Protocols for the Development of HINT in A New Language

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Introduction

Development of the HINT in any new language is a collaborative project between the local researchers in the country where the language is spoken and the researchers at HEI. Development of the HINT proceeds through several well-defined steps. This document describes each step in detail, providing information about the amount of time and resources required for each step.

Step 1: Prepare Written Sentences

Objective

The objective of this step is to produce a set of 700-800 simple sentences that will be recorded for possible use in the new HINT. These sentences should be short enough so that they do not require extensive memory. (The English sentences are 5-7 syllables in length.) The vocabulary, syntax, and usage should be "natural," as rated by native speakers of the language.

Procedure

1. **Make lists of sentences**. Sentences can be found in children's books, from translation of HINT sentences in other languages (e.g., English), or they can be written. The sentences should be typed into an Excel file with one sentence per row for later use in obtaining naturalness ratings.
2. **Determine naturalness of sentences**. Prepare a naturalness rating form by adding columns to the Excel file for naturalness ratings (1-5) and suggested modifications to improve naturalness. Print these forms. Ask 5-7 subjects who have not participated in the development of the sentences to read each sentence and rate its naturalness. Explain that a natural sounding sentence is one that has no unusual words and that sounds like it could be used in normal conversation. If a sentence is rated as unnatural, the subject should give written suggestions how the sentence could be changed to make it sound more natural.

Results

The ratings of the 5-7 subjects should be pooled in an Excel file so that the average rating for each sentence can be calculated. Suggested changed to improve naturalness should be made, and the changed sentences should be identified in the file. Sentences that receive consistently low ratings and that cannot be changed to improve their naturalness should be deleted from the file. This file can be emailed to HEI for use in recording the sentences.

Staffing

Preparation of the sentences can be done by a Masters level graduate student in the Hearing and Speech or Communication Disorders Department. Ideally, two graduate students should work together on this task under the supervision of a faculty member with expertise in one or more of the following areas: speech

pathology, speech science, linguistics, audiology, experimental psychology. HINT development often works well as a Masters thesis project for one or two students.

Resources

No special resources are required, except for a computer with Excel software and access to email and the Internet.

Time and Effort

Prepare sentence lists: 2-3 days.

Obtain and score naturalness ratings: 2-3 days.

Step 2: Make Recordings of Sentences

Objective

The objective of this step is to make high quality digital recordings of the selected sentences. These recordings will be edited and processed for subsequent use in the listening tests to be performed in the country where the HINT will be used.

Procedure

The sentence lists will be recorded at HEI using a professional voice actor who is a native speaker of the language. We will work closely with the collaborators in the country and local resources to identify the appropriate person for the recordings. The recordings will be made on DAT and transferred digitally to computer for editing and processing. The sentences will be equalized for RMS level, and their long-term average spectrum will be calculated. A masking noise with the same spectrum and RMS level as the sentences will be synthesized. The sentences and noise will be placed in an appropriate file format for use with the testing software.

Results

Digital files containing each individual sentence and the masking noise will be produced in a format compatible with the HEI software used for the listening tests. These files will be placed on HEI's web site for download using FTP. A CDROM containing these materials will also be prepared and mailed to the collaborators to provide backup for the FTP files.

Staffing

All staffing for this task will be provided by HEI, including the professional voice actor and a person who is fluent in the language to assist with editing and processing of the recordings.

Resources

All resources for this task will also be provided by HEI.

Time and Effort

Recording and transfer of sentences to computer: 2 days.

Editing and processing of sentences: 10 days.

Step 3: Determine Performance-Intensity Function

Objective

The objective of this step in the development of the HINT is to estimate the relationship between S/N ratio and percent word intelligibility in the sentences. This relationship is defined by the performance-intensity function (PI function). The PI function will be used in the remainder of the project to determine how to adjust the S/N ratio for individual sentences to equalize their intelligibility in noise.

