage of nonorganicity detection. Further analysis of the data from Part I shows the combined usage of the atypical and typical Type V criteria detected 140 (89.7 percent) of the nonorganics. Thus by adding the typical Type V definition to the atypical Type V definition more nonorganics were detected than by either the atypical or typical Type V definition used alone.

Part II

Part II of the study compared the atypical Type V definition, the typical Type V definition, and LOT-Bekesy audiometry for the frequency of identification of functional hearing loss. The results of Part II show the atypical Type V definition to be significantly superior to both the typical Type V definition and LOT-Bekesy audiometry in frequency of nonorganicity detection.

The results of Part II also showed LOT-Bekesy to be a significantly more frequent detector of nonorganicity than the typical Type V definition. Although LOT-Bekesy significantly exceeded the typical Type V definition in nonorganicity detection, both LOT-Bekesy and the typical Type V definition were weak detectors of nonorganicity. The percentage of nonorganicity detection by LOT-Bekesy reported in this study (43 percent) is consistent with the finding of Citron and Reddell, (50 percent) and well below that originally reported by Hattler (95 percent).

The typical Type V definition percentages of nonorganicity detection reported in Parts I and II of this study (34 percent and 25 percent respectively) are more consistent with the finding reported by Sedge (58 percent) than that reported by Rintelmann and Harford (76 percent).

Part III

Part III of the study compared the atypical Type V definition, the typical Type V definition, and LOT-Bekesy audiometry for the incidence of false-positive findings among subjects giving no indication of nonorganicity on any other audiometric tests. The results of Part III show that there was no significant difference among the three methods in frequency of false-positive findings. Of the 20 conventional sweep-frequency Bekesy audiograms traced by the 10 subjects, none met the atypical Type V criteria and one met the typical Type V criteria. None of the 20 LOT-Bekesy audiograms traced by the 10 subjects was positive for nonorganicity.

Implications

Part I

The results of Part I of the study indicate that the atypical Type V definition is a viable means for detecting nonorganicity. Moreover, the atypical Type V definition detected a higher percentage of nonorganics than the traditionally used typical Type V definition.

The results also indicate that the typical Type V definition used in combination with the more efficient atypical Type V definition yields an even higher percentage of nonorganicity detection than by the atypical Type V definition used alone. Hence, the typical Type V definition has insufficient but positive attributes for detecting nonorganicity. By combining the attributes of the typical Type V definition with those of the atypical Type V definition a highly efficient tool for detecting nonorganicity may be achieved.

Part II

The results of Part II show the atypical Type V definition to be significantly superior to LOT-Bekesy audiometry and the typical Type V definition in frequency of nonorganicity detection. The results indicate that the atypical Type V definition is an highly efficient means for detecting nonorganicity. With the use of the atypical Type V definition, 42 (95 percent) of 44 Bekesy audiograms traced by nonorganic subjects were correctly identified as opposed to 19 (43 percent) identified by LOT-Bekesy audiometry and 11 (25 percent) identified by the typical Type V definition.

A relatively small 7.2 percent discrepancy exists between the percentages of nonorganicity detection reported for the atypical Type V difinition in Part I (87.8 percent) and Part II (95 percent). A possible explanation of this discrepancy may be the different test method parameters which were used in Part I (various attenuation rates and rates of frequency change) and Part II (2.5 dB/second attenuation rate and 1 octave/minute rate of frequency change). However, the important result is that the atypical Type V definition has been established as an effective means for detecting nonorganicity.

The different results found by this study, Rintelmann and Harford (1967), and Hattler (1971) are too large to be easily explained. The differences become especially significant when one recalls that this study duplicated as closely as possible all test parameters and interpretation procedures specified by Rintelmann and Harford (1967) and Hattler (1971). However, there were several parameters of Hattler's study which were insufficiently detailed. Perhaps the most important weaknesses of Hattler's study were the lack of specificity in determining nonorganicity in his population, and the relatively inexact method used to determine possitivity of a LOT-Bekesy tracing.

