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Virtual Environments for Standardized Validation of Amplification Benefit: Recording & Reproduction

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Abstract

A sound field test environment, consisting of a five-loudspeaker array, and designed for verification of benefit from hearing aids with advanced technology features, has been previously described. Based on the HINT, the test environment provides a norm-referenced, clinically valid, and repeatable in situ method for obtaining objective performance benefits from individual hearing aid features such as multi-channel compression, noise reduction algorithms, and directional microphones. The test environment also meets the sound field requirements of the HIA guidelines for establishing performance claims for hearing aids. In order to increase the utility and value of the test environment, it is desirable to create a clinically valid, norm-referenced method for assessing subjective benefit and sound quality in real-world listening situations. This paper describes the first steps in on-going research to qualify, record, and reproduce in said sound field, listening environments representative of those idealized in standardized self-report instruments such as the PHAP and APHAB. Future reports will include correlation studies of the laboratory apparatus to real-world data.

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INTRODUCTION

Recently, playback of audio recordings in the clinic has become popular for demonstrating the effectiveness of amplification and features1, but such methods have never been standardized such that they provide meaningful and quantifiable measures of clinical outcomes. Figure 1 depicts a two-dimensionally-diffuse (2DD) sound field test environment that has been previously described2, 3 and used extensively for evaluating objective performance with amplification4, 5. We propose using the same sound field test system for both objective hearing in noise tests and subjective benefit measures.

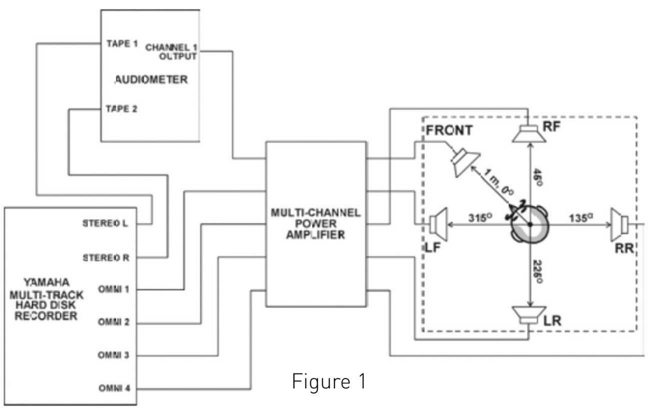


Figure 1

The APHAB is a standardized, norm-referenced self-report of amplification benefit6 traditionally administered over two sessions: one to collect unaided responses and a second to collect aided responses, often several weeks post-fitting.

The intent of the present paper is to review the recording techniques used for a few of the listening environments represented in the APHAB and the extent to which playback in the sound field recreates the listening environments. The evaluation included the ability to deliver a sense of realism and listener envelopment7, and an initial look at the prospects for correlation with the traditional APHAB.

METHODS

Recording Equipment and Techniques. The 2DD sound field in Figure 1 delivers masking noise that completely surrounds the listener. The listening environments for the proposed subjective measures require a similarly enveloping experience from the sound field, as this is how the real environments are perceived.

Figure 2

Digital recordings were made directly to four individual tracks of the Yamaha digital recorder using a 4-quadrant microphone array (Figure 2). The front microphones are Shure KSM44s arranged as an near-coincident pair per the Office de Radiodifussion-Television Francaise (ORTF) specification (Figure 3). This arrangement takes advantage of time-of-arrival cues as well as level differences between sounds picked up from the front left and right. The rear microphone is a stereo coincident unit with two capsules. The coincident technique relies strictly on level differences between the two capsules to resolve left-right sound sources behind the listener. The vertical planes of the front and rear microphone arrays are spaced 24 cm apart. A fifth microphone at the center of the array records the intensity of the live material for reference.

Recordings of Listening Environments. The APHAB is a set of statements related to difficulty in communicative situations that are rated on a 7-point scale as to subject agreement with the statement. The situations are separated into four subscales: Ease of Communication (EC), Background Noise (BN), Reverberation (RV), and Aversiveness (AV) of sounds. For the present paper, a test item was selected from each subscale and recorded in the real world with the 4-microphone array. The microphone array was placed at the listening position and the front microphone pair was aimed along the line of sight. Target speech information was scripted for each item (other than for the AV item) and spoken with the natural conversational effort required by each environment.