Procedure

A group of 10 native users of the language with normal hearing should be tested to estimate the PI function. Each subject should have audiometric thresholds ≤ 25 dBHL for 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The age range for the subjects is from 20 to 50 years. Each subject should be a native speaker of language, and educated in the language at least through age 17.

The recorded sentences and masking noise together with software for conducting the listening tests will be provided by HEI. The following steps should be followed to install the software and to calibrate the sound output levels.

1. **Software installation**. Copy the "MySpeechFiles" and "HINT Study" folders from the CDROM to the root directory on the C: drive. The "MySpeechFiles" folder contains the Speech Utility program (SpchUtil.exe) and all of the sound files: the sentences, the masking noise, and a calibration tone. The "HINT Study" folder contains the subject data files and script files for the percent-intelligibility (PI) and equalization (EQ) studies.
2. **Calibration**. The output from the sound card should be routed to one of the tape inputs for the audiometer. Use the following procedure for loudspeaker calibration. A measuring microphone should be positioned 1 meter from the face of the speaker that will be presenting the speech stimuli. (During subject testing, the center of the subject's head should be positioned 1 meter from the speaker. The subject should face the speaker.) Launch the Speech Utility program found in the "MySpeechFiles" folder. In the Speech Utility program (Figure 1) enter the path and file name for the calibration tone (SpCal.wav) in the "Noise File" field. This may be done simply by using the Browse button to navigate to the file. On the audiometer, select tape input, soundfield speaker and select the interrupt switch for continuous play. In the Speech Utility program, select the "Play Noise Only" button and present the tone. Set the vu meter of the audiometer to 0 dB VU. Next, enter the path and file name for the calibration noise (SpNoise.wav) into the "Noise File" field. Select the "Play Noise Only" button to present the noise to the soundfield speaker. Adjust the audiometer attenuator until the level of the noise at the measuring microphone reaches 65 dBA. Write down the dial setting of the audiometer that produces 0 dB VU. The VU meter must be set to 0 dB VU for the calibration tone and the audiometer dial must be set to the level established above in order to produce a noise level of 65 dBA. If headphones are to be used for testing, the calibration procedure is the same, except that an appropriate headphone coupler is used in conjunction with the measuring microphone and sound level meter to make the sound measurements.

The purpose of this study is to determine the PI function by measuring intelligibility at three signal to noise ratios (S/N ratios) using the spectrally matched masking noise. Three 50-sentence lists will be used in this study. The noise level will be fixed at 65 dBA. The tester will determine the number of words repeated correctly at each of the following S/N ratios: -7 dB S/N, -4 dB S/N, and –2 dB S/N. Ten subjects should be tested, with each subject listening to all three S/N ratios. Conditions should be presented in the order listed below. The legend for the table is as follows. Order: sequential order in which the test conditions are to be administered. List: the list number to be used in each test condition. Script: the name of the script file used by the testing software to select the specific sentences and to set the S/N ratio for the test. (By selecting the specified script file, the correct list and S/N ratio will be administered to the subject in

each condition.) For example, Subject 1 will be tested first at –7 dB S/N with list 2 using script file PI2a, second at –4 dB S/N with list 3 using script file PI3b, and third at –2 dB S/N with list 1 using script file PI1c. This design ensures that each list will be used at each S/N ratio in each testing order.

	-7 dB S/N			**-4 dB S/N**			**-2 dB S/N**		
Subject	**Order**	**List**	**Script**	**Order**	**List**	**Script**	**Order**	**List**	**Script**
1	1	2	PI2a	2	3	PI3b	3	1	PI1c
2	2	3	PI3a	3	2	PI2b	1	1	PI1c
3	3	2	PI2a	1	1	PI1b	2	3	PI3c
4	3	3	PI3a	2	1	PI1b	1	2	PI2c
5	1	1	PI1a	3	2	PI2b	2	3	PI3c
6	2	1	PI1a	1	3	PI3b	3	2	PI2c
7	1	2	PI2a	2	3	PI3b	3	1	PI1c
8	2	3	PI3a	3	2	PI2b	1	1	PI1c
9	3	2	PI2a	1	1	PI1b	2	3	PI3c
10	3	3	PI3a	2	1	PI1b	1	2	PI2c

Subject information and scoring forms for individual subjects will be prepared by HEI and provided with the software. These forms can be printed for use with each subject. The subject should complete the Subject Information Form. The Data Form will be used for sentence scoring by the tester.

