# RELATIONSHIPS BETWEEN SPEECH DISCRIMINATION ABILITY AND COMFORTABLE LISTENING LEVELS

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## ABSTRACT

Subjects with normal hearing and sensorineural hearing loss selected comfort levels for intelligibility (MCL-I) and loudness (MCL-L). Monosyllabic Pb words and connected speech were used as stimuli. These selected comfort levels were compared to the level at which maximum discrimination (Pb Max) was obtained. Normals obtained Pb Max at a lower hearing level than MCL while hearing loss subjects selected MCL levels which were significantly lower than the level at which Pb Max was obtained. Selected levels for intelligibility and loudness of Pb words and intelligibility of connected speech were the same. Discrimination scores at the MCL levels were significantly lower than Pb Max scores for the hearing loss Ss indicating maximum discrimination would not be obtained at MCL even when Pb words were used for both measures.

## INTRODUCTION

Measurement of suprathreshold word discrimination ability is a routine part of the audiological test battery. The traditional measure of this discrimination is Pb Max (Maximum discrimination score for phonetically balanced words). Numerous suggestions have been made regarding the appropriate dB level at which Pb Max can be obtained. These include plotting an articulation function — obtaining word discrimination scores at a number of sensation levels re: SRT, (Carhart, 1965), testing at a predetermined level — usually 25 to 50 dB above SRT (Newby, 1971; Goetzinger, 1972), or testing at each subject's pre-established MCL (Berger, 1972; Goetzinger, 1972).

Plotting an articulation function has been recommended as the most accurate method (Carhart, 1965), but a survey by Martin and Pennington (1971) indicated it is used in only 3% of audiological facilities. As the procedure is time consuming it may be regarded as impractical in the clinical setting (Clemis and Carver, 1967). Obtaining Pb Max at a predetermined sensation level is often the method of choice. MCL has frequently been suggested as appropriate, and this hypothesis has been the subject of numerous investigations (Lezak, 1961, 1963; Clemis and Carver, 1967; Posner, 1974; Ulrich and Grimm, 1975; Posner and Ventry, 1977). Results of these studies suggest discrimination scores obtained at MCL are lower than Pb Max, and MCL hearing levels are also lower than those at which Pb Max is obtained.

Previous investigators typically used some form of sentence material to establish MCL, including cold running speech, connected discourse, or Fulton Lewis Jr.'s radio broadcast "Top of the News". Pb Max was obtained using phonetically balanced single words. These different stimuli could have caused at least some of the variance in HL for MCL and Pb Max. Monosyllabic words may well need to be louder for equal intelligibility. They possess restricted phoneme information and the message set is open, thus misunderstanding only one phoneme could cause a recognition error. Missed information in connected speech can be "filled in" much more easily as contextual clues are available. This filling in or "closure" could provide the additional information necessary for correct identification at quieter levels (Sanders, 1971).

MCL established with single monosyllabic words thus might be higher than MCL established with connected speech stimuli. Should this obtain and hearing levels for MCL and Pb Max be equal, clinicians could then routinely use MCL as the level for discrimination testing, confident they would be obtaining a subject's Pb Max. To investigate this possibility, the following question was posed.

Will the levels that subjects select as most comfortable for loudness (MCL-L) and intelligibility (MCL-I) be the same as the level at which Pb Max is obtained, when monosyllabic Pb words are used as stimuli?

## METHOD

### Subjects

Groups I Ss (N=15, Mean Age 20.9; Range 19-24) were normal hearing (15 dB or better, 250-6000 Hz, ANSI S3.6, 1969) students from the Communicative Disorders Program. Group II Ss (N=15, Mean Age 46.7; Range 19-68) were persons with sensorineural hearing loss. Average hearing levels (500-1000-2000 Hz) were between 35-75 dB HL. Mean SRT was 46.5 dB HL (Range 30-60 dB). A 60 dB SRT cut-off was arbitrarily selected to insure suprathreshold measures of word discrimination could be made.

All 30 Ss were fluent in English and free of any medical problems which would interfere with task performance. None had previous experience with the experimental procedure. Participation was voluntary.