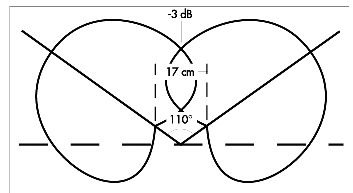


Figure 3: Front microphone pair: ORTF array.

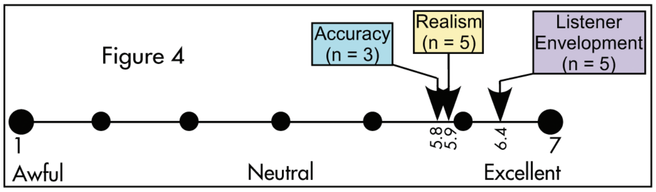
Playback took place in the 2DD sound field. The level of playback at the center of the listening position was set to the level monitored at the time the recording was made. A panel of normal-hearing listeners rated the recordings for realism and listener envelopment on a 7-point scale. Listeners present at the recording sessions also rated the playback for accuracy.

The recordings were also played back for in situ APHAB ratings by hearing-impaired individuals (n = 4) who had previously completed the APHAB in the traditional manner as part of a hearing aid study. Correlation of their unaided and aided responses to the same items on their previous, traditional APHAB, and those on the in situ, virtual APHAB, was then determined.

RESULTS

Rating the Recordings. The mean ratings of realism, listener envelopment, and accuracy from the normal-hearing panel are shown at their relative positions on the 7-point scale in Figure 4.

The item representing the RV subscale received the lowest score in all three categories, but no single score was less than 5.0.



Traditional vs. Virtual APHAB. The first question to be answered by the hearing-impaired subjects was if there were differences between the traditional and virtual methods on all APHAB responses, so both unaided and aided scores were compared on the two methods. The scatterplot in Figure 5 represents how the in situ, virtual APHAB scores correlate with those of the traditional APHAB on the same items. While the correlation coefficient is weak, it trends in the desired direction. Also note that the data are all below the dashed line representing equivalency. This observation suggests some global differences between the traditional and virtual APHAB methods making both unaided and aided scores lower with the virtual method.

CONCLUSIONS

Interviews were conducted with the normal-hearing panelists and the hearing-impaired APHAB subjects in order to find and reproduced for the present paper were generally more difficult than those the subjects had in mind when completing a traditional APHAB.

• Rating labels in the traditional APHAB assume aggregate experience over several exposures to the various listening situations.

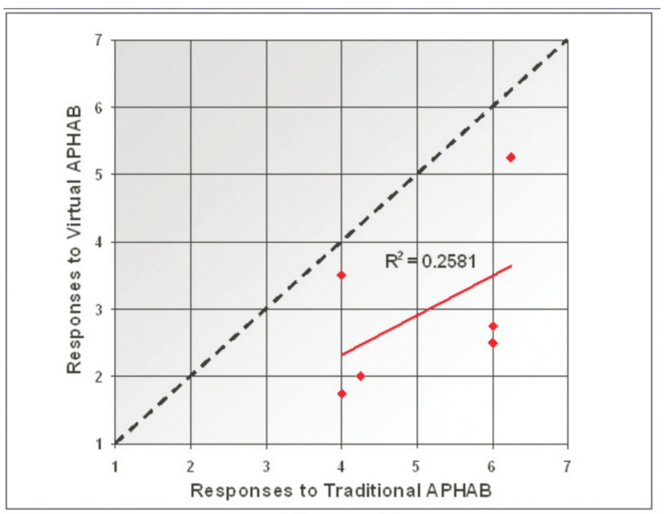


Figure 5

Now that the viability of the recording and reproducing methods have been established, future work will include multiple recordings of each APHAB item at different levels of difficulty to find those that best correlate with the traditional APHAB. Data collection at multiple sites will also be undertaken, at locations where the 2DD sound field is already installed.

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