Subjects should be instructed to listen carefully to each sentence presented in noise. After each sentence is presented, the subject is to repeat as much of the sentence as possible. Subjects should be encouraged to guess, if they are unsure of the sentence. After each sentence response, the tester will write the number of words correct for the sentence on the score sheet. The following is a detailed step-by-step description of the test protocol for the PI study.

1. In the Speech Utility program (SpchUtil.exe) enter the path and file name for the calibration tone (SpCal.wav) in the “Noise File” field.
2. On the audiometer select tape input and speaker or headphone for output.
3. In the Speech Utility program, select the “Play Noise Only” button and present the tone. Set the vu meter of the audiometer to 0 dB vu.
4. Next, enter the path and file name for the calibration noise (SpNoise.wav) into the “Noise File” field.
5. Select the “Play Noise Only” button to present the noise to the soundfield speaker. Listen to make sure that the noise is delivered through the appropriate speaker.
6. Adjust the audiometer attenuator to the dial setting found in the calibration procedure. Throughout the PI study the audiometer dial, or vu meter settings will not be adjusted.
7. Refer to the table above and enter the appropriate path and file name for the script file in the Speech Script File field of the Speech Utility.
8. Set the following test parameters in the Speech Utility program; Test in Noise, Noise begins 0.5 seconds before speech, Noise ends 0 seconds after speech, Play Files Individually.
9. Instruct the subject to listen carefully to each sentence and repeat as much of the sentence as possible. Also, encourage the subject to guess if he/she is unsure of what the sentence is.
10. With the appropriate sentence list in hand, select the Begin button to present the first sentence.
11. After the subject repeats the sentence, count the number of words correct and enter this in the Words Correct column of the Data form.

12. Select the Next button to deliver the next sentence.
13. Repeat the procedure above for each of the 50 sentences in the list.
14. At the conclusion of the test, enter the response data and the subject information in the appropriate Excel files for transfer via email to HEI.

Results

The results of this study will be completed data sheets for 10 subjects tested at three S/N ratios. Average percent intelligibility at each S/N ratios will be calculated for the 10 subjects and a linear function will be fit to the three data points (one for each S/N ratio). The slope of this function will be calculated in percent intelligibility change / dB S/N ratio change. This slope is expected to be approximately 10% / 1 dB S/N. The calculated slope will be used determine how much each sentence's RMS level needs to be adjusted to equate intelligibility in a fixed level masking noise during the next study.

Staffing

This study can also be done by a Masters level graduate student in the Hearing and Speech or Communication Disorders Department. Ideally, two graduate students should work together on this task under the supervision of a faculty member with expertise in one or more of the following areas: speech pathology, speech science, linguistics, audiology, experimental psychology.

Resources

A PC with a sound card, an audiometer or suitable audio amplifier, a soundroom with loudspeaker and/or headphone, an intercom system, and access to email and internet are needed for this study. A sound level meter is required for calibration of the loudspeakers. If testing is to be done under headphones, a headphone coupler will also be needed in combination with the sound level meter for calibration of the headphones.

Listening tests should be administered in a soundroom if possible. However, if the sentences are to be administered via headphones, a quiet room may be used instead.

Time and Effort

Setup, calibration, and practice: 1-2 days.

Test 10 subjects and enter data in Excel forms: 5-7 days.

