Matrix Sentence Test in Indian-English to assess Speech Identification Scores

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This Dissertation is submitted as part of fulfillment for the Degree of Master of Science in Audiology University of Mysore, Mysore

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CERTIFICATE

This is to certify that this dissertation entitled "**Matrix Sentence Test in Indian-English to assess Speech Identification Scores**" is a bonafide work submitted in part fulfillment for the Degree of Master of Science (Audiology) of the student (Registration No.: 13AUD005). This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any of the University for award of any other Diploma or Degree.

Mysore
May, 2015

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CERTIFICATE

This is to certify that this dissertation entitled "**Matrix Sentence Test in Indian-English to assess Speech Identification Scores**" has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in other University for the award of any Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled "**Matrix Sentence Test in Indian-English to assess Speech Identification Scores**" is the result of my own study under the guidance of Dr. Asha Yathiraj, Professor in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in other University for the award of any Diploma or Degree.

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Register No.: 13AUD005

Dedication

I am very much thankful and dedicate my dissertation work to my **family and teachers**.

A special feeling of gratitude to my loving parents **Mr.Govind and Mrs. Sita Bhattarai** for their encouragement and instilling the importance of hard work and higher education.

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Abstract

Assessment of hearing using speech material is essential as it provides useful diagnostic information that cannot be obtained with the use of pure-tones. Sentences tests have been noted to provide information about the difficulties faced by individuals in a real life situation. The Matrix sentence test has the added advantage of having reduced redundancy unlike other sentence tests. The present study aimed to develop a Matrix Sentence Test in Indian-English (MST-IE) and validate it on children aged seven to ten years. The developed test followed the format given by Hagerman in 1982, which has a fixed syntactic structure with unpredictable sentences. From a base matrix, 730 sentences were generated that had grammatically correct and natural sounding sentences. Validation of these sentences was done on 30 children in the age range of seven to ten years. From the 520 sentences that the children could identify, 500 were used to construct 50 lists containing ten sentences each and 20 practice items. The lists had equal distribution of consonants. The equivalency of these lists in terms of 3 RMS amplitude measures (average, minimum, & maximum) was statistically assessed using a repeated measure ANOVA. No significant difference was observed between the 50 lists for all three amplitude measures. Thus, the sentences that were perceptually equivalent were also found to be equal in terms of their amplitude. It was concluded that the lists could be used interchangeably with no adverse effect on perception scores. It was recommended that further research requires to be carried out to confirm the equivalence of the lists in the presence of noise.

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Chapter 1

Introduction

Speech stimuli have been noted to provide valuable diagnostic information in the field of audiology. Clinically, speech tests are generally regarded more acceptable than pure-tone audiometry for identifying individuals with poor auditory analytical capability, as they also assess higher-level linguistic activities (Wang, Mannell, Newall, Zhang, & Han, 2007). Speech identification scores have been used for a variety of reasons. A few of the reasons include identification of site of lesion (McArdle & Hnath-Chisolm, 2009); assessment of the central auditory system (Beasley, Schwimmer, & Rintelmann, 1972