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Validation of the Rapid Speech Transmission Index (Rasti) in a Classroom Environment

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VALIDATION OF THE RAPID SPEECH TRANSMISSION INDEX (RASTI) IN A CLASSROOM ENVIRONMENT

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PROBLEM STATEMENT

Because the acoustics of a room have a substantial impact on speech intelligibility, researchers have tried over the years to develop the most effective way to evaluate the effects of the acoustic environment on speech intelligibility. Both subjective and objective measures of speech intelligibility have been devised. For the purposes of this study, subjective measures are those in which a speech recognition test is given to a group of subjects whose scores provide a direct indication of speech intelligibility at each position in the listening environment (Steeneken & Houtgast, 1980). Objective measures are those that determine the acoustic factors that affect speech intelligibility in a room, and through the use of a formula or calculation scheme, determine the loss of speech intelligibility in a room (Rao, 1992). Subjective measures are useful in that they have high face validity, but they require trained listeners and speakers. They can become expensive and also can take a long time to do (Rao, 1992). Objective measures are less time consuming and less expensive, but their face validity is low. Because of the ease of using objective measures, researchers have attempted to prove their validity by comparing them with subjective measures (Houtgast, 1981; Houtgast & Steeneken, 1984).

Objective measures of speech intelligibility, such as the Speech Transmission Index (STI), have become very useful in the measurement of the speech intelligibility of large auditoriums (Rao, 1992). The STI, developed over several years, takes into

account the three factors that most affect speech intelligibility in rooms. These three factors are background noise, reverberation time, and distance from the speaker (Berg, 1987). The use of the STI in auditoriums has been validated in a number of studies by comparing the STI scores with subjective measures using talkers and listeners (Rao, 1992). In one such study, Houtgast and Steeneken (1984) tested a simplified version of the STI, the Rapid Speech Transmission Index (RASTI), in auditoriums in seven countries and found the objective measures provided by the RASTI to be in good agreement with subjective word recognition scores. This study, and others like it, have helped validate the wide use of objective measures in the acoustic assessment of auditoriums.

Speech intelligibility is such a vital consideration for learning in the classroom (Ross, 1972) that this listening environment would benefit greatly from efforts to determine how to best assess its acoustic characteristics. Because of the greater ease of use of objective measures, it would be advantageous to know if objective measures can accurately assess the degradation of speech intelligibility in a classroom. Unfortunately, few studies have addressed the issue of whether or not objective measures, including both the STI and the RASTI, are valid indicators of this degradation.

A study by Houtgast (1981) tested the effect of ambient noise on speech intelligibility in the classroom by comparing the results obtained from the STI with a subjective measure, the

Articulation Loss of Consonants. It was shown that agreement between the two measures was very high for young adult listeners with normal hearing.

Leavitt and Flexer (1991) used the RASTI to evaluate the degradation of the speech signal in a classroom. Their results showed objective measurements that systematically decreased as the distance from the source increased, but they did not validate their findings with a subjective measure of speech intelligibility.

Rao (1992) attempted to test the validity of the RASTI in a classroom. She compared the objective measurements of speech intelligibility, as shown by the RASTI, with the results of a subjective word discrimination test, the Word Intelligibility by Picture Identification (WIPI) test. Her subjects were children from grades 1 through 3 and from grade 5. The results of her study showed little agreement between the two measures. As stated by Rao, this lack of agreement may be related to the age of her subjects or to the simplicity of the subjective test she used, but these results leave some question as to the validity of using the RASTI to measure speech intelligibility in small enclosures.

These three studies represent the extent of research concerning the use of objective measures of speech intelligibility in the classroom environment. Since the study by Rao (1992) raised some question about the validity of these objective measurements, more research is needed to determine the usefulness of objective measures of speech intelligibility, such

as the RASTI, in classrooms. In an attempt to clarify some of the procedural concerns present in Rao's research, this study replicated her study, but young adults were used as subjects and more difficult subjective tests of speech intelligibility were administered.

REVIEW OF THE LITERATURE

Speech intelligibility in an enclosure is affected by many acoustical factors. The three that play the most prominent role are reverberation, distance of the listener from the speaker, and interfering noise (Berg, 1987). The combination of these three factors can greatly reduce the ability of listeners within an enclosure to comprehend messages given by a speaker in the room. This becomes especially important in the classroom, where it has been shown that most learning takes place through the auditory channel (Berg, 1987). The interaction of all three factors must be considered when describing the acoustics of a room, because overlooking or omitting any one factor will lead to estimates not representative of the effect each one has on speech intelligibility (Houtgast, 1981).