Another implication of the results is that the typical Type V definition and the LOT-Bekesy test are inadequate detectors of nonorganicity. The present findings, supported by other recent studies (Citron and Reddell, 1976; Sedge, 1974), strongly suggest that the constructs which these tests use for detecting nonorganicity are either inconstant or unsubstantial. If the procedural differences mentioned earlier were not the major contributors to the large discrepancy between detection rates, then perhaps the explanation lies with the basic assumptions and constructs regarding loudness memory which underlie both the LOT-Bekesy and typical Type V definition. It would appear, then, that the early work by Hattler (1968) may require closer scrutiny by replication to examine further the loudness memory effect on detection of nonorganicity.

It is possible that the typical Type V definition and LOT-Bekesy audiometry may be useful if modified or if used in conjunction with another test. In Part I of this study the highest percentage of nonorganicity detection was achieved by the combined usage of the atypical and typical Type V definitions. However, when used alone, both the typical Type V definition and the LOT-Bekesy test are insufficient and accordingly invalid means for detecting nonorganicity.

When viewed in conjunction with the results of Sedge (1974), Citron and Reddell (1976), Hattler (1971) and Rintelmann and Hartford (1967), an additional implication of the present study is that the typical Type V definition and LOT-Bekesy audiometry are both unreliable means for detecting nonorganicity. LOT-Bekesy audiometry has been reported to detect 95 percent, 50 percent, and 43 percent of nonorganics by these different studies. The typical Type V definition has been reported to detect 76 percent, 58 percent, 21 percent, and 25 percent of nonorganics by these different studies. This wide variability of nonorganicity detection is too great to establish either test as a reliable instrument.

In sum, this study has established the atypical Type V definition as an highly efficient detector of nonorganicity which is significantly superior to both LOT-Bekesy audiometry and the typical Type V definition in frequency of nonorganicity detection. Additionally, the validity and reliability of both LOT-Bekesy audiometry and the typical Type V definition have been questioned.

Part III

The results of Part III show that there was no significant difference among the atypical Type V definition, the typical Type V definition, and LOT-Bekesy audiometry in frequency of false-positive findings among subjects giving no indication of nonorganicity on any other audiometric tests. Since all three methods are essentially equivalent on this parameter, the comparative efficiency of the three methods must be based upon the frequency of true-positive findings among nonorganic subjects.

Suggestions for Future Research

In view of the present findings, several suggestions for future research are made:

(1) Further investigation of the internal validity of the atypical Type V definition through the use of GSR or another objective test as the sole means for including a subject as a nonorganic.

(2) Establishment of the atypical Type V definition's external validity by study of its incidence among non-military and non-Veterans Administration populations with functional hearing loss.

(3) Replication of the present study with a similar population to establish the reliability of the atypical Type V definition.

(4) Replication of the present study using test method parameters of 5 dB/second attenuation rate and 2 octaves/minute rate of frequency change to assess the effect on the efficiency of the atypical Type V definition.

(5) Further investigation of the effects of duty cycle as it relates to loudness and detection of nonorganicity.

Comment

While the results of the present study indicate that the atypical Type V definition is a most promising method for detecting nonorganicity, the true efficacy and applicability of the atypical Type V definition is dependent upon further investigation, particularly of its reliability.

APPENDIX A

DEFINITION OF NONORGANICITY

For the purposes of this study, nonorganic hearing loss refers to hearing problems which are not correlated with actual pathology of the hearing mechanism. Also for the purposes of this study, functional hearing loss and pseudohypoacusis are used synonymously with nonorganicity.

APPENDIX B

PILOT STUDY

The primary purpose of the main study is to devise a more efficient way of distinguishing, by Bekesy audiometry, between organic and nonorganic hearing loss. Several possible indices of nonorganicity in the Bekesy audiogram have been explored. The relationships between the Bekesy pulsed tone trace and the Speech Reception Threshold and the Bekesy pulsed tone trace and the conventional pure tone test have appeared the most valuable. These relationships between the Bekesy pulsed tone trace and the Speech Reception Threshold and the conventional pure tone test have been tentatively formulated into the definition of the atypical Type V tracing.

In conjunction with the development of the atypical Type V definition this pilot study was conducted. The purpose of the pilot study was to evaluate the ability of the atypical Type V definition to detect nonorganicity. The pilot study also investigated the incidence of the typical Type V tracing.

The typical Type V pattern is defined as a sweep-frequency Bekesy audiogram meeting the criteria of Rintelmann and Harford (1967) for classification as Type V.

