Global Review of Speech Audiometry Tests

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Global Review of Speech Audiometry Tests

- **Historical perspective**
- **Speech audiometry is important**
  - An essential component in a diagnostic test battery
  - Types of speech audiometry procedures
  - Advantages of recorded test materials
- **Development of speech audiometry materials in the Chinese languages**
Foundation of Speech Audiometry: Bell Telephone Laboratories

Harvey Fletcher (1884-1981)  Western Electric Speech Audiometer
Bell Labs
Foundation of Speech Audiometry:
Bell Telephone Laboratories

Foundation of Speech Audiometry: Articulation Index Research is Applied in the “Count-the-Dots” Audiogram
Foundation of Speech Audiometry: Psychoacoustics Laboratory (PAL) Harvard University (1940s and 1950s)

SS Stevens (1906-1973)
Foundation of Speech Audiometry:
Psychoacoustics Laboratory (PAL)
Harvard University (1940s and 1950s)

Hallowell Davis
(1896-1992)

Ira Hirsh
(1922-2010)
Foundation of Speech Audiometry
Psychoacoustics Laboratory (PAL)
Harvard University (1940s and 1950s)

- Davis H (1948). The articulation area and the social adequacy index for hearing. Laryngoscope, 58, 761-778
Audiology Test Battery: 60+ years Ago

- Test battery at the beginning of our profession, in order of test administration
  - Air-conduction pure tone audiometry
  - Bone-conduction pure tone audiometry
  - Speech reception thresholds
  - Word recognition (PB word lists)
  - Uncomfortable loudness level (UCL), i.e., loudness discomfort level (LDL)


Raymond Carhart
James Jerger
“Father of Diagnostic Audiology”
Developed Speech Audiometry Procedures in the 1960s

GSI 162 Speech Audiometer
Audiometers for Speech Audiometry from the 1970s to the Present

GSI 10

GSI 61

GSI 16

GSI AudioStar
A Modern Audiometer for Speech Audiometry
GSI AudioStar Pro
A Modern Audiometer for Speech Audiometry
GSI AudioStar Pro
A Modern Audiometer for Speech Audiometry
GSI AudioStar Pro
Global Review of Speech Audiometry Tests

- Historical perspective
- **Speech audiometry is important to evaluate communication**
  - Types of speech audiometry procedures
  - Advantages of recorded test materials
- Development of speech audiometry materials in the Chinese languages
Speech Audiometry in Evidence-Based Practice: Categories of Research Evidence (ASHA, 2004)

**Identification**
- Screening
- History
- Self-Referral
- Professional referral

**Diagnosis**
- Immittance measures
- OAEs
- Pure tone audiometry
- **Speech audiometry**
- Special Tests

**Intervention**
- Hearing aids
- Aural Rehab
- Counseling
- Cochlear implant (s)
- Vestibular rehab
- Drugs
- Surgery

**Outcome**
- Effective communication
- Efficient communication
- Academic success
- Quality of life
Speech Audiometry Assessment of the Peripheral Auditory System
Speech Audiometry Procedures for General Auditory Assessment

- **Threshold measures**
  - Speech awareness or detection tests (SAT or SDT)
  - Speech recognition threshold (SRT)

- **Word recognition tests**
  - Phonetically balanced word lists (≥ 25 words)
  - Verbal or picture pointing response mode
  - Efficiency is increased with 10 most difficult words first
  - **Performance intensity functions are most accurate measure**

- **Speech-in-noise tests, e.g.,**
  - Speech-in-noise (SIN) or QuickSIN
  - Hearing in Noise Test (HINT)
Speech Audiometry Procedures for Performance Intensity Functions for PB Words

Copyright Pearson 2014
Hall JW III. *Introduction to Audiology Today*
A Modern Audiometer for Speech Audiometry
GSI AudioStar Pro with QuickSIN
We Hear with Our Brain! Speech Audiometry Permits Efficient and Sensitive Assessment of the Central Auditory Nervous System
Speech Audiometry Procedures for Central Auditory Assessment

- **Behavioral measures**
  - Speech-in-noise tests
  - Distorted speech tests
    - Filtered speech materials
    - Time compressed speech materials
  - **Dichotic listening tests**

- **Objective measures**
  - Speech evoked auditory brainstem response (ABR)
  - Speech evoked cortical auditory evoked responses
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- Historical perspective
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Tests consist of carefully selected words spoken by a single person without a distinct dialect

Materials are available for male or female speakers

Speech is professionally recorded in a sound studio with high quality equipment

Speech intensity level is calibrated with an audiometer and presented consistently throughout the test

Variability in patient performance is minimized permitting comparison of test results over time

