The Enigma of Hearing Aid Selection

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There have been many modifications and innovations of philosophy, methodology and materials in the hearing aid evaluation literature over the past thirty years. There has also been a trend toward making the hearing aid evaluation process an integral component of comprehensive programs of aural habilitation and rehabilitation. While the details of this integration is worthy of much study and discussion it is beyond the scope of this short paper.

The purpose and scope of my discourse today will be limited to a definition of our intent in the evaluation process and an outline of what we must do now and in the future. One common purpose of our clinical evaluation efforts, which is embraced by an ever increasing number of practitioners, is the selection of the most appropriate electroacoustic system *for a particular individual.*

Mark Ross in 1976 presented a simplified but attractive model of the tasks an audiologist must accomplish in order to meet the aforementioned purpose. I quote here his succinct description: "by administering one or more speech discrimination measures under a variety of possible test conditions, through a limited sample of a vast array of electroacoustic variations, to a client who exhibits a unique configuration of psychoacoustic capacities, we are supposed to predict which particular electroacoustic system will result in the optimal communication efficiency under normal environment conditions."

The astute audiologist will of course recognize that this model parallels the evaluation philosophy set forth by Carhart in 1946 and which we affectionately refer to as the conventional approach. The salient motivating feature of this approach is to establish invariant relationships between hearing aid performance and listener performance, by system-

atically varying selected electroacoustic properties of hearing aids and measuring their effects on the psychoacoustic performance of listeners.

As we may all be painfully aware, there has been substantial criticism of the reliability and validity of the electroacoustic and psychoacoustic measurement schemes which are integral to the conventional approach (Chial and Hayes, 1974; Millin, 1975). Indeed, doubts in these areas have encouraged outright abandonment of the concept in many circles. In addition the doubts are primarily responsible for the diversity mentioned earlier and have prevented serious attempts at unification of clinical approach.

To digress for a moment, the value of a unified approach among audiologists, subject to dynamic but studied change, in a process composed of as many difficult to control variables as implied in the model outlined by Ross, is perhaps self evident. The presently pervasive attitude of individualism demonstrated by clinicians and clinics, wherein procedures and materials are often dictated by convenience and convention rather than empirical data is reproachable in a science based profession.

The doubts too have allowed an aura of enigma to permeate our thoughts in evaluation matters and it is to rarefication of this aura that the rest of my comments are addressed.

While inadequacies in the electroacoustic and psychoacoustic measurement schemes limit the ability of the conventional approach from establishing unambiguous relationships between hearing aid performance and listener performance, its use does not necessarily obviate establishment of such relationships. In fact, when used with discretion and efforts made to address inadequacies, the approach can be made to yield valuable information not only for the selection of appropriate electroacoustic characteristics, but data that would be useful in overall rehabilitative management.

In the following I will identify some of the major inadequacies of the conventional approach and annotate possible direction for improvements; my comments are not meant to be comprehensive, only to point out the tips of icebergs which require our attention and trend setting involvement.

In the electroacoustic arena, most measurements are made in an acoustic coupler which represents real ear aided acoustics in a less than desirable fashion. The reliability of these measurements is good albeit the validity is seriously suspect. Improvement can be afforded by use of realistic ear simulators like the four-branch and two-branch devices now receiving attention, the use of manikin systems or clinical implementation of concepts like functional gain and electroacoustically based evaluation procedures.

Secondly, existing standards demand measurement strategies which are

to a large extent second-order derivatives in which available information is lost to interpretation or difficult to interpret unambiguously. While the use of such standards foster consistency in measurement data, they reduce the validity of the data, because many electroacoustic factors of presumed or demonstrated importance to speech processed through a hearing prosthesis are ignored. The situation is further complicated when we learn that many measurements, especially unstandardized but potentially relevant indices of nonlinearity, are largely dependent on details of the sampling technique.

Still it seems to me that a thoughtful profession should be able to reach an informal concensus for more valid electroacoustic measurement, free from the inertia of a formal standard and easily changeable in order to quickly respond to new scientific data. State of the art advances make very realistic specification of electroacoustic parameters possible and to an increasingly greater degree, the parameters can be independently manipulated. Systematic study, therefore, of the effects of independent changes in electroacoustic performance is possible, almost for the first time, unconfounded by uncontrolled differences among other electroacoustic factors. It is an exciting prospect!