### Stimulus Materials

MCL test stimuli were a cassette tape of the original Fulton Lewis Jr. radio broadcast "Top of the News", and a cassette tape of W-22 lists 1A, 2A, and 1B prepared by one of the authors. Recording of the word lists was made with an Electrovoice 638 microphone routed to a Nakamichi cassette deck. A 1000 Hz calibration tone preceded the words and the carrier phrase "You will say" was eliminated. The level of this calibration tone corresponded to the average of peak deflections on the V.U. meter for both the Fulton Lewis and Pb word stimuli. Each Pb word was separated by approximately 0.5 to 0.75 seconds and average variability among the recorded words was 1.3 dB. A cassette tape of the W-22 (Hirsh) lists was used to establish articulation functions for each subject. An earlier pilot study indicated articulation functions for the prepared lists and the original W-22 (Hirsh) lists were essentially the same.

### Instrumentation

Testing was performed in an IAC model 1204 sound suite. A Nakamichi Model 1000 cassette deck was used for recording and playback of taped material. Stimuli were routed through a GS 1701 audiometer to a TDH-39 MX41-AR cushion headset arrangement.

Ss controlled stimulus intensity with a hand switch and used the clinical method of adjustment to determine their MCL hearing levels. Their tracking of MCL was recorded on a Hewlett-Packard X-Y plotter with an attenuation rate of 2.5 dB per second. Daily calibration checks of equipment were performed.

### Procedure

Data from each subject included the following: SRT, articulation function with CID-W-

22 (Hirsh) half lists at 10, 20, 30 40, and 50 dB SL (re: SRT), MCL using Fulton Lewis "Top of the News", and MCL using the prepared list of W-22 words. Subjects were instructed to track at a level which was most comfortable with regard to intelligibility (MCL-I). Earlier research (Posner and Ventry, 1977) indicated hearing levels for MCL established with connected speech were the same for "loudness" and intelligibility, thus only intelligibility instructions were used for the Fulton Lewis measures of MCL.

The frequency dial of the GS1701 was set at "Speech" (ANSI, 1969 reference level; 20 dB SPL). Live voice SRT was established first using the 5 dB procedure (Chaiklin and Ventry, 1964). All other experimental conditions (MCL-I-Fulton Lewis; MCL-I-W-22; MCL-L-W-22; Articulation Function) were presented in random order. In addition, order of presentation regarding sensation level for articulation functions was also randomized.

MCL was determined by presenting test stimuli initially at SRT and recording subject performance over 90 seconds. Only the final 60 seconds were used for data analysis to insure that Ss had sufficient time to stabilize tracking performance. Hearing levels were determined by taking the mean of the high and low pen excursions over four-fifteen second intervals. If a high or low point lay midway between two values, the lower dB value was noted. Calculations were made after all testing was completed. If the mean MCL did not correspond to any of the 10 dB points on the articulation function, subjects were immediately given an additional half list of words at the established MCL.

## RESULTS

### Normal Hearing Subjects

As indicated in Table 1, the normal hearing Ss obtained a mean hearing level for Pb Max of 31.7 dB. Mean MCL-I HLs were 42.9 dB (Fulton Lewis) and 40.4 dB (W-22). Mean MCL-L HL was 39.2 dB (W-22). Analysis of variance indicated significance for these hearing levels ($F=25.7$ $p<0.01$). Post hoc analysis (Tukey A test, Meyers, 1966) indicated the mean HL for Pb Max was significantly lower than all three mean MCL HLs. (Fulton Lewis-1, $F=11.76$; W-22-I, $F=9.18$; W-22-L, $F=7.91$; $p<0.01$).

The mean Pb Max was 100%. Mean discrimination scores at the three MCL HLs were 100%, 99.7% and 100%. The one extremely small difference (0.3%) was not significant.

| | MCL-Intelligibility | | MCL-Loudness | Pb |
|---|---|---|---|---|
| | Fulton Lewis | PB Words | Pb Words | Max |
| Hearing Level (dBHL) | 42.9 | 40.4 | 39.2 | 31.7 |
| (SD) | (11.4) | (9.9) | (10.1) | (5.3) |
| Discrimination Score (%) | 100 | 99.7 | 100 | 100 |
| (SD) | (0) | (1.0) | (0) | (0) |

**Table 1. Mean hearing levels (in dB) and mean discrimination scores (in %) for each procedure used for normal hearing subjects.**