The atypical Type V tracing is defined as a sweep-frequency Bekesy audiogram which is not in agreement with conventional pure tone test results and/or Speech Reception Threshold (SRT) test results.

A Bekesy audiogram is considered not to be in agreement with the SRT if the average of the two lowest thresholds of the speech frequencies (500, 1000, 2000 Hz) for the Bekesy interrupted tone trace disagrees with the SRT by ± 9dB or more.

A Bekesy audiogram is considered not to be in agreement with the conventional pure tone test if the average of the two lowest thresholds of the speech frequencies for the Bekesy interrupted tone trace disagrees with the average of the two lowest thresholds of the speech frequencies for the conventional pure tone test by ± 15dB or more.

The first twenty-five folders (alphabetically) from the file of nonorganics at the Albuquerque Veterans Administration Hospital, Speech Pathology and Audiology Clinic were evaluated. In total, these twenty-five folders contained fifty-two sweep-frequency Bekesy audiograms. The typical and atypical Type V definitions were applied to the Bekesy audiogram if on non-Bekesy measures for that ear there was evidence of nonorganicity.

Of the fifty-two Bekesy audiograms, forty-one were analyzed with the typical and atypical Type V criteria. Eleven Bekesy audiograms were not analyzed because non-Bekesy measures for that ear did not establish nonorganicity. Of the forty-one Bekesy audiograms which were analyzed, 38 (93%) met the atypical Type V definition, 12% or 5 met the typical Type V definition and 3% or 1 did not meet the typical or atypical Type V definitions.

The data show that the atypical Type V definition increases the diagnostic ability of conventional Bekesy audiometry in detecting nonorganicity. The increased incidence of identification of nonorganicity by the atypical Type V definition merits further study.

APPENDIX C

THE STENGER TEST

The Stenger test is a test of unilateral nonorganic hearing loss. The pure tone Stenger test is based on the principle that when two tones of the same frequency are introduced simultaneously, one into each ear, only the louder tone will be perceived. The test is administered by simultaneously presenting a tone to the "good" ear at a sensation level of 5 or 10dB and a tone to the "bad" ear at 0dB HTL. The level in the "bad" ear is raised 5dB with each successive presentation of tone to the ears while the presentation level to the "good" ear remains at 5 SL. If there is a true loss of hearing in the "bad" ear, the patient will be unaware of any tone in the bad ear and will continue to respond to the tone in the "good" ear. This is a negative Stenger result. However, when the tone is above true threshold in the "bad" ear, the patient will be unaware of the tone in the "good" ear. Since the nonorganic patient does not want to admit hearing in the "bad" ear and is unaware of the tone in the good ear, he stops responding. This is a positive Stenger result. The minimum presentation level to the "bad" ear which caused the patient to stop responding is called the minimum contralateral interference level (Martin, 1972). Chaiklin and Ventry (1965) found that positive Stenger results are more likely in nonorganic cases with large interaural differences (greater than 40dB) or large nonorganic components in the "poorer" ear.

The Speech Stenger test is a modification of the pure tone Stenger test. The Speech Stenger test is used if the difference in SRT between the ears is at least 20dB. Spondees are presented to the "good" ear at a level 10dB above the SRT. At successively increasing levels the same words are simultaneously presented through the same input source to the "bad" ear. If the patient ceases responding at a level significantly below the voluntary SRT for the poorer ear, the test is positive (Chaiklin and Ventry, 1963).

APPENDIX D

INAPPROPRIATE LATERALIZATION

Inappropriate lateralization is a sign of nonorganicity in unilateral hearing loss. Inappropriate lateralization is usually reflected by the absence of a shadow curve or an elevation of the shadow curve beyond that ordinarily expected (Chaiklin and Ventry, 1963). According to Newby (1964),

> In the case of an organic unilateral hearing problem, one would expect to obtain a shadow curve by air conduction in the poor ear that would differ from the hearing levels of the good ear by 50-60dB, and, without masking, the bone conduction hearing levels of the poor ear should approach rather closely those of the good ear. (p. 155)

APPENDIX E

TEST INSTRUCTIONS

Speech Reception Threshold Testing:

I am going to say the words which you just read out loud. When you think that you know the word that I am saying, take a guess and repeat it back to me. The words will be very faint so when you think that you know the word that I am saying, take a guess and repeat it back.

