Invited Paper

PURE TONE AND SPEECH BEKESY AUDIOGRAMS AND THE MALINGERER.

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In 1960, while advancing the use of the four classical Bekesy tracings in clinical diagnosis, Jerger noted a questionable pattern in which the continuous tone is produced at a lower intensity than the pulsed signal. At that time, the pattern was considered irregular because it could not be related to any organic malfunction.

Later, Jerger and Herer (1961) disclosed that this unusual pattern was seen in three cases which, interestingly enough, eventually demonstrated normal hearing. This led to the initial supposition that the fifth Bekesy pattern (Type V) could be used as a reliable indicator of malingering.

Further research with psuedohypoacusic populations by Resnick and Burke (1962), Stein (1963), Rintelmann and Harford (1963), and Peterson (1963) lent credence to the rise of the use of the Type V when testing for non-organic hearing loss.

It has been suggested, specifically by Rintelmann and Carhart (1964), that loudness tracking is at the basis of the Type V. Apparently, the interrupted (pulsed) stimuli are perceived as less loud than continuous tones. Melnick (1967) reported that his subjects demonstrated a larger discrepancy between the pulsed and continuous tones when tracing with a reference loudness in the opposite ear. He explained the large diffferences between the levels of the pulsed and continuous signals in terms of a subjectively inadequate definition of loudness. Several other studies have shown that the continuous stimulus is traced below the interrupted stimulus when normal hearing subjects are performing MCL tracings (Hattler, 1968; Melnick, 1967; Rintelmann and Carhart,

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1964). Ventry (1971) noted that his subject's MCL tracings were very similar to the Type V audiograms obtained when the same subject was tracking theshold.

In 1965, Hopkinson raised some serious question about the validity of the pattern as an indicator of malingerer. She indicated that 48 per cent of those with a conductive impairment may be mis-classified if the Type V is defined by a particularly restrictive criteria. Rintelmann and Harford (1967) suggested that the Hopkinson description was inaccurate, and, after examining their case files for patients who had traced a sweep frequency Bekesy and were later judged to be psuedohypocusic arrived at the following, now generally accepted definition of the Type V Bekesy:

> The continuous tone tracing occurs at a lower SPL than the interrupted tracing by a minimum of 10 dB, measured at the midpoints of the two tracings for a range of at least two octaves. The break (between C and P) 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 C and P traces) of at least 15 dB.

Although the Rintelmann and Harford definition of the Type V has not been fully validated in a large number of additional studies, it has been reported (Ventry, 1971) that it "stands up well" as a measure of functional hearing loss. Rintelmann and Harford reported 76 per cent of their thirty-three cases with a functional hearing loss yielded a Type V pattern, Ventry has reported 80 per cent, and an unpublished study at the University of Nebraska (Mencher, Boyden and Taylor, 1969) also reported 80 per cent identification of pseudohypocusis with the Type V Bekesy pattern as defined above.

Speech Bekesy tracings appear to relate, in a meaningful way, to existing audiological procedures for establishing thresholds for speech intelligibility (Haspiel and Havens, 1966; Falconer and Davis, 1947). There apparently is high face validity between speech Bekesy and spondee thesholds, and thus it would seem unnecessary to incorporate both in clinical testing procedures. The literature, however, has not dealt with the question of how a speech Bekesy audiogram would appear when traced by a patient with a functional hearing loss. There is no information currently available indicating whether the malingerer tracing a Type V pure tone Bekesy audiogram will also trace an unusual speech Bekesy audiogram, which could even further increase the accuracy of the test. Such a possibility is not beyond the realm of feasibility. The pattern of loudness which a malingerer has determined to follow may be easily confused because of natural intensity variations on the speech signals. This could result in an inconsistency in the perceived loudness of the signal, causing subjects to trace highly recognizable patterns which may resemble the Type V, or which may have some distinctive configuration of their own.

The present investigation was conducted to compare normal Bekesy pure tone and speech tracings to pure tone and speech Bekesy tracings obtained from the same subjects while feigning a hearing loss. Specifically, we sought patterns of information concerning thresholds, tracing types, and excursion sizes for speech Bekesy audiograms obtained under conditions of a feigned hearing loss.

Abstract

In order to determine if speech Bekesy tracings may be used to identify functional hearing loss, ten subjects were trained to recognize a 40 dB SPL tone, and asked to trace false threshold pure tone and speech Bekesy audiograms approximating in intensity the memorized tone.