Speech materials are the same
  - Each time they are used in a clinic
  - From one clinic to the next
Historical perspective

Speech audiometry is important
- An essential component in a diagnostic test battery
- Types of speech audiometry procedures
- Advantages of recorded test materials

Development of speech audiometry materials in the Chinese languages

- Cheng JY (1966). Selecting and editing of Chinese speech audiometry test lists. Zong Hua Er Bi Yan Hou Ke Za Zhi, 12, 106-111
- Shen Y & Wang SX (1983). Development of a speech audiometry testing material. Xin Li Xue Bao, 16, 75-87
Development of a Mandarin monosyllable test material with homogenous items (I): Homogeneity selection

FEI JI*, XIN XI*, AI-TING CHEN, JUN YING, QIU-JU WANG & SHI-MING YANG

Department of Otolaryngology/Head and Neck Surgery, Chinese PLA Institute of Otolaryngology, Chinese PLA General Hospital, Beijing, China
Chinese speech audiometry material: Past, present, future

XIAORAN MA1, BRADLEY McPHERSON1 & LIAN MA2

1Division of Speech and Hearing Sciences, Faculty of Education, The University of Hong Kong, Hong Kong, and 2School of Stomatology, Beijing University, Beijing, China
In 2008, the Mandarin Multisyllabic Lexical Neighbourhood Test (M-MLNT) (56) was developed, following Lexical Neighbourhood Test principles (57), which used the Neighbourhood Activation Model to evaluate speech perception performance in children with hearing loss. Since this set of lists is not constrained by phonetic balance principles, more familiar and conventional words could be used as test items. In 2008, psychometric measures of Mandarin speech intelligibility material in babble noise were published (58). The babble noise applied in this material was fitted and matched with the long-term average speech spectrum of Chinese speakers, and was designed to reflect the daily communicative environment. The 27 test lists were found to be equivalent among preschool children, and the material may be useful in the evaluation of the effectiveness of noise reduction functions in cochlear implants and hearing aids (59). Further work on this material was published in 2012 (60), with 32 test lists.

As mentioned above, speech tests for young children are few in number in China, and tone perception measures in Mandarin are also rarely reported. However, this is an important assessment area for rehabilitation outcome in a lexical tone language such as Mandarin. A study at Renmin Hospital, Wuhan University (61) made a major contribution to this area. Test materials created in this study can be applied to evaluate tone discrimination abilities for children aged two to three years, and thereby provide guidance for rehabilitation training.

In 2009, the Mandarin Paediatric Speech Intelligibility (MPSI) test and the Mandarin Early Speech Perception (MESP) test were produced. MPSI is a Mandarin closed-set sentence recognition test based on the English language Paediatric Speech Intelligibility (PSI) test and used for assessing speech perception in children as young as three years of age (62). MESP (63) has six categories of material, including speech sound detection, speech pattern, spondee, vowel, consonant and tone perception. Children as young as two years can be assessed with the MESP, and it is part of a Mandarin hierarchical test battery for evaluating speech perception in young children (63). A summary of the speech tests developed for mainland China adults is provided in Table 1.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Institute</th>
<th>Test materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhang Y et al.</td>
<td>1955</td>
<td>Beijing Hospital</td>
<td>Disyllabic words First speech test material in Mainland China</td>
</tr>
<tr>
<td>Cai X (22)</td>
<td>1963</td>
<td>PLA Guangzhou General Hospital</td>
<td>Disyllabic spondaic words First to relate speech test results to hearing loss pathologies</td>
</tr>
<tr>
<td>Cheng J (23)</td>
<td>1966</td>
<td>Shanghai Ruijin Hospital</td>
<td>Monosyllabic, disyllabic, and trisyllabic words Structure followed the test battery developed at the Harvard Psychoacoustic Laboratory</td>
</tr>
<tr>
<td>Shen Y, Wang S</td>
<td>1983</td>
<td>Institute of Psychology, Chinese Academy of Sciences</td>
<td>Monosyllabic words Psychometrical equivalence</td>
</tr>
<tr>
<td>Bao Z (25)</td>
<td>1986</td>
<td>Institute of Acoustics, Nanning</td>
<td>Monosyllabic words For assessing the intelligibility of speech transduced through communication equipment</td>
</tr>
<tr>
<td>Gu R et al. (26)</td>
<td>1986</td>
<td>PLA General Hospital, Beijing</td>
<td>Staggered spondaic words and competing sentences Collected normative data</td>
</tr>
<tr>
<td>Zhang H et al. (27)</td>
<td>1990</td>
<td>Institute of Psychology, Chinese Academy of Sciences</td>
<td>Monosyllabic words Speech material and lip-reading test material For patients with profound hearing loss</td>
</tr>
<tr>
<td>Zhang J (31)</td>
<td>1995</td>
<td>Chinese National Technical Committee</td>
<td>Monosyllabic words Standardized lists by Chinese National Technical Committee</td>
</tr>
<tr>
<td>Krenmayr A et al.</td>
<td>2011</td>
<td>Beijing Institute of Otolaryngology, and the University of Innsbruck</td>
<td>Loudness-balanced syllables in all four Mandarin tones Tonal speech test for cochlear implant adults</td>
</tr>
<tr>
<td>Chen X et al. (46)</td>
<td>2001</td>
<td>Beijing Institute of Otolaryngology</td>
<td>Words, sentences, tones, vowels, consonants Computerized training and evaluation system</td>
</tr>
<tr>
<td>Zhang H et al. (47)</td>
<td>2005</td>
<td>Brigham Young University, Utah</td>
<td>Monosyllabic words and spondaic words Well-validated phonetically balanced material</td>
</tr>
<tr>
<td>Gu X et al. (48)</td>
<td>2007</td>
<td>PLA Institute of Otolaryngology, Beijing</td>
<td>Monosyllabic words and vowels Well-validated material for assessing the multithreading of language proficiency</td>
</tr>
<tr>
<td>Niu S et al. (49)</td>
<td>2012</td>
<td>Institute of Otolaryngology, Beijing</td>
<td>Monosyllabic words and spondaic words For patients with profound hearing loss</td>
</tr>
<tr>
<td>Zhou Y et al. (50)</td>
<td>2012</td>
<td>PLA Institute of Otolaryngology, Beijing</td>
<td>Disyllabic words Materials were psychometrically equivalent and digitally recorded</td>
</tr>
<tr>
<td>Wong L et al. (74)</td>
<td>2007</td>
<td>The University of Hong Kong, and Beijing Institute of Otolaryngology</td>
<td>Sentences Adaptive test protocols for adult Mandarin speakers</td>
</tr>
</tbody>
</table>
Development of the Mandarin Hearing in Noise Test (MHINT)