Pure tone Threshold Testing:

On the next test you are going to hear some beeping tones. Raise your hand as soon as you hear the beeping tones and put your hand down as soon as you no longer hear the beeping tones. The beeping tones will be very faint so when you think you hear the beeping tones raise your hand.

Conventional and LOT-Bekesy:

You are going to hear a beeping sound. Press the button down as soon as you hear the beeping sound and hold it down as long as you hear the beeping sound. As soon as you don't hear the beeping sound, let the button up. Press the button down as soon as you hear the beeping sound, and let the button up when you don't hear the beeping sound.

Following these instructions a tracing was made with the interrupted test signal. At the termination of this tracing the subject was reinstructed as follows:

Now you are going to hear a steady sound. Press the button down as soon as you hear the steady sound and hold it down as long as you hear the steady sound. As soon as you don't hear the steady sound, let the button up. Press the button down as soon as you hear the steady sound, and let the button up when you don't hear the steady sound.

APPENDIX F

Subject, direction, and sign for sign test comparison of Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry for frequency of identification of functional hearing loss.

Subject	Direction	Sign
R = right ear	a = atypical	
L = left ear	L = LOT	
1 R	L = a	0
L	L < a	+
2 R	L < a	+
L	L < a	+
3 L	L = a	0
4 R	L < a	+
L	L < a	+
5 L	L < a	+
6 R	L < a	+
L	L < a	+
7 L	L = a	0
8 R	L = a	0
9 R	L < a	+
L	L < a	+
10 R	L < a	+
11 R	L < a	+
12 R	L = a	0
L	L = a	0
13 R	L < a	+
14 R	L = a	0
L	L = a	0

Subject	Direction	Sign
15 R	L = a	0
L	L < a	+
16 R	L = a	0
17 R	L = a	0
L	L < a	+
18 R	L = a	0
L	L < a	+
19 R	L = a	0
L	L = a	0
20 R	L = a	0
L	L < a	+
21 R	L = a	0
L	L = a	0
22 R	L < a	+
L	L = a	0
23 R	L > a	-
L	L = a	0
24 R	L < a	+
L	L < a	+
25 R	L < a	+
26 R	L < a	+
L	L < a	+
27 L	L < a	+

APPENDIX G

Subject, direction, and sign for sign test comparison of Bekesy audiometry analyzed with atypical Type V criteria and typical Type V criteria for frequency of identification of functional hearing loss.

Subject	Direction	Sign
R = right ear L = left ear	a = atypical t = typical	
1 R	t < a	+
L	t = a	0
2 R	t < a	+
L	t < a	+
3 L	t < a	+
4 R	t < a	+
L	t < a	+
5 L	t < a	+
6 R	t = a	0
L	t = a	0
7 L	t = a	0
8 R	t = a	0
9 R	t < a	+
L	t < a	+
10 R	t < a	+
11 R	t < a	+
12 R	t < a	+
L	t = a	0
13 R	t < a	+
14 R	t < a	+
L	t < a	+

Subject	Direction	Sign
15 R	$t = a$	0
L	$t = a$	0
16 R	$t = a$	0
17 R	$t < a$	+
L	$t < a$	+
18 R	$t < a$	+
L	$t < a$	+
19 R	$t < a$	+
L	$t < a$	+
20 R	$t < a$	+
L	$t < a$	+
21 R	$t = a$	0
L	$t < a$	+
22 R	$t < a$	+
L	$t = a$	0
23 R	$t = a$	0
L	$t = a$	0
24 R	$t < a$	+
L	$t < a$	+
25 R	$t < a$	+
26 R	$t < a$	+
L	$t < a$	+
27 L	$t < a$	+

APPENDIX H

Subject, direction, and sign for sign test comparison of audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry for frequency of identification of functional hearing loss.