Eighty percent of the false pure tone audiograms were classified as Type V. The false speech threshold Bekesy audiograms did not resemble Type V, or any other unusual pattern. They most closely approximated Type I. It appears that pure tone Bekesy is more applicable than speech Bekesy in identifying a pseudo-hypoacusic population.

METHODOLOGY

Pulsed and continuous tracing Bekesy audiograms were obtained from ten normal hearing college women under four conditions:

1) Fixed frequency pure tones at 500, 1000 and 2000 Hz. — True thresholds
2) Fixed frequency pure tones at 500, 1000 and 2000 Hz. — Fake thresholds
3) Speech Bekesy Thresholds — True thresholds
4) Speech Bekesy Thresholds — Fake thresholds

Subjects passed a 10 dB (ISO) screening at 250, 500, 1000, 2000, 4000 and 8000 Hz. Prior to tracing faked thresholds, subjects were trained to recognize pure tones and speech presented at 40 dB SPL.

Procedures

On the first of two consecutive testing days, subjects were asked to trace both a pure tone fixed frequency tracing at 500, 1000 and 2000 Hz. and a speech Bekesy audiogram in the pulsed and continuous modes, and then trained by a series of matched-comparison tasks to identify a memorized reference level of 40 dB SPL. On Day Two, memorization of the reference tone was confirmed, and false threshold fixed frequency pure tone and speech Bekesy tracings were obtained in both the pulsed and continuous modes.

A Grason-Stadler Bekesy audiometer (Model E-800) set at an attenuation rate of 2.5 dB per second was employed. The reference pen was engaged at the SPL setting.

Speech Bekesy Audiometry

Recording the Speech Signal: A recording of a Fulton Lewis Jr. radio broadcast was recorded on tape at fifteen inches per second (ips). An Ampex Tape Deck was connected into the stimulus input located on the front panel of the Bekesy audiometer. The tape of the broadcast could then be played on the tape deck, calibrated, and the signal presented from the Bekesy audiometer to the subjects through the earphones.

Training for the 40 dB SPL Memorized Reference Tone: Each subject was asked to memorize tones of 40 dB SPL presented at 500, 1000 and 2000 Hz. via the Bekesy audiometer.

After listening to the test signals and others, comparatively, and intermittently, over a period of fifteen minutes, subjects were tested to verify memorization. The standard Alternate Bilateral Loudness Balance test (ABLB) instructions were given, and the individual was asked to designate when a stimulus was of higher, lower, or equal intensity to the memorized reference. When each individual was able to perform the matched loudness task, he was termed a "trained malingerer." A similar method of training was incorporated with the speech signal.

RESULTS AND DISCUSSION

Normal threshold data obtained from pure tone fixed-frequency Bekesy audiograms and speech Bekesy audiograms, traced under normal conditions, was examined in terms of the relationship between thresholds obtained under the pulsed and continuous modes (gap size) and the size of the excursions.

Résumé

Pour déterminer si les calques de voix Békesy pouvait être identifier l'oui perdu fonctionnaire, dix sujects etaient trainé reconnaître un ton de 40 dB SPL, et demandaient tracer les pur ton et l'audiogram de voix Békesy faux approximativement en intensite le ton memorizé. Quatre-vingt pur cent des audiograms pur ton faux étaient classifié comme le Type V. Les calques de voix Békesy ne resemblaient pas le Type V ni aucuns autre modele remarquable. Ils resemblaient plus le Type I. En conclusion il apparait que le pur ton Békesy est plus applicable que les calques de voix Békesy en identificant une pupulation "pseudohypoacusic."

The midpoint of ten consecutive excursions at each frequency (500, 1000 and 2000 Hz.) for the pure tone and in the first, second and third portions of the speech audiograms was determined. The decibel values at these midpoints were averaged to give the mean threshold for each frequency and each portion of the speech audiogram under each condition (pulsed and continuous). No significant difference was found between the subject's pulsed and continuous tracings for any of the three pure tone frequencies tested or any of the three portions of the speech Bekesy audiogram.

According to Jerger (1960), a Type I Bekesy audiogram, usually seen with normal response, is indicated by the superimposition of the continuous on the pulsed excursions. There was no gap between the pulsed (P) and continuous (C) tracings on any of the twenty normal threshold pure tone and speech Bekesy audiograms in this study and, using Jerger's classification system, all would be called Type I (Jerger, 1960).