Step 4: Equalize Sentence Intelligibility

Objective

The objective of this study is to equate the intelligibility of the HINT sentences when they presented in masking noise at a fixed level. The RMS level of easy sentences is reduced slightly, thus reducing their S/N ratio slightly, to make them more difficult. Likewise, the RMS level of difficult sentences is increased to make them easier. The amount by which sentence RMS levels is increased or decreased is based on the slope of the PI function determined in the previous study. Sentences that are very easy or very difficult are identified and deleted, as are sentence that do not exhibit appropriate changes in intelligibility after their S/N ratio has been adjusted.

Procedure

A group of 10 native users of the language with normal hearing should be tested in each round of equalization testing. As many as four rounds of testing may be needed with a new set of 10 subjects recruited

for each round. Each subject should have audiometric thresholds ≤ 25 dBHL for 250, 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz. The age range for the subjects is from 20 to 50 years. Each subject should be a native speaker of the language, and educated in the language at least through age 17.

The specific aim of this study is to determine the percent words correct for each sentence delivered at a S/N ratio that corresponds to 70% intelligibility, as determined from the results of the PI study. Several rounds of testing will be required, with adjustments to the RMS levels of the sentences that deviate from 70% intelligibility after each round. Ten subjects should participate in each round of testing. Each subject will listen to five sentence lists in the randomization order specified in the table below. The associated script files and list numbers are also listed below. (New tables will be produced for each round of testing at the time this study is performed.)

Subject	**List 1 Script EQ 1**	**List 2 Script EQ 2**	**List 3 Script EQ 3**	**List 4 Script EQ 4**	**List 5 Script EQ 5**
1	1	5	3	2	4
2	5	2	3	4	1
3	3	2	4	1	5
4	3	1	4	5	2
5	3	5	2	4	1
6	3	1	4	2	5
7	3	1	2	4	5
8	4	1	5	2	3
9	5	2	1	3	4
10	1	5	4	3	2

Subject information and scoring forms for individual subjects will be prepared by HEI and provided with the software, as in the previous study. These forms can be printed for use with each subject. The subject should complete the subject information form. The data form will be used for sentence scoring by the tester.

Once the data forms are completed, the tester should transfer the scores on each sentence from the paper form to the Excel spreadsheet, which will automatically score the sentences and the lists. The following is a detailed step-by-step description of the protocol for the equalization study.

1. In the Speech Utility program (SpchUtil.exe) enter the path and file name for the calibration tone (SpCal.wav) in the "Noise File" field. This may be done by simply using the Browse button to navigate to the appropriate file.
2. On the audiometer select tape input and speaker or headphone for output.
3. In the Speech Utility program, select the "Play Noise Only" button and present the tone. Set the vu meter of the audiometer to 0 dB vu.
4. Next, enter the path and file name for the calibration noise (SpNoise.wav) into the "Noise File" field. This may be done by simply using the Browse button to navigate to the appropriate file.
5. Select the "Play Noise Only" button to present the noise to the soundfield speaker. Listen to make sure that the noise is delivered through the appropriate speaker.
6. Adjust the audiometer attenuator to the dial setting found in the calibration procedure. Note that the audiometer dial setting is the level required to deliver a noise level of 65 dBA. The audiometer dial setting is not necessarily equal to the actual level of the noise. Throughout this study the audiometer dial, or vu meter settings will not be adjusted.

7. Refer to the table above and enter the appropriate path and file name for the script file in the Speech Script File field of the Speech Utility. Make sure that the appropriate S/N ratios have been entered in the Speech Script File.
8. Set the following test parameters in the Speech Utility program; Test in Noise, Noise begins 0.5 seconds before speech, Noise ends 0 seconds after speech, Play Files Individually.
9. Instruct the subject to carefully listen to each sentence and repeat as much of the sentence as possible. Also, encourage the subject to guess if he/she is unsure of what the sentence is.
10. With the appropriate sentence list, select the Begin button to present the first sentence.
11. After the subject repeats the sentence. Count the number of words correct and enter this in the Words Correct column of the Data form.
12. Select the Next button to deliver the next sentence for the remaining sentences in the list.
13. Refer to the table above for the next list and script file.
14. At the conclusion of the test, enter the data in the appropriate Excel file.

