THE VALIDITY OF OBJECTIVE SPEECH AUDIOMETRY

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RECENT advances in the development of tests for determining auditory sensitivity have made use of the technique of *psychogalvanic skin response* (GSR) *audiometry or electrodermal audiometry* as it is sometimes called. Various investigators have demonstrated the application of this method on both reliable subjects and subjects who are either unable or unwilling to give valid voluntary responses. Following the clinical acceptance of GSR puretone audiometry, many refinements were made in its use in the United States and abroad.

GSR puretone audiometry employs various modes of classical conditioning with the conditioned stimulus being an audible puretone and the unconditioned stimulus a mild-to-moderate electric shock. Burk (1958) investigated the validity of GSR audiometry and found a high positive correlation between auditory thresholds determined by GSR audiometry and thresholds determined by standard puretone audiometry using college freshmen as subjects. Kodman and Lyons (1959) found acceptable validity of the GSR method with normal six-year-old children. Kodman, Fein, and Mixson (1959) used the method with retarded children and compared the results with subjective speech audiometry. Numerous clinical studies have been reported in the literature regarding the use of GSR puretone audiometry.

There is some evidence to suggest that standard puretone thresholds show slightly better sensitivity (less hearing loss) than that found by GSR audiometry. Hardy and Bordley (1950) report comparisons between the two methods on two separate samples of clinical cases in a non-experimental situation. In one sample of 30 ears using adults with known hearing impairment at the octave frequencies 500-4000 cps., the mean deviation was $\pm 2 \cdot 46$ db. In a second sample of 53 ears of children with known hearing impairment at the same frequencies, the mean deviation was $\pm\ 3 \cdot 57$.

Appearing in the literature recently were the results of a new type of test based on the psychogalvanic skin response. The authors, Ruhm and Carhart (1958), reported on the results of this method referring to it as

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objective speech audiometry. This method differs from standard GSR audiometry in that the condition stimulus is a spondaic word or speech stimulus instead of the puretone stimulus that has been previously used. It becomes apparent that one must give due consideration to the validity of objective measurements that employ the GSR technique. Objective puretone or GSR puretone audiometry does not yield a 1:1 relationship between itself and speech perception due to the differential nature of the conditioned stimulus.

Ruhm and Carhart have shown that thresholds determined by objective speech audiometry correlate highly with thresholds determined by the voluntary or subjective responses of the subjects. It seemed pertinent to investigate objective speech audiometry to see if it could be considered a valid objective measurement of the auditory threshold.

This study reports the results of an experiment designed to obtain an estimate of the validity of objective speech audiometry. Its validity was determined by means of correlation with two outside criteria whose validity has been previously established. These criteria are standard puretone audiometry and standard or subjective speech audiometry.

Procedure

All tests were administered in a sound-treated laboratory appropriate for the determination of auditory thresholds. Data were collected by two experimenters who were not informed of each other's results. One experimenter determined the standard puretone thresholds, the other experimenter collaborated in determining the GSR speech thresholds.

Subjects. Forty, white, males participated in the experiment. They were randomly selected from the introductory course in psychology at the University of Kentucky. The subjects range in age from 17 to 25 years, with a mean age of 19 years, 9 months. Their hearing was expected to fall largely within the range of normal sensitivity.

Standard Puretone Thresholds. The puretone thresholds were obtained using a calibrated Maico, Model MA-1 Audiometer. A modified method of limits was used as suggested by Meyers and Harris (1950). The three test frequencies were 500, 1000, and 2000 cycles. Each threshold was the mean of two ascending and two descending crossings.

Subjective Speech Thresholds. A subjective speech threshold was determined immediately following administration of the puretone test. This threshold was determined over an Allison, Model 20-A, Speech Audiometer using monitored live voice. The experimenter systematically varied the level at which the words were presented, using five db. decrements until the threshold of intelligibility was reached. This threshold was defined as the minimum sound pressure level at which the subject correctly identified three out of six test words.

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Objective Speech Thresholds. The instruments employed in obtaining the GSR speech thresholds consisted of the Allison, Model 20-A, Speech Audiometer and a Grason-Stadler Psychogalvanometer, Model E664. In evaluating the objective speech thresholds both experimenters were involved. One experimenter, seated in the testing room, operated the psychogalvanometer and determined when the subject gave an acceptable response to the stimulus words. The other experimenter, seated in the control room, presented the spondaic words to the subject preceded by a carrier phrase. He raised or lowered the sound pressure level of the speech depending upon instructions from the other experimenter. The latter did not know at any time during the testing at what sound pressure level the words were being presented. The experimenter in the control room recorded the acceptable responses given by the subjects.

Further details for determining objective speech thresholds can be found in the Ruhm and Carhart (1958) experiment. The present study followed the procedures with the following exceptions: (*a*) the sample used in this study had essentially normal hearing; (*b*) three measures were made of the subject's auditory sensitivity; (*c*) all thresholds were determined consecutively during one test session, and (*d*) when determining the subjective speech threshold, a decrement of five db. was used instead of two db. steps.

The common and pickup electrodes were taped to the fingertips of the subject's first and third fingers of the left hand. The shock electrode was applied to the forearm of the left arm. Following application of the electrodes the subject was informed that he would hear a list of words which he was not to repeat. He was told that these words might or might not be followed by an electric shock. Following Ruhm and Carhart's example, the word *baseball* was designated as the key word with which the unconditioned stimulus was to be paired. One trial of stimulus presentation consisted of four spondaic words including the word *baseball*. The interval between words was varied from 5 to 20 seconds while the interval between trials ranged from 20 to 40 seconds.