As sound is projected in waves from its source, these sound waves strike objects and the energy of the wave is reflected from the object. In a room, these reflections can be numerous, thus causing the listener to hear not only the direct signal, but many reflected parts of the signal at the same time. This effect is called reverberation, and it is measured by determining the time

it takes for a sound to diminish by 60 dB after the source has been stopped (Ross, 1972). According to Lochner and Burger (1964), reverberation is considered to be the single most important factor in determining the acoustical qualities of a room.

Another factor that influences speech intelligibility in a room is the distance of the listener from the speaker or sound source. The signal of a speaker is always at its highest level directly at the sound source. Based on the inverse-square law, each time the distance from the source is doubled, the level of the signal decreases by 6 dB (Peutz, 1971). Peutz explained that this systematic decrease in the signal level occurs until the critical distance is reached. The critical distance is the point at which the original direct sound waves are as strong as the reflected sound waves in a room. Once this critical distance has been reached, the level of the speech signal remains constant, and speech intelligibility is only affected by the reverberation in the room.

The third factor which affects speech intelligibility is interfering noise. Noise is described as any undesired sound that interferes with the sound the listener wants to hear (Kryter, 1970). The effects of noise are often determined by comparing the difference in decibels between the intensity of the desired sound and the intensity level of the noise. This difference is expressed as the signal-to-noise ratio (S/N). When the S/N is high, there is a greater opportunity for the listener to hear the

speaker's voice as clearly as his/her auditory skills will allow (Ross, 1972).

For years, researchers have tried to develop the best way to measure the effects of these and other factors on speech intelligibility in enclosures. The different approaches they have used can be put into the two categories of subjective and objective measures.

Subjective measures utilize trained listeners who are placed in various positions throughout a room and are given speech recognition tasks (Steeneken & Houtgast, 1980). Their scores on these tasks are then compared to see what effects their positions in the room had upon their ability to understand what was presented. This kind of testing has the advantage of having high face validity. Unfortunately, these subjective measures take a great deal of time and can be expensive, due to the payment of these trained listeners. Also, this kind of testing is not useful in the design stages of a room or auditorium (Rao, 1992). It can only be carried out in already existing rooms.

The classic example of a subjective measurement method used to assess speech intelligibility in a room is a study by Finitzo-Hieber and Tillman (1978). Reverberation times and signal-to-noise ratios were varied in rooms where two different groups of children were given monosyllabic word recognition tasks. The first group of children had normal hearing, and the second consisted of children who had been identified as having moderate hearing losses bilaterally. The children repeated words presented

through a loudspeaker 12 feet in front of them. A child's score was represented by the percentage of words he/she repeated correctly. Results were analyzed for both individual and group scores to determine the effects of the acoustic characteristics and the interaction of the two variables. Subjective measurement techniques such as this, while time consuming and many times expensive, are nonetheless extremely useful and direct.

Because of the disadvantages involved in using subjective forms of assessing speech intelligibility, objective methods have been created and developed. Objective measure are those in which the measurements of acoustic factors that affect speech intelligibility are plugged into a formula or calculation scheme which determines the loss of speech intelligibility for that room (Rao, 1992). These methods can be obtained more quickly than subjective measures and can save money.

The first objective method to be developed was the Articulation Index (AI) (Fletcher & Galt, 1950; French & Steinberg, 1947). This method predicted speech intelligibility by dividing the speech spectrum into 20 frequency bands and measuring the physical parameters of each. Kryter (1962) improved this method by introducing a calculation scheme, worksheets, and tables for the AI. This method worked well for distortions of frequency, such as interfering noise, but was not effective when reverberation and nonlinear distortions, such as peak clipping, were involved.

To account for the deficiencies in the AI, Steeneken and

Houtgast (1980) expanded the AI into the Speech Transmission Index (STI). It gives a single index to express speech intelligibility in rooms and is derived by acoustically analyzing a test signal at the listener's position (Rao, 1992). This index accounted for reverberation, echoes, and interfering noise. Scores from the STI were shown to be within 5% of scores from a subjective test administered in the same room using phonetically balanced words.