These steps will be repeated for each round of testing. After a round of testing has been completed, the Excel files containing the data for each subject will be emailed to HEI for processing and analysis. The results of the analysis will be a set of new script files (one for each of the five lists) that will contain the adjusted RMS levels for each sentence. The adjustments made between rounds will attempt to equalize the intelligibility of all sentences to approximately 70% words correct.

The new script files will be emailed from HEI after each round of testing. Subjects for the next round of testing can be recruited during the time HEI is scoring the data from the current round.

Results

The results of the equalization study will produce a set of at least 240 HINT sentences of approximately equal 70% intelligibility when presented in masking noise at 65 dB(A). Many of the sentences will have had small adjustments to RMS level to equate their intelligibility in fixed level noise. These small RMS adjustments will be permanently applied to the sentences for use in subsequent adaptive testing. At least two additional sets of 20 sentences each will also be identified for use as practice materials. The remaining rejected sentences can be used for other research purposes.

Staffing

This study can also be done by a Masters level graduate student in the Hearing and Speech or Communication Disorders Department. Ideally, two graduate students should work together on this task under the supervision of a faculty member with expertise in one or more of the following areas: speech pathology, speech science, linguistics, audiology, experimental psychology.

Resources

A PC with a sound card, an audiometer or suitable audio amplifier, a soundroom with loudspeaker and/or headphone, an intercom system, and access to email and internet are needed for this study. A sound level meter is required for calibration of the loudspeakers. If testing is to be done under headphones, a headphone coupler will also be needed in combination with the sound level meter for calibration of the headphones.

Listening tests should be administered in a soundroom if possible. However, if the sentences are to be administered via headphones, a quiet room may be used instead.

Time and Effort

Test 10 subjects in one round of the equalization study and enter data in Excel forms: 5-7 days.

NOTE: As many as three or four rounds of testing may be required to complete this study.

Step 5: Make Sentence Lists

Objective

The objective of this study is to form 24 phonemically matched 10-sentence lists from the 240 sentences. Pairs of these 10-sentence lists will be combined to make 12 20-sentence lists that will ultimately comprise the HINT materials.

Procedure

A phonemic transcription of each of the 240 sentences needs to be made. These transcriptions are used to obtain a count of individual phonemes in each sentence. The phoneme counts are pooled across all sentences to determine the phoneme distribution for the entire 240-sentence set. Sets of 10 sentences are formed and the phoneme distribution of each is compared with the overall distribution. A trial-and-error procedure is used to adjust the composition of the 24 10-sentence sets to obtain the closest match of their distributions to the overall distribution.

Once an acceptable composition of the 10-sentence lists is formed, adaptive HINT thresholds are measured for each in a sample of 5-7 subjects who meet the same selection criteria as in the previous studies. Thresholds are averaged across subjects for each list, and the lists with the highest and lowest thresholds are combined to make a 20-sentence list. Next, the 10-sentence lists with the highest and lowest thresholds from the remaining lists are combined to make another 20-sentence list. This procedure is repeated until 12 20-sentence lists have been formed. The phoneme distributions of these lists are calculated and compared with the overall distribution to ensure that none of the pairings have produced discrepant phoneme distributions.

Results

The results of this study will comprise the final 20-sentence lists for use in adaptive HINT threshold measurements. The 20-sentence lists will be phonemically matched with the overall phoneme distribution of the entire sentence set. The lists should also be of approximately equal difficulty, as determined from the equalization study and the procedure used to pair the easiest and most difficult 10-sentence lists. The 20-sentence lists will be in a form that will allow them to be installed as a new language module in the HINT for Windows system.