The height of ten middle excursions at each of the pure tone frequencies (500, 1000 and 2000 Hz.) and at the three divisions of the speech audiogram was determined by measuring the distance between the extreme points of intensity increment and intensity decrement. These values were averaged to give a mean excursion size for each frequency under each of the conditions.

In order to determine if excursion sizes for the pure tone tracings were normal, as compared to reports in the literature, the excursions recorded for all three frequences were averaged to give a mean excursion size for each subject's tracing under each condition. In spite of a few individual differences, the group mean excursion sizes obtained under both conditions were within normal range (pulsed = 8.3 dB, continuous = 8.6 dB). The standard deviations for the two group means were computed (pulsed = 1.3 dB, continuous = 2.5 dB). The small standard deviations denoted little variance from the means, indicating relatively uniform excursion sizes for the group.

The excursions recorded for all three divisions of the speech audiogram were averaged to give a mean excursion size for each subject's tracing under each condition. A group mean was recorded.

The group mean excursion size for P was 10.6 dB (s.d. = 3.7 dB). The mean excursion size for C was 10.9 dB (s.d. = 3.3 dB). The small standard deviations indicate that the excursion sizes were reasonably uniform, generally falling near the mean. Reports in the literature (LeZak, *et. al.*, 1964; Haspial and Havens, 1966; Dahle, *et. al.*, 1968) indicate that speech excursion sizes tend to be slightly larger than those of pure tone Bekesy tracings. Apparently excursion size was not noticeably affected in this study when the subjects were tracing their normal speech Bekesy thresholds.

Comparison of Normal Pure Tone and Normal Speech Thresholds

When the pure tone normal thresholds were compared to the normal speech thresholds (Table 1) the data corresponded with that reported by Haspiel and Havens in 1966. Those investigators noted

TABLE 1

COMPARISON OF NORMAL TRACINGS

In dB

Thresholds			**Excursion**	**Size**
	P	C	P	C
Pure Tone	12.4	12.4	8.3	8.6
Speech	16.3	15.0	10.6	10.9

that the difference in threshold was close to the three to five decibel difference found by conventional audiometry. The group mean pure tone average for the ten subjects pulsed tracing was lower in intensity than their speech average for the pulsed stimulus by 3.9 dB. The mean pure tone average for the combined (all ten subjects) continuous tracing was lower in intensity than the mean speech average by 2.6 dB.

The absence of a gap between P and C enabled classification of the twenty normal threshold Bekesy audiograms (ten pure tone and ten speech) as Type I according to the criteria specified by Jerger. Although the excursion sizes for speech were reported as larger than those of the pure tone, larger excursion sizes are known to occur under the speech condition. The data thus far reported indicates that the equipment and procedures of this study were appropriate for examination of Bekesy audiograms.

False Thresholds

The means for the subject's false threshold audiograms were obtained in the same manner as the means of the normal threshold audiograms. (Table 2).

TABLE 2

COMPARISON OF FAKED PURE TONE AND SPEECH THRESHOLDS

In dB

	PURE TONE	SPEECH
Pulsed	52.7 (s.d. 8.9)	48.0 (s.d. 8.5)
Continuous	41.3 (s.d. 8.8)	46.7 (s.d. 8.7)
	8 Type V 2 Questionable	10 Type I

Although a slight gap was seen between the threshold and tracings of the P and C speech Bekesy audiograms, it did not fall within the Rintelmann-Harford criteria at any one of the three measured points for any subject. When a mean threshold for each subject was computed for the P and C conditions, and those thresholds compared, no significant difference was found between the tracings.

The Rintelmann-Harford criteria were utilized in classifying the 10 false threshold pure tone Bekesy audiograms. Eight showed an occurrence of a 10 dB gap and were classified as Type V. The two subjects who did not fall within the criterion exhibited a gap of ten decibels or greater over at least one frequency, but not over two frequencies in consecutive order as required by Rintelmann and Harford. All ten subjects traced a Type V pattern at least one of the three frequencies. None of the ten deliberately faked pure tone Bekesy audiograms was a Type I, II, III or IV.

The mean excursion size for the false threshold pure tone and speech Bekesy tracings was obtained in the same manner as those of the normal threshold speech and pure tone Bekesy tracings. (Table 3). Mean excursion sizes of all 20 audiograms fell within the six to nine decibel range reported as normal for pure tone Bekesy audiograms, rather than the larger range (14.5 to 10.2 dB) reported for normal speech Bekesy audiometry. Note that the excursion size for all faked tracings is consistently smaller than normal but the standard deviation shows some overlap.