Houtgast, Steeneken, and Plomp (1980) further expanded the STI to include the factors of the volume of the room, the room's reverberation time, the noise level, the level of the speaker's voice, and the distance of the listener from the speaker. They validated their approach by comparing its predictions with subjective measures of speech intelligibility, finding them to be in agreement.

Additional modifications of the STI have been made by several researchers (Houtgast & Steeneken, 1985; Humes, Boney, & Loven, 1987; Humes, Dirks, Bell, Ahlstrom, & Kincaid, 1986). One modification which has received a good deal of attention is a simplified version called the Rapid Speech Transmission Index (RASTI). The RASTI looks at two octave bands with only a few modulation frequencies considered, instead of the seven octave bands and 14 modulation frequencies of the normal STI. It was designed as a screening instrument that would give a fast evaluation of speech transmission in auditoriums, accounting for both reverberation and interfering noise (Houtgast & Steeneken,

1985). The index gives a score between 0 and 1, with a score of 1 representing a perfect replication of the transmitted signal.

In 1984, the International Electrotechnical Commission examined the RASTI in 14 auditoriums in 11 countries with varying reverberation and/or interfering noise values by comparing it to subjective word recognition tests. It was shown that for those subjective tests in which a carrier phrase was used (7 countries), the results of the two measures were in good agreement. These results suggested that it was valid to use the RASTI as a screening instrument for determining the acoustic and speech intelligibility properties of auditoriums.

Despite the fact that the RASTI has been shown to be an effective measure for screening the acoustic properties of auditoriums, its validity in the classroom environment has not been determined. It is obvious that the acoustic properties of a classroom are critical for learning (Berg, 1987). Thus far only two studies have evaluated the use of the RASTI in the classroom environment.

The first study (Leavitt & Fletcher, 1991) used the Bruel & Kjaer RASTI system to evaluate the degradation of the speech signal in a typical college classroom. With 34 adults in the room, RASTI measurements were taken at 17 different seating locations. The results showed a substantial decrease in the integrity of the speech signal, even at the front-row center seat. The significance of these results in terms of the effect on speech intelligibility was not validated by comparing them with a

subjective or other measure.

A study by Rao (1992) attempted to test the validity of the RASTI as a measure of speech intelligibility in a classroom using children as subjects. Rao compared the results of the RASTI measurements with the results of a word recognition test, the Word Intelligibility by Picture Identification (WIPI) test, given to children from grades 1 through 3 and grade 5. The results of her study showed little agreement between the two measures. Rao suggested that this lack of agreement may have been related to the age of her subjects or to the simplicity of the word recognition test given to the children. Despite these possible explanations, Rao's results leave some question as to the ability of the RASTI to predict speech intelligibility in classrooms.

As pointed out by Rao, one of the major considerations in assessing speech intelligibility is the type of material used. Typically, the more meaningful and the more redundant the material, the higher the score (Miller, Heise, & Lichten, 1951). Many types of speech materials, including syllables, words, sentences, and paragraphs have been used to assess speech intelligibility. The two most commonly used types of materials are words and sentences.

One list of words that can be used to assess speech intelligibility is the California Consonant Test (CCT) (Owens & Schubert, 1977). This test consists of 100 items in a multiple choice, closed-set format that tests the identification of consonants from single word stimuli. Items on the test are based

on data gathered to evaluate phoneme recognition errors in subjects with hearing impairments, with each word differing in only the initial or final consonant position. This test uses words with high-frequency characteristics and has been shown to be especially sensitive for high-frequency hearing losses (Schwartz & Surr, 1979).

One list of sentences used in assessing speech intelligibility is the Speech Perception In Noise (SPIN) test (Kalikow, Stevens, & Elliot, 1977). This test is in an open-set format that requires the listener to repeat or write down the last word from each of 50 sentences. The sentences consist of 25 sentences where the last word is highly predictable from the context of the sentence and 25 sentences with final words that have a low predictability from the context of the sentence. The sentences are presented in a background of noise which consists of a babble of 12 talkers.

PURPOSE AND OBJECTIVES

The use of the RASTI, an objective measure of speech intelligibility, in evaluating the acoustic properties of auditoriums has been adequately shown (Houtgast & Steeneken, 1984). However, its ability to predict the loss of speech intelligibility in classrooms has been brought into question by a study comparing measurements made by the RASTI in a classroom with the results of a subjective test given to children (Rao, 1992). Rao's study used young children as subjects, and the

subjective measure of speech intelligibility used was perhaps too easy to identify subtle differences in the children's ability to identify words.