Lena L. N. Wong, Sigfrid D. Soli, Sha Liu, Na Han, and Ming-Wei Huang

Objective: To develop two versions of the Mandarin Hearing In Noise Test (MHINT). These tests are adaptive tests that measure the reception threshold for sentences (RTSs) in quiet and in noise. The RTS is the presentation level at which half the sentences are correctly recognized.

Results: Two versions of the test materials, consisting of 24, 20-sentence lists each in Mandarin spoken in the Mainland (the MHINT-M) and the dialect of Mandarin spoken in Taiwan (the MHINT-T), were created from two sets of 240 sentences containing 10 syllables per sentence. The mean Quiet RTS was 14.7 dBA, using the MHINT-M, and 19.4 dBA, using the MHINT-T. Using the MHINT-M, the mean RTS for Noise Front was –4.3 dB signal-to-noise ratio (SNR), –11.7 dB SNR for Noise Right, and –11.7 dB SNR for Noise Left. Using the MHINT-T, the Noise Front RTS was –4.0 dB SNR, –10.7 dB SNR for Noise Right, and –11.0 dB SNR for Noise Left. Results in noise are slightly better than those seen for the English HINT norms. Response variability within list was low, and inter-list reliability was high, indicating that consistent results can be obtained using any list. Confidence intervals are reported.

Conclusions: The two versions of the MHINT are the first standardized Mandarin sentence speech intelligibility tests. Similar to other language versions of the HINT, the MHINT was developed using the same rationale as the English HINT, allowing norm-referenced results for the MHINT to be compared directly with results in other languages. The MHINT would benefit from further evaluation of its validity.

Speech audiometry serves as a diagnostic tool and an outcome measure in the evaluation of hearing devices. Such evaluation of Chinese speakers is difficult, since there are only a few monosyllabic or spondaic test materials available (e.g., Zhang, 1990), evaluation of candidacy and outcomes is difficult. The making of a Chinese speech test is a major challenge, because there are multiple dialects of Mandarin spoken in the Mainland, Taiwan, and around the world. Diversities in accent and vocabulary are enhanced by differences in urbanization, traditions, and educational status. The form of Mandarin spoken in Mainland China is also referred to as Putonghua. This research developed two versions of a Mandarin sentence test, the Mandarin Hearing In Noise Test (MHINT), for use in Mainland (the MHINT-M) and Taiwan (MHINT-T), respectively. Because Mandarin is a tonal language, lexical tone must be considered in developing the MHINT.