Staffing

This study can also be done by a Masters level graduate student in the Hearing and Speech or Communication Disorders Department. Ideally, two graduate students should work together on this task under the supervision of a faculty member with expertise in one or more of the following areas: speech pathology, speech science, linguistics, audiology, experimental psychology.

Resources

A PC with the HINT for Windows system, a soundroom with loudspeaker and/or headphone, an intercom system, and access to email and Internet are needed for this study. A sound level meter is required for calibration of the loudspeakers. If testing is to be done under headphones, a headphone coupler will also be needed in combination with the sound level meter for calibration of the headphones.

The HINT for Windows system consists of the hearing test device (HTD) manufactured by Maico Diagnostics, the CDROM containing Version 6.2.X software and language modules, and associated cables and connectors.

Listening tests should be administered in a soundroom if possible. However, if the sentences are to be administered via headphones, a quiet room may be used instead.

Time and Effort

Make phonemic transcriptions of all sentences and form phonemically matched 10-sentence lists: 3-4 days.

Measure adaptive HINT thresholds with 20-sentence lists for 5-7 subjects: 2-3 days.

Step 6: Develop Norms and Reliability for Lists

Objective

The objective of this study is to develop norms for the HINT in the standard test conditions: Quiet, Noise Front, Noise Right, and Noise Left. Norms can be developed for both headphone and soundfield administration, depending on how the test is to be used. A second objective of this study is to determine the reliability and measurement error of the HINT.

Procedure

The norms and reliability assessment can be performed in conjunction with other research and clinical applications of the HINT. Normally hearing subjects, as defined in the previous studies, should be administered the HINT in each of the standard test conditions. Ideally, two HINT thresholds should be measured per condition to allow calculation of test-retest reliability. Approximately 50 subjects should be tested in the standard conditions to produce acceptable norms and reliability coefficients.

Results

The norm results will consist of mean and standard deviations for HINT thresholds in each condition. Once the normative parameters are known, they can be entered into the HINT for Windows software in the HINT module to be used in scoring and interpretation of results.

Staffing

No additional staffing is required for this study if the normative and reliability data are collected in conjunction with other research and clinical applications of the HINT. If the norms and reliability are to be established in a separate study, the same staffing as in the previous studies is recommended.

Resources

A PC with the HINT for Windows system, a soundroom with two loudspeakers and headphones, an intercom system, and access to email and Internet are needed for this study. A sound level meter is required for calibration of the loudspeakers. If testing is to be done under headphones, a headphone coupler will also be needed in combination with the sound level meter for calibration of the headphones.

The HINT for Windows system consists of the hearing test device (HTD) manufactured by Maico Diagnostics, the CDROM containing Version 6.2.X software and language modules, and associated cables and connectors.

Time and Effort

If the norms and reliability studies are conducted apart from other research studies, approximately two hours per subject will be required for testing (audiogram plus 12 20-sentence HINT lists). Up to 50 subjects should be tested to establish the headphone and soundfield norms.

Summary of Staffing, Resources and Time/Effort for Entire HINT Development Project

Study	Staffing	Resources	Time/Effort
1. Prepare Sentences	1 or 2 Masters students, faculty advisor (communication disorders or audiology)	PC with internet/email access, Excel	4-6 days
2. Record Sentences	HEI task	HEI task	HEI task
3. Measure PI Function	Same as 1.	PC, soundcard, audiometer, soundroom, headphones or speakers, sound level meter, testing software, sentence and noise recordings	6-9 days
4. Equalize Sentences	Same as 1.	Same as 3.	15-30 days
5. Form Sentence Lists	Same as 1.	PC, HINT for Windows system, headphones or speakers, sound level meter, language module	5-7 days
6. Develop Norms	Same as 1.	Same as 5, except must have both headphones and speakers.	25-30 days (optional)
TOTAL TIME/EFFORT Required (no Norms) 30 days minimum 52 days maximum Optional (with Norms) 55 days minimum 82 days maximum			