The purpose of this study was to replicate Rao's study with young adults instead of children, using two more difficult speech recognition tests. By controlling the variables of age and speech materials, it was possible to determine the ability of the RASTI to predict speech recognition scores in a classroom. Both words and sentences were used as speech materials to determine if there was a better correlation between RASTI scores and a word recognition test or between RASTI scores and a sentence recognition task.

The objectives of this study were as follows:

1. To determine if there is a relationship between RASTI values and word recognition scores from the California Consonant Test (CCT) obtained by young adult listeners with normal hearing in a classroom.
2. To determine if there is a relationship between RASTI values and the speech recognition scores from the Speech Perception in Noise (SPIN) test obtained by young adult listeners with normal hearing in a classroom.
3. To determine if there is a relationship between RASTI values and speech recognition scores from the low predictability sentences of the SPIN test obtained in a classroom by young adult listeners with normal hearing.
4. To determine if there is a relationship between RASTI values

and speech recognition scores from the high predictability sentences of the SPIN test obtained in a classroom by young adult listeners with normal hearing.

5. To determine if the relationship obtained for the RASTI and the Speech Perception in Noise test is significantly different from the relationship for the RASTI and the California Consonant Test.

PROCEDURES

Population and Sample

Subjects for this study were 30 young adults between the ages of 18 and 30 years. Each had hearing sensitivity within the normal range and no history of chronic middle ear disease. Subjects with normal hearing were used because the RASTI measurement is designed to reflect speech intelligibility for listeners with normal hearing. Subjects were from the Cache Valley area because they were readily available and because it was believed that their auditory abilities were representative of young adults with normal hearing throughout the world.

Specific Procedures

Subjects in this study were identified by requesting volunteers from Communicative Disorders classes and from friends of the researcher. Each subject had a hearing screening which was performed in the sound booths of the Utah State University Speech-Language-Hearing Clinic on the morning of the study. The screening consisted of the presentation of 500, 1000, 2000, and

4000 Hz tones at a 20 dB level in each ear. Subjects had to hear all tones in both ears to pass the screening.

All subjects completed and signed a form (see Appendix A) on the morning of the data collection. The form described the purpose of the research, insured confidentiality, and notified all participants that they could withdraw from the research study at any time. Additionally the subjects indicated their age and if they had a history of chronic middle ear problems. Chronic middle ear problems were defined as the presence of more than three ear infections in any one year period or a positive history of ear surgery.

The afternoon of the day the study was performed, all subjects reported to a classroom in the Edith Bowen Laboratory School where the data were collected. The classroom was arranged in rows typical of a standard classroom with each desk assigned an identification number. The subjects kept their same chosen seat throughout the testing so as to insure valid results.

Two subjective measures of speech intelligibility were used, the California Consonant Test (CCT) and a variation of the Speech Perception in Noise (SPIN) test. These were administered before the RASTI measurements were taken, as it was believed that the newness of the experience for the subjects lent itself to maximum attention at the first of the experiment. A recording of both tests, made by a male speaker with a standard American dialect, was presented through a loudspeaker in the classroom. The recording for the CCT was the one commercially available from

Auditec of St. Louis, while the recording of the SPIN sentences was made locally. The loud speaker was placed in the middle, front position of the classroom, 6 feet from the front row at a height of 5 feet to replicate the height of a teacher's mouth. The presentation level for the speech recognition test was 70 dB SPL at one meter from the loud speaker, as measured by a sound level meter.

Subjects were given answer forms, one with 100 blanks for the CCT and one with 50 blanks for the SPIN test, to write their response for each item. They were encouraged to print or write legibly so that their responses could be scored accurately. Each form had an identification number that matched the identification number of the desk at which the subject was seated. Both tests were administered to all subjects simultaneously.

The CCT was administered first because it is the more difficult test. Rao pointed out that the subjective measure she used, which used a closed-set response, might have been too simple for her subjects. To avoid this, the CCT was administered in an open-set format, rather than in its normal closed-set presentation, thus making the word recognition task more difficult. The SPIN test was administered next with one modification from its normal use. Typically, this test is administered in noise, but the noise was omitted for the purposes of this study.

Finally, three RASTI measurements were made at each subject's position. The microphone for measurement was placed

just above the ear for each subject nearer the loud speaker. The transmitter unit was placed in the teacher's position. All three RASTI measurements were recorded, but, as suggested by both Leavitt and Flexer (1991) and Rao (1992), only the largest measurement was used in the calculations.