Subject	Direction	Sign
R = right ear L = left ear	t = typical L = LOT	
1 R	t < L	-
L	t > L	+
2 R	t = L	0
L	t = L	0
3 L	t < L	-
4 R	t = L	0
L	t = L	0
5 L	t = L	0
6 R	t > L	+
L	t > L	+
7 L	t = L	0
8 R	t = L	0
9 R	t = L	0
L	t = L	0
10 R	t = L	0
11 R	t = L	0
12 R	t < L	-
L	t = L	0
13 R	t = L	0
14 R	t < L	-
L	t < L	-

Subject	Direction	Sign
15 R	t = L	0
L	t > L	+
16 R	t = L	0
17 R	t < L	-
L	t = L	0
18 R	t < L	-
L	t = L	0
19 R	t < L	-
L	t < L	-
20 R	t < L	-
L	t = L	0
21 R	t = L	0
L	t < L	-
22 R	t = L	0
L	t = L	0
23 R	t < L	-
L	t = L	0
24 R	t = L	0
L	t = L	0
25 R	t = L	0
26 R	t = L	0
L	t = L	0
27 L	t = L	0

APPENDIX I

Subject, direction, and sign for sign test comparison of Bekesy audiometry analyzed with atypical Type V criteria and LOT-Bekesy audiometry for frequency of false-positive findings.

Subject	Direction	Sign
R = right ear L = left ear	a = atypical L = LOT	
1 R	L = a	0
L	L = a	0
2 R	L = a	0
L	L = a	0
3 R	L = a	0
L	L = a	0
4 R	L = a	0
L	L = a	0
5 R	L = a	0
L	L = a	0
6 R	L = a	0
L	L = a	0
7 R	L = a	0
L	L = a	0
8 R	L = a	0
L	L = a	0
9 R	L = a	0
L	L = a	0
10 R	L = a	0
L	L = a	0

APPENDIX J

Subject, direction, and sign for sign test comparison of Bekesy audiometry analyzed with atypical Type V criteria and typical Type V criteria for frequency of false-positive findings.

Subject	Direction	Sign
R = right ear L = left ear	a = atypical t = typical	
1 R	t = a	0
L	t = a	0
2 R	t = a	0
L	t = a	0
3 R	t = a	0
L	t = a	0
4 R	t = a	0
L	t = a	0
5 R	t = a	0
L	t = a	0
6 R	t = a	0
L	t = a	0
7 R	t = a	0
L	t = a	0
8 R	t = a	0
L	t = a	0
9 R	t = a	0
L	t = a	0
10 R	t < a	-
L	t = a	0

APPENDIX K

Subject, direction, and sign for sign test comparison of Bekesy audiometry analyzed with typical Type V criteria and LOT-Bekesy audiometry for frequency of false-positive findings.

Subject		Direction	Sign
R = right ear L = left ear		t = typical L = LOT	
1	R	t = L	0
	L	t = L	0
2	R	t = L	0
	L	t = L	0
3	R	t = L	0
	L	t = L	0
4	R	t = L	0
	L	t = L	0
5	R	t = L	0
	L	t = L	0
6	R	t = L	0
	L	t = L	0
7	R	t = L	0
	L	t = L	0
8	R	t = L	0
	L	t = L	0
9	R	t = L	0
	L	t = L	0
10	R	t < L	+
	L	t = L	0

BIBLIOGRAPHY

Beagley, H. A., and Knight, J. J., "The Evaluation of Suspected Non-organic Hearing Loss," Journal of Laryngology, 82 (1968), 693-705.

Bekesy, Georg., "A New Audiometer," Acta Otolaryngologica, 35 (1947), 411-22.

Burk, K. W., "Traditional and Psychogalvanic Skin Response Audiometry," Journal of Speech and Hearing Research, 1 (1958), 275-78.

Burns, W., and Hinchcliffe, R., "Comparison of the Auditory Threshold as measured by Individual Pure Tone and by Bekesy Audiometry," Journal of the Acoustical Society of America, 29 (1957), 1274-77.

Chaiklin, J., Font, J., and Dixon, R., "Spondee Thresholds Measured in Ascending 5dB Steps," Journal of Speech and Hearing Research, 10 (1967), 141-5.

Chaiklin, J. B., and Ventry, I. M., "Functional Hearing Loss," Modern Developments in Audiology, ed. J. Jerger (New York: Academic Press, 1963), p. 94.

Chaiklin, J., and Ventry, I., "The Efficiency of Audiometric Measures Used to Identify Functional Hearing Loss," Journal of Auditory Research, 5 (1965), 196-211.