Comparison of False Pure Tone and False Speech Tracings

The group mean faked pulsed pure tone average for 500, 1000, and 2000 Hz. was 4.7 dB greater in intensity than that of the faked pulsed speech signal. (Table 3). The group mean faked continuous

TABLE 3

COMPARISON OF EXCURSION SIZES – ALL TRACINGS

In dB

PURE TONE	NORMAL	FAKED
P	8.3 (s.d. 1.3)	6.8 (s.d. 2.7)
C	8.6 (s.d. 2.5)	6.1 (s.d. 2.9)
SPEECH		
P	10.6 (s.d. 3.7)	9.2 (s.d. 4.5)
C	10.9 (s.d. 3.3)	8.9 (s.d. 4.9)

(Expected Normal: Pure Tone – 6 to 9 dB, Speech – 10.2 to 14.5 dB)

pure tone average for 500, 1000, and 2000 Hz. was 5.4 dB less in intensity than the faked pulsed speech average. In tracing the false threshold pure tone Bekesy audiogram, as has been suggested earlier, the subject apparently does increase the intensity of the pulsed stimulus because he hears it as lower in in intensity than the continuous. It may be that the pulsed speech stimulus is traced at a greater intensity than the continuous speech for the same reason. The results substantiate Haspiel and Havens (1966) report that the difference between pure tone and speech Bekesy tracings is similar to that reported between the pure tone and speech stimulus of conventional audiometry.

The subjects had been trained to identify and feign a 40 dB SPL signal. From Table 2 it can be seen that the group mean results were quite good, with the group mean for the continuous pure only 1.3 dB from the attempted mark, and all three of the tracings within 6 dB of each other and 12 dB of the mark. It should be noted, however, that individual thresholds ranged from perfect 40 dB thresholds to $\pm$ 25 dB from the mark, with speech tracings being the most deviant. It appears from the data, that it is possible for a subject to fake a hearing loss if tested by speech Bekesy audiometry, but not necessarily do so at the specific level which he has memorized.

Audiological tests have various percentages of success in identifying the etiology of specific hearing problems. Johnson (1965), reporting the accuracy for basic tests used in audiological evaluation, suggested air and bone conduction testing is accurate only seventy percent of the time. He also indicated that the SISI test is accurate seventy-five percent of the time, and that Type III or Type IV Bekesy tracings occur slightly more than seventy percent of the time in retrocochlear lesions.

The eighty percent occurrence of Type V Bekesy audiograms in a malingering population, as reported in previous studies and in this project, is the highest efficiency quota for an audiological test that has, as of yet, been reported. Further, a large discrepancy in hearing levels between the two ears, a problem if the Stenger is used, is not a major factor in tracing the Type V audiogram as the Bekesy is administered to one ear at a time.

All twenty of the speech Bekesy audiograms (ten normal and ten false thresholds) fell within Jerger's (1960) Type I classification. When asked to do so, the ten subjects were able to simulate a hearing loss using the speech stimulus.

The fact that a Type V tracing is not seen when speech is the stimulus may be related to inconsistency in the loudness of that type of signal. Unlike pure tones, speech does not remain at a constant loudness. Natural increases and decreases in loudness, depending upon the consonants and vowels used causes "ups" and "downs" in the signal, making the tracking of one specific loudness level extremely difficult, if not impossible. It is probable that the subject simulates a hearing loss by listening to the tonal quality of the speaker rather than the specific intensity of the signal presented. He may decide to wait until the speaker's voice is loud enough before indicating a response. In either case, tracking specific loudness is difficult and makes it nearly impossible to fake a memorized tone.

Excursion sizes did not appear to be a factor in tracing Bekesy audiograms. However, it should be noted that the faked tracings yielded smaller excursions than the normal audiograms.

The data from this study suggests reasonable success with continued use of the pure tone Bekesy as a test for identification of functional hearing loss. The examiner can expect that the test may fail to identify twenty percent of those malingering. The results of this study indicate speech Bekesy will not assist in identification of the functional hearing loss as no specific abnormal pattern can be seen. In fact, a patient can trace Type I audiogram, which suggests normal hearing, when it is really a false threshold and speech is the signal.

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Acknowledgements

This study is based on Mrs. Boyden's Master's thesis completed at the University of Nebraska, Lincoln, Nebraska, U.S.A., under the direction of Dr. George T. Mencher.