All subjects remained seated quietly in the room throughout all tests and the RASTI measurements. At the completion of the study, each subject was paid $10 for their participation.

Data and Instrumentation

The Bruel & Kjaer RASTI equipment, model number 3361, which consists of the transmitter type 4225 and receiver type 4419, was utilized for the RASTI readings. The manufacturer's specifications were followed to verify that the instrument was functioning properly prior to the collection of the data. The tapes for the speech recognition tests were played on a stereo cassette tape deck (Technics M234X) through an Eico amplifier to an Altec loudspeaker. The level of presentation was 70 dB SPL, as measured with a Larson-Davis 800B sound level meter prior to the presentation of the tests.

Each subject's response sheets for the two subjective measures were coded with an identification number corresponding to their desk identification number and position in the classroom. The response sheets were checked for accuracy, and the total number of correct responses was tallied for each test for each subject. Results were reported as the percent of correct responses. The SPIN tests were also scored as a percent of

correct responses for the high-predictability sentences only and for the low-predictability sentences only. RASTI scores were given identification numbers that matched the identification numbers on the desks where the measurements were taken. All three RASTI measurements were recorded, but only the largest of the three measurements was used in calculations.

Analysis

To determine if the RASTI values were a valid predictor of speech intelligibility in a classroom as measured by subjective speech recognition tests, correlation coefficients between the RASTI values and each speech recognition score were calculated. For the SPIN test, the correlation coefficient was calculated for the test as a whole and for the low-predictability and high-predictability sentences separately. The largest RASTI value was considered for each of these calculations. In order to determine the practical significance of these relationships, r^2 was also computed to indicate the proportion of variance that each subjective measure had in common with the RASTI value. The statistical significance of the difference between the correlation coefficient obtained for the CCT and for the SPIN as a whole was calculated to assess if one test is a better predictor of the RASTI score.

RESULTS

The total number of young adults who participated in the study was 29. All subjects passed a pure tone screening on the

morning of the study, and they completed a form indicating that they had no history of chronic middle ear problems.

A pictorial layout of the classroom with the identification number for each subject is provided in Appendix B. All 29 subjects were within 20 feet of the loudspeaker and the RASTI transmitter during all testing, with the closest subject being 6 feet away. The noise level in the classroom was approximately 31.2 dB SPL when the subjects were seated at their desks during the testing. The reverberation time for room when the subjects were not present was approximately 0.5 seconds.

Each subject's scores on the California Consonant Test (CCT), the Speech Perception in Noise (SPIN) test, and the RASTI measurement are provided in Appendix C. As shown in Table 1, the range for the CCT scores for the subjects was from 37 to 72%. The mean score for the CCT was 52.9% with a standard deviation of 10.8. The scores for the total SPIN test ranged from 56 to 96% with a mean score of 85.2% (SD = 8.1). When the high-predictability sentences and the low-predictability sentences for the SPIN test were analyzed separately, it was found that the scores for the high-predictability sentences ranged from 64 to 100%, and the scores for the low-predictability sentences were between 44 and 92%. The mean score for the highly predictable sentences was 98.5% (SD = 6.7), and the mean for the sentences with low predictability was 72.0% (SD = 12.1). The largest RASTI value for the 29 subjects was between 0.72 and 0.84 with a mean of 0.77 and a standard deviation of 0.026.

Table 1

The Ranges, Means, and Standard Deviations for the Subjective and Objective Measures of Speech Intelligibility for 29 Subjects

Test	Range of Scores	Mean	Standard Deviation
CCT	37 - 72%	52.9%	10.8
SPIN (Total)	56 - 96%	85.2%	8.1
SPIN (High Pred.)	64 - 100%	98.5%	6.7
SPIN (Low Pred.)	44 - 92%	72.0%	12.1
RASTI	0.72 - 0.84	0.766	0.026

DISCUSSION

This study attempted to validate the use of an objective measure of speech intelligibility, the RASTI, for young adult listeners in a classroom by correlating their RASTI scores with their scores on two subjective measures of speech intelligibility. The results will be discussed for each of the five objectives established for the research.