The psychoacoustic arena is more troublesome, although some intriguing alternatives have been proposed such as adaptive articulation test procedures. The tests commonly used in the evaluation process can be impugned because of the unreliably small differences in listener score that they produce when processed through hearing aids with known electroacoustic and qualitative differences, and in their potency to forecast the degree of success an individual will later achieve in normal listening environments.

Millin in 1975 presented an illuminating discussion of this point in which he notes that psychoacoustic performance is not a unitary variable, but the result of a complex set of interdependent factors. Only when the electroacoustic effects are larger than the variability produced by these factors can the information be useful in drawing conclusions about electroacoustic consequences. Of course we studiously attempt to minimize or stabilize these factors across listeners, but we do not often test for success of our efforts. Very infrequently do we perform test-retest or split-half assessments on the test results obtained during the evaluation process. The reliability of our results therefore, are unknown and hinder the utility of the conclusions drawn from them.

We have attempted to resolve psychoacoustic test weaknesses in other ways too, but we need to put them into clinical practice. For example, the sensitivity and resolving power of test material to electroacoustic and psychoacoustic differences can be increased by the introduction of a competing signal. In the absence of tests with known sensitivity this

shotgun approach is perhaps acceptable. However, the scenario of improvement from our knowledge of critical ratios and masking level differences is likely to vary with spectral composition of the competing signal, signal to competition ratio, and loudspeaker placement. Still the trend is refreshing because there is now ample evidence that listeners with sensorineural losses are less resistent to masking, especially by competing speech, than normal listeners, which may relate in some non-trivial ways to cognitive processes like short term memory capacity.

Another example is the development of speech material having greater face validity. The major thrust has been in the direction of sentence length material requiring comprehension of the intended message, rather than analytic reproduction or discrimination of words or nonsense syllables in isolation. When individual variation in linguistic competency is controlled, sentence materials would seem a likely candidate to sample an individual's use of speech code cues, as well as cognitive and memory processes required for comprehension. Additionally the effects upon listener performance of common acoustic distortion such as poor speaker enunciation, competing signals, reverberation and the like, can be more readily assessed in the sentence situation.

Other examples would of course be given like controls on redundancy of the test material, scaling of listener performance over a range of signal-to-competition ratios, insistence on objective listener responses—the list is very long. Instead of reciting it here, however, let me move on to my last point and largest iceberg.

Regardless of the reliability and validity of the electroacoustic and psychoacoustic schemes employed, the utility and accountability of our clinical efforts can only be gauged to the extent we are able to predict the degree of success an individual will later achieve with the aid in normal listening environments. In the past we have not demanded this kind of *criterion validation* and relied heavily on face validity, earnestly attempting to retain features in our test environment which would likely operate in real life listening situations. Not to underestimate the difficulty implicit in achieving empirical validation, we need a trend in the direction of studies which seek to relate predictions of particular aid and listener performance in the clinic, to the same and listener performance outside the clinic. This is a difficult task because the criterion we use for validation of the psychoacoustic test results, must itself be reliable and valid. Perhaps if we were all to use the same criterion instrument, even though untested with regard to reliability and validity, we could at least stabilize the validity of the psychoacoustic tests used in the evaluation process. The Hearing Performance Inventory recently proposed by Giolas, Owen, Lamb and Schubert (1976) might be useful in this regard and should be vigorously pursued.

In summary, at least for the present, the conventional hearing aid evaluation philosophy seems viable, and may become more so as we increase our emphasis on compensation for individual deficits through complex signal processing. The salient features of the philosophy appear well founded, but the electroacoustic and psychoacoustic schemes which comprise it are lacking in reliability and validity. These inadequacies have precipitated an immense diversity in clinical evaluation practice, but no real remediation of the deficits. In the future we must address ourselves to the complexities of this remediative task. A coordinated, unified effort to identify promising research strategies and interrelate research efforts and clinical practice is the most likely vehicle for resolving the problems inherent in the conventional hearing aid evaluation process. I hope that the membership of an organization like the Academy of Rehabilitative Audiology can and will assume this necessary guidance.

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