During acquisition the sound pressure level at which the stimulus was presented was varied. Four sound pressure levels were used and these were randomized. The levels chosen were 40, 50, 60 and 70 db. above audiometric zero. Since the unconditioned stimulus appeared only once in four trials, it was felt that 100 per cent. reinforcement would be most appropriate. Hence, each time the key word *baseball* was presented the subject received an electric shock. The level of the electric shock varied according to the discretion of the experimenter.

After the subject was conditioned to respond to the unconditioned stimulus the speech circuit of the Allison Audiometer was set for maximum attenuation (—10 db.). There was first an ascension series until an acceptable GSR response was obtained, then a descension series until the

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subject failed to give a GSR response. The speech threshold was designated as the mean of four crossings of the threshold.

Results and Discussion

With regard to reliability the experimenter arbitrarily designated one-half of his 40 subjects for repeated measurement of the puretone and the subjective speech threshold. The reliability coefficient between the first and second measurement was ·85 for the puretone thresholds and ·70 for the standard speech thresholds.

The range, mean and standard deviation of results obtained by the three test methods are given in Table I. These data along with other

TABLE I.

THE RANGE, MEAN, AND STANDARD DEVIATION OF THREE TEST METHODS.

Test	M	SD	Range
Subjective Speech Audiometry	6·50	3·20	2·5–12·5 db
Objective Speech Audiometry	5·96	1·95	3·3–10·8 db
Puretone Mean	5·81	1·84	2·5–10·5 db

statistics were computed in accordance with suggestions by Edwards (1954). It is apparent from these data that all subjects possessed essentially normal hearing for the ear tested. The range of measurement is restricted, and the means of the three methods deviate less than 1 db. from each other.

The relationship between objective speech audiometry and the two outside criteria with which it was correlated is summarized in Table II.

TABLE II.

CORRELATION COEFFICIENTS BETWEEN THE TESTS EMPLOYED IN THE THRESHOLD MEASUREMENTS.

	Objective SRT	Mean	Test Frequencies		
			500	1000	2000
Sub. SRT	·786**	·858**	·457**	·575**	·466**
Obj. SRT		·853**	·397*	·631**	·513**
Puretone Mean			·491**	·586**	·631**

* Significant at ·05 level.
** Significant at ·01 level.

This table displays a comparison of the correlations between the various methods used in measuring auditory sensitivity in this study. Scattergrams were made, and showed that the data met the assumptions of rectilinearity. The Pearson product-moment correlation coefficient between objective speech audiometry and standard puretone audiometry

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is ·85, while the correlation between objective speech audiometry and subjective speech audiometry is ·78. These correlations are high despite the fact that the range of the measurements is restricted.

It was assumed that if a high positive correlation could be demonstrated between objective speech audiometry and the two outside valid criteria, then the former could be recommended as a method for the evaluation of the auditory threshold. Since a significant positive correlation was found between objective speech audiometry, subjective speech audiometry, and subjective puretone audiometry it is felt that objective speech audiometry could be used clinically in determining the auditory threshold.

The significance of an objective measurement of a subject's speech threshold is important clinically in certain types of hearing loss. Since the validity was supported by the magnitude of the correlations, objective speech audiometry should be worthy of consideration as a laboratory method. It should also be important as a diagnostic tool.

The relationship between the two outside criteria was identical to that found between objective speech audiometry and puretone audiometry. The correlation between standard speech audiometry and standard puretone audiometry has been found to range from ·75 to ·90 by previous investigators. A correlation of ·85 was found between these two measurements in the present study and would lend further support to the hypothesis that an individual's speech threshold can be determined objectively. This correlation is comparable to that found by Carhart (1946), Harris (1946), and Quiggle, *et al.* (1951).

One other statistic which seemed pertinent to compute was the standard error of estimate. One can see from Table III that the standard

TABLE III.

Error of Predictability of the Three Sets of Measurements.

Prediction	Standard Error of Estimate in db
Subjective SRT from Objective SRT	2·02
Subjective SRT from Puretone Means	1·69
Objective SRT from Subjective SRT	1·23
Objective SRT from Puretone Means	1·03
Puretone Means from Subjective SRT	1·00
Puretone Means from Objective SRT	1·00

error of estimate is rather small. The reader will note that the error of predictability for the three measures ranged from 1·00 to 2·02 db. Viewed statistically, the results for objective speech audiometry were, in this investigation, comparable to the results for either subjective speech audiometry or standard puretone audiometry.

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Summary and Conclusion

This investigation was concerned with the validity of a new method of auditory measurement referred to as *objective speech audiometry*. The results consisted primarily of threshold measurements which were compared by means of correlational techniques with thresholds obtained by standard puretone audiometry and standard or subjective speech audiometry. The objective speech threshold was obtained by a procedure involving classical conditioning. A single monaural threshold was measured for each subject. Ears, stimulus intervals, and test frequencies were randomized.

The following are the major findings;

1. Objective speech audiometry showed a correlation of ·85 with standard puretone audiometry and ·78 with standard speech audiometry. The results support the validity of objective speech audiometry as a laboratory method for measuring the auditory threshold and lend support to the pioneer study by Ruhm and Carhart.

2. The two outside validity criteria, standard puretone audiometry and standard speech audiometry, correlated ·85 and support the results generally reported in the scientific literature by other investigators.

3. Regarding the three test methods used in this study, the standard error of the estimate predicts the results for one of the test methods from each of the other two methods on the order of one to two db.

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