Objective One

The first objective of this study was to determine if there was a relationship between the objective RASTI values and the subjective speech recognition scores obtained from the California Consonant Test (CCT). In order to determine if a relationship existed for the subjects in this study, a correlation coefficient was calculated. The correlation coefficient of 0.36 was

significant at the $p<.05$ level (see Table 2) and revealed a low positive relationship between the CCT scores and the RASTI values. However, when the practical significance of the

Table 2

Correlations Between RASTI Values and the Various Subjective Speech Intelligibility Measures

Test	r	r^2
CCT	0.36 *	0.13
SPIN (Total)	0.37 *	0.14
SPIN (High Predict.)	0.19	0.04
SPIN (Low Predict.)	0.44 *	0.19

* $p< .05$.

relationship was calculated, r^2 was only 0.13 indicating that only 13% of the variability of these two measures could be attributed to the relationship between these measures. Eighty-seven percent of the variability was not accounted for.

The low positive relationship between these two measures suggests that the deterioration of the RASTI values is somewhat related to the speech recognition scores obtained on the CCT. The r^2 value, however, reveals that the RASTI cannot accurately predict the speech recognition scores obtained from the CCT because there is a large amount of variability that the RASTI

does not take into account. It is likely that factors such as intelligence, auditory processing skills, and attention also contributed to the speech recognition scores obtained by the subjects.

Objectives Two, Three, and Four

The second, third, and fourth objectives were to determine the relationship between the RASTI values and the three scores obtained from the SPIN test. The three SPIN test scores included the overall scores, the scores from those sentences whose target words are highly predictable from the context of the sentence, and the scores from those sentences whose target words have a low predictability from the context of the sentence. Correlation coefficients for each relationship are shown in Table 2.

The correlation coefficient for the RASTI values and the overall SPIN test was 0.37, which was significant at the 0.05 level of confidence. As with the CCT, the correlation coefficient showed a low positive relationship between the two measures. The proportion of variability that the two sets of scores had in common (r^2) was only 14%.

The correlation coefficient obtained between the scores for the sentences with highly predictable target words and the RASTI values was 0.19, showing a very low, positive relationship which was not significant at the 0.05 level of confidence. When r^2 was calculated, only 4% of the variability of these two measures could be attributed to their relationship.

When the scores from SPIN sentences with target words with

low predictability from the context of the sentence were correlated with the RASTI scores, the correlation coefficient was 0.44, which revealed a low positive correlation. Although this correlation was significant at the 0.05 level of confidence, the amount of variability the two measures had in common, as revealed by r^2 was only 19%, leaving 81% of the variability unaccounted for.

It was interesting to note that with an easy speech recognition task like the sentences with high predictability, the correlation coefficient of 0.19, showing a poor relationship with the RASTI values, was very close to the coefficients obtained by RAO (1992). This would support her theory that the WIPI test was too easy to accurately show the difficulties that room acoustics can have on the speech signal in the classroom.

The low positive relationship found between the RASTI values and the low-predictability SPIN sentences was felt to indicate that the RASTI values are related to the subjective speech recognition scores obtained in a classroom with the low-predictability SPIN sentences. However, based on the r^2 value, the RASTI is not able to accurately predict the speech recognition scores in a classroom. It is believed that this is because there are too many variables associated with the listener that the RASTI does not take into account. The low positive relationship between overall scores and the RASTI values was due to the influence that the scores from the low-predictability sentences had on the overall SPIN scores.

Objective Five

In order to determine if there was a difference in the ability of the RASTI to predict the speech recognition scores obtained with the CCT as compared to those obtained with the SPIN test, the correlation coefficients for the two speech recognition tests were compared using a chi-square analysis (Cochran & Cox, 1957). A chi-square value of 0.40 was obtained with a degree of freedom of 1. This value was not significant, suggesting that there was no significant difference between the correlations obtained for these two tests. They were therefore felt to be approximately equal in terms of their difficulty for the subjects in the study.

CONCLUSIONS AND RECOMMENDATIONS

This research was undertaken to replicate a study performed by Rao (1992) and to account for some of the procedural concerns present in her study. This was done to obtain a clearer picture of the ability of the RASTI to predict the subjective speech intelligibility in a typical classroom. The low positive relationships obtained between the RASTI values and the CCT, the total SPIN test, and the high-predictability SPIN sentences indicate that there is a relationship between the RASTI, as an objective measure of speech intelligibility, and the various subjective measures. Despite the fact that these relationships were all significant at the 0.05 level of confidence, the practical significance of these relationships, as measured by r^2,

was very low. In the best case, only 19% of the variability of the two measures could be attributed to their relationship, leaving 81% of the variability not accounted for.