The development of the MHINT follows its predecessors, the English HINT (Nilsson et al., 1994) and the Cantonese-Chinese HINT (CHINT; Wong & Soli, 2005). The HINT measures Reception Threshold for Sentences (RTS), defined as the presentation level necessary for a listener to recognize half the sentences accurately (Nilsson et al., 1994; Wong & Soli, 2005). Four studies were undertaken to (1) develop sentence materials, (2) equalize sentence difficulty, (3) create sentence lists; and (4) evaluate within-list response variability and inter-list reliability, and produce normative data.
Development of the Cantonese Hearing In Noise Test (CHINT)

Lena L. N. Wong and Sigfrid D. Soli

Objective: To develop a Cantonese version of the Hearing In Noise Test (CHINT) with the same features as the English Hearing In Noise Test (HINT) (Nilsson, Soli, & Sullivan, 1994).

The CHINT would benefit from further evaluation of validity.

(Ear & Hearing 2005;26;276–289)

These 549 sentences were judged to be natural and easily understood by children at first grade level. The resultant PI function slope was 9.7% per dB change in SNR, quite similar to that of 10% per dB for the American English HINT (e.g., Eisenberg et al., 1998). This PI function slope could be used in the following study to determine the amount of RMS level adjustment to be made on each sentence to equate the difficulty level.

The overall mean standard deviation of performance of the three subjects across the various SNRs was 15.3%. The PI function slopes for these longer, more complex sentences were much more consistent across subjects than those in the pilot study. Thus, these 10-character sentences were deemed suitable materials for an adaptive test procedure.

Study II: Equating Sentence Difficulty

The difficulty of sentences was equated in this study so that the materials can be used for adaptive testing. The presentation levels of difficult sentences were made higher so that subjects can hear them better; the levels of easy sentences were reduced to increase their difficulty level. The aim is to have a set of sentences with equal difficulty.

Subjects

A total of 30 subjects, divided into five groups of six each, participated in this study. These subjects were different from those who participated in the pilot study. Each group of subjects participated in one round of testing. Six subjects were used because this sample size as used in the study by Nilsson et al. (1994) yielded reliable scaling factors for equating the difficulty of sentences. Testing performed later on a larger sample showed small measurement errors, like the English HINT materials. The number of subject groups was dependent on the number of test iterations required to equalize the sentences. Five iterations were required for the Cantonese sentences.

Equipment

The sentences and the speech-spectrum shaped noise were presented via a computer. The signals were mixed and played back using custom software and a Soundblaster (Live Value) sound card connected to a Madsen OB822 audiometer. The output of the headphones was calibrated daily to present the speech-spectrum noise at 65 dB A, as measured in a 6-cc coupler.

Procedures

Sentences must be evaluated at a SNR that does not yield ceiling and floor effects, to determine the scaling factor necessary to adjust the level of the sentences to equate their intelligibility in noise. The PI function study in study I showed that a SNR of $\frac{1}{2} \pm 6$ dB yielded an average of 65% of words repeated correctly in the sentences. This SNR was selected as the starting point to estimate the scaling factor.

The 549 sentences were presented at $\frac{1}{2} \pm 6$ dB SNR with noise set at 65 dBA to the first group of subjects. The mean percent correct score of each sentence was calculated from the number of characters repeated correctly by each subject. Exact repetition was required. Sentences with large inter-subject variations (i.e., standard deviations greater than 25%) or that were too difficult (scores less than 30%) were discarded. These difficult sentences often had a few sounds that some subjects found particularly difficult to recognize and might have required a high presentation level that would result in clipping of signals. The reference point for scaling was defined as the average score for the remaining sentences, that is, 65% correct. Based on a PI function slope of 9.7% per dB change in SNR, the overall RMS level of each sentence was increased 1 dB for each 9.7% below the 65% reference point and reduced 1 dB for each 9.7% above the reference of 65%. These modified SNRs were used for testing in the second round.

Additional criteria were used to evaluate the sentences based on their average scores from the second round of testing:

1. Sentences yielding scores that were not within $\pm 25\%$ of the 65% target were rejected, that is, those sentences where the average scores exceeded the range of 40 to 90% correct.
2. Those sentences with reversed scores, that is, better SNR in the second round of testing resulted in poorer intelligibility, or vice versa, were removed.

The same procedure was repeated for three additional rounds of testing. The sentences were scaled according to the results of each round before the next round of testing. Sentences tested in the second through the fifth rounds were selected using the criteria above. Sentences with intelligibility within

Fig. 1. Long-term average spectrum of Cantonese and English Hearing In Noise Test speech and noise.

**Two Syllable Word Materials**

### Appendix 1

Example of disyllable test list.