Citron, David, and Reddell, Rayford, "Electrodermal Response, Delayed Auditory Feedback, and Lengthened Off-Time Procedures," Archives of Otolaryngology, 102 (1976), 204-206.

Dieroff, H. G., "Concerning Bekesy Type V Audiograms as Evidence of Functional Hearing Loss," International Audiology, 9 (1970), 149-55.

Hattler, Karl, "The Type V Bekesy Pattern: The Effects of Loudness Memory," Journal of Speech and Hearing Research, 11 (1968), 566-75.

________, "Lengthened Off-Time: A Self-Recording Screening Device for Nonorganicity," Journal of Speech and Hearing Disorders, 35 (1970), 113-22.

________, "The Development of the LOT-Bekesy Test for Nonorganic Hearing Loss," Journal of Speech and Hearing Research, 14 (1971), 605-17.

Hattler, K., and Schuchman, G., "Clinical Efficiency of the LOT-Bekesy Test," Archives of Otolaryngology, 12 (1970), 348-52.

Hood, W. H., Campbell, R. A., and Hutton, C. L., " An Evaluation of The Bekesy Ascending Descending Gap," Journal of Speech and Hearing Research, 7 (1964), 123-32.

Hopkinson, Norma, "Type V Bekesy Audiograms: Specification and Clinical Utility," Journal of Speech and Hearing Disorders, 30 (1965), 243-51.

Hughson, W., and Westlake, H., "Manual for Program Outline for Rehabilitation of Aural Casualities Both Military and Civilian," Trans American Academy of Opthamology and Otolaryngology, Supplement, 48 (1943-44), 3-15.

Jerger, J., "Bekesy Audiometry in Analysis of Auditory Disorders," Journal of Speech and Hearing Research, 3 (1960), 275-87.

________, "Bekesy Audiometry - a Misunderstanding," Journal of Speech and Hearing Disorders, 30 (1965), 302-3.

Jerger, J., and Herer, G., "An Unexpected Dividend in Bekesy Audiometry," Journal of Speech and Hearing Disorders, 29 (1961), 390-1.

Kacker, S. W., "Bekesy Audiometry in Simulated Hearing Loss," Journal of Speech and Hearing Disorders, 36 (1971), 506-10.

Locke, J., and Richards A., "Type V Bekesy Audiograms in Normal Hearers," Journal of Auditory Research, 6 (1966), 393-5.

Martin, F. N., "Nonorganic Hearing Loss: An Overview and Pure Tone Tests," Handbook of Clinical Audiology, ed. J. Katz (Baltimore: Waverly Press, 1972), 364-5.

Newby, H., Audiology, New York: Appleton Century Crafts Company, 1964, 155-158.

Peterson, J. L., "Nonorganic Hearing Loss in Children and Bekesy Audiometry," Journal of Speech and Hearing Disorders, 28 (1963), 153-8.

Price, L., Sheperd, D., and Goldstein, R., "Abnormal Bekesy Tracings in Normal Ears," Journal of Speech and Hearing Disorders, 30 (1965), 139-44.

Resnick, D., and Burke, K., "Bekesy Audiometry in Non-organic Auditory Problems," Archives of Otolaryngology, 76 (1962), 38-41.

Rintelmann, W. F., and Carhart, R., "Loudness Tracking by Normal Hearers Via Bekesy Audiometer," Journal of Speech and Hearing Research, 29 (1964), 456-68.

Rintelmann, W., and Harford, E., "The Detection and Assessment of Pseudohypoacusis Among School-Age Children," Journal of Speech and Hearing Disorders, 28 (1963), 141-52.

________, "Type V Bekesy Pattern: Interpretation and Clinical Utility," Journal of Speech and Hearing Research, 10 (1967), 733-44.

Sedge, Roy, "A Comparison of the Conventional Bekesy Test and the Sweep-Frequency Lengthened Off-Time Test as an Aid in the Detection of Pseudohypoacusis," (5250 Prince Valiant, San Antonio, Texas 78218, 1974). (Mimeographed)

Stein, Laszlo, "Some Observations on Type V Bekesy Tracings," Journal of Speech and Hearing Research, 6 (1963), 339-48.

Ventry, Ira, "Bekesy Audiometry in Functional Hearing Loss: A Case Study," Journal of Speech and Hearing Disorders, 36 (1971), 125-41.