The practical inability of the RASTI to predict subjective speech intelligibility scores was felt to be due to the large number of other factors involved in testing human subjects. Attention, auditory processing skills, and intelligence are just a few of these factors which were not addressed in this study and which may influence the subjective scores obtained by the subjects.

These findings contrast with those of Rao (1992) in that there was a significant relationship found between the RASTI and three of the subjective measures of speech intelligibility. This difference in results was felt to be due to the ease of Rao's subjective speech recognition measure, as Rao herself suggested, and to the relative difficulty of the subjective speech recognition measures used in this study. This finding was supported by the fact that the correlation between the scores from the high-predictability SPIN sentences and the RASTI was very low and not significant. The high-predictability SPIN sentences provide the listeners with an easy test, and the correlation coefficient between it and the RASTI was similar to the poor correlation Rao reported in her study between the WIPI scores and the RASTI values.

Based on the results of this study, it is recommended that:

1. Professionals recognize that the RASTI value can predict

deterioration of a speech signal across a classroom (Leavitt & Flexer, 1991), but that it cannot accurately predict the specific speech recognition score obtained by a listener.

2. The RASTI be used to measure the integrity of the speech signal in classrooms, particularly when attempting to improve the acoustical characteristics of the classrooms through environmental modifications or through the use of classroom FM systems. The RASTI value will provide an indication of improvements in the acoustical environment, but it should be recognized that changes in these values may not significantly impact the subjective speech recognition directly.

3. Future research continue to address the use of an objective measure of speech intelligibility in classrooms in order to provide a method to document how the acoustical environment of a classroom impacts listeners, including both adults and children.

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APPENDIXES

Appendix A. Form of Explanation and Permission for Participation in the Study

UTAH STATE UNIVERSITY • LOGAN, UTAH 84322-1000

DEPARTMENT OF COMMUNICATIVE DISORDERS
Speech-Language-Hearing Center
(801) 750-1375

January 16, 1993

Dear Participant:

This study is trying to determine how well a relatively new objective screening measure of speech degradation in auditoriums, the Rapid Speech Transmission Index (RASTI), can predict how much intelligibility is lost at different positions in a classroom. To evaluate this, we will perform two different subjective speech recognition tests on young adults with normal hearing and compare the results with the measurements from the RASTI.

By choosing to participate, you will have a hearing screening at the USU Speech-Language-Hearing Center the morning of the day the study is performed. Then, that same afternoon at 2:30pm you will report to the Edith Bowen Laboratory School (just across from the Speech-Language-Hearing Center) for the study. You should plan on 1/2 hour in the morning for the hearing screening and 1 and 1/2 hours for the study.

All results, both from the hearing screening and the study, will be kept strictly confidential and you may withdraw yourself at any point during the study. Participants who complete the study will be paid $10 for their time

Please complete the following short questionnaire:

-Your age:_______

-Have you ever had more than 3 middle ear infections in any one year period? (yes/no) __________