<table>
<thead>
<tr>
<th>Number</th>
<th>Mandarin</th>
<th>Chinese Pinyin</th>
<th>English meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>上课</td>
<td>shàng kè</td>
<td>class</td>
</tr>
<tr>
<td>2</td>
<td>集合</td>
<td>jí hé</td>
<td>put together</td>
</tr>
<tr>
<td>3</td>
<td>大门</td>
<td>dà mén</td>
<td>gate</td>
</tr>
<tr>
<td>4</td>
<td>设立</td>
<td>shè lì</td>
<td>found</td>
</tr>
<tr>
<td>5</td>
<td>担心</td>
<td>dān xīn</td>
<td>worry</td>
</tr>
<tr>
<td>6</td>
<td>忘记</td>
<td>wàng jì</td>
<td>forget</td>
</tr>
<tr>
<td>7</td>
<td>道歉</td>
<td>dào qiàn</td>
<td>sorry</td>
</tr>
<tr>
<td>8</td>
<td>电池</td>
<td>diàn chí</td>
<td>battery</td>
</tr>
<tr>
<td>9</td>
<td>地址</td>
<td>dì zhì</td>
<td>address</td>
</tr>
<tr>
<td>10</td>
<td>儿童</td>
<td>ér tóng</td>
<td>child</td>
</tr>
</tbody>
</table>
Appendix 2
Example of sentence test list.

<table>
<thead>
<tr>
<th>Number</th>
<th>Mandarin Sentence</th>
<th>Number of keywords</th>
<th>Chinese Pinyin</th>
<th>English meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>快请进！</td>
<td>2</td>
<td>kuài qǐng jìn!</td>
<td>Please come in!</td>
</tr>
<tr>
<td>2</td>
<td>现在起床。</td>
<td>2</td>
<td>xiàn zài qǐ chuáng.</td>
<td>Get up now.</td>
</tr>
<tr>
<td>3</td>
<td>这双鞋太小了。</td>
<td>3</td>
<td>zhè shuāng xiē tài xiǎo le.</td>
<td>These shoes are too small.</td>
</tr>
<tr>
<td>4</td>
<td>他去邮局买邮票。</td>
<td>7</td>
<td>tā qù yóu jú mǎi yóu piào.</td>
<td>He goes to the post office to buy stamps.</td>
</tr>
<tr>
<td>5</td>
<td>星期天一起去爬山。</td>
<td>7</td>
<td>xīng qī tiān yī qǐ qù pá shān.</td>
<td>We will climb a mountain together on Sunday.</td>
</tr>
<tr>
<td>6</td>
<td>借的东西我已经还了。</td>
<td>6</td>
<td>jiè de dōng xī wǒ yǐ jǐng huá le.</td>
<td>I already returned all the things I borrowed.</td>
</tr>
</tbody>
</table>
International Hearing Care Technician Certificate
American Institute of Balance
www.dizzy.com or http://aicme.com

Purpose

1. Reach over 278 million children & adults who are in need of hearing healthcare services.

2. Educate technicians to support physicians & audiologists, increasing capacity.

3. Create jobs with the IHCT Certificate, improving sustainability.

4. Utilize existing internet access for online education. Classes may be viewed on computers, tablets and smart phones.
**Core Curriculum**

Is designed to provide general knowledge and skills required by a hearing care technician who will work under the supervision and direction of a physician, otolaryngologist or audiologist. Successful completion of the core curriculum leads to a Hearing Care Technician Certificate.

**Each Course features**

A 48-60 minute instruction through a narrated PowerPoint presentation on a focused topic. Presentations include text, figures, and video demonstrations to enhance the learning experience.

Selected readings and resources, including websites and other internet sources information, are recommended for each topic.

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24/7 access to courses and content. Enduring – you own the courses / materials forever.

**International Hearing Care Technician Certificate**

American Institute of Balance

www.dizzy.com or http://aicme.com
### Basic hearing
- Auditory anatomy and physiology
- Hearing & Sound (hearing science)
- Professional responsibility
- History taking and record keeping
- Patient contact and counseling
- Medical and audiological terminology

### Auditory disorders
- Otoscopic inspection and ear examination
- Middle ear disorders
- Inner ear disorders
- Retrocochlear (neural) disorders

### Assessment Techniques
- Introduction to the audiometer
- Pure tone hearing test techniques: Air conduction
- Pure tone hearing test techniques: Bone conduction
- Masking theory and techniques
- Audiogram patterns
- Simple speech audiometry
- Tympanometry
- Otoacoustic emissions
- Introduction to diagnostic audiological assessment
- Audiology applications of tele-health