**Hearing Impaired Subjects**

As indicated in Table 2, the hearing loss Ss obtained a mean hearing level for Pb Max of 86.7 dB. Mean MCL-I HLs were 71.8 dB (Fulton Lewis) and 72 dB (W-22). Mean MCL-L HL was 73.0 dB (W-22). Analysis of variance for repeated measures indicated significance for these hearing levels ($F=36.7$, $p < 0.01$). Post hoc analysis (Tukey A test; Myers, 1966) indicated the mean HL for Pb Max was significantly higher than all three mean MCL HLs. (MCL-I-Fulton Lewis, $F=12.52$; MCL-I-W-22, $F=12.3$; MCL-1-W-22, $F=11.51$; $p < 0.01$). The small differences between mean MCL HLs (0.2 dB, 1.2 dB, 1.0 dB) were not statistically significant.

| | MCL-Intelligibility | | MCL-Loudness | Pb |
|---|---|---|---|---|
| | Fulton Lewis | Pb Words | Pb Words | Max |
| Hearing Level (dBHL) (SD) | 71.8 (14.4) | 72.0 (12.8) | 73.0 (12.6) | 86.7 (11.6) |
| Discrimination Score (%) (SD) | 71.8 (11.2) | 71.8 (12.2) | 72.1 (12.1) | 89.4 (9.2) |

**Table 2. Mean hearing levels (in dB) and mean discrimination scores (in %) for each procedure used for hearing loss subjects.**

The mean Pb Max was 89.4%. Mean discrimination scores at MCL-I were: 71.8% (Fulton Lewis) and 71.8% (W-22). Mean MCL-L (W-22) was 72.06%. Analysis of variance indicated significance for these discrimination scores ($F=22.30$, $p < 0.01$). Post hoc analysis (Tukey A test) indicated all three mean discrimination scores obtained at MCL were significantly lower than the mean Pb Max score [Fulton Lewis - I, $F=9.29$; W-22-I, $F=9.37$; W-22-L, $F=9.29$; $p < 0.01$]. The small differences among the three mean MCL discrimination scores (0%, 0.26%, 0.26%) were not statistically significant.

## DISCUSSION

For normal hearing Ss, the mean HL for Pb Max (31.7 dB) obtained in this study agrees well with previous data (Goetzinger, 1972, p. 159). The fact that subject selected MCL HLs were approximately 10 dB higher is not surprising as these levels (42.9 dB, 40.4 dB, 39.2 dB) approximate what is typically regarded as the level of quiet conversational speech. Even though normal listeners can obtain maximum discrimination scores at hearing levels below MCL, they "prefer" and if given the opportunity, will select a listening level for speech which is slightly higher than the level at which Pb Max can be obtained.

With regard to sensorineural hearing loss Ss, the present findings support previous research (Lezak, 1961, 1963; Posner, 1974; Ulrich and Grimm, 1976; Posner and Ventry, 1977) indicating MCL hearing levels are significantly lower than those at which Pb Max is obtained. In addition, discrimination scores obtained at MCL levels are significantly lower than Pb Max scores.

The mean MCL obtained with connected speech (71.8 dB HL) was essentially identical to both MCLs obtained with Pb words. This finding was not entirely expected. It may

have occurred because the words were separated by relatively short time periods, and subjects listened to the single words in the same manner as they listened to connected speech. Actual understanding of the words did not have to be demonstrated, as is the case when obtaining discrimination scores, thus subjects may well have selected a comfortable loudness level for listening, paying little attention to the verbal or phonemic content of the message.

Mean hearing levels for loudness (73.0 dB HL) and intelligibility (72.0 dB HL) with Pb words as stimuli were virtually identical. Both of these were also the same as the intelligibility level for connected speech (71.8 dB HL). These findings are consistent with previous research (Posner and Ventry, 1977) in which connected speech was the stimulus material.

The present data indicate that testing word discrimination of hearing loss Ss at MCL will result in incorrect estimation of maximum discrimination abilities. In this study no subject obtained maximum discrimination at MCL. In addition, attempting to establish maximum discrimination at a predetermined level, for example, 40 dB SL, will also lead to error in many cases. Only three of 15 Ss obtained their Pb Max at 40 SL, this result again being consistent with previous research (Posner and Ventry, 1977).

In summary, the present findings indicate that normal and sensorineural hearing loss subjects select the same MCL hearing levels when either connected speech or Pb words are used as stimuli. Tracking for loudness or intelligibility of the Pb words does not change the levels. Normal Ss obtain Pb Max at a level below MCL, while hearing loss Ss obtain Pb Max at a higher hearing level than any of the three selected MCLs. For hearing loss Ss, continued use of MCL as the single level for obtaining Pb Max is thus of questionable value. The most satisfactory method may still be generation of articulation functions for each subject.

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