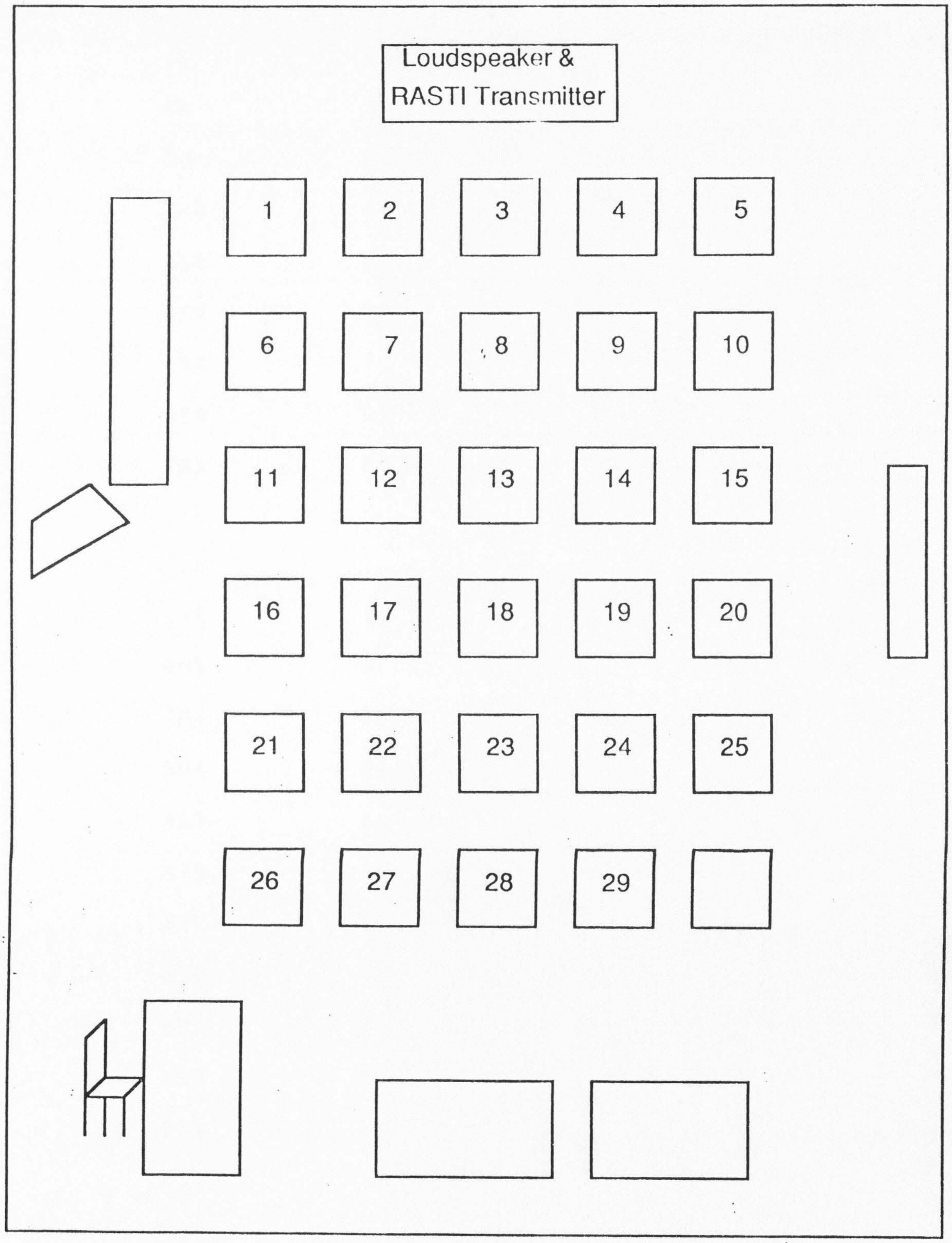
-Have you ever had ventilation (P.E.) tubes in your ears or had surgery on your ears? (yes/no) _________

I have read the explanation of this study and answered the questions above as honestly as possible. I realize that the results from both the hearing screening and the study will be kept confidential and that I may withdraw from the testing at any point in the study.

______________________________ (your signature) ________________ date

Pass _____

Appendix B. Diagram of Classroom Showing Identification Numbers



Appendix C. Subject's Scores on CCT, SPIN, and RASTI Measurements

Subject	CCT Score	SPIN(Total)	SPIN(High)	SPIN(Low)	RASTI
1	63	84	100	68	.78
2	64	92	100	84	.84
3	68	96	100	92	.84
4	64%	86%	100%	72%	.79
5	45%	80%	100%	60%	.81
6	48%	90%	100%	80%	.78
7	68%	90%	100%	80%	.81
8	68%	92%	100%	84%	.81
9	72%	90%	100%	80%	.80
10	53%	84%	100%	68%	.77
11	38%	72%	100%	44%	.77
12	61%	94%	100%	88%	.80
13	66%	94%	100%	88%	.79
14	46%	92%	100%	84%	.79
15	50%	88%	100%	76%	.80
16	45%	86%	100%	72%	.74
17	47%	88%	100%	76%	.83
18	47%	84%	100%	68%	.77
19	43%	82%	96%	68%	.77
20	42%	90%	100%	80%	.79
21	59%	82%	100%	64%	.76
22	56%	56%	64%	48%	.77
23	41%	74%	96%	52%	.78

Subject	CCT Score	SPIN(Total)	SPIN(High)	SPIN(Low)	RASTI
24	47%	86%	100%	72%	.77
25	41%	78%	100%	56%	.77
26	66%	88%	100%	76%	.72
27	37%	82%	100%	64%	.75
28	46%	82%	100%	64%	.78
29	43%	90%	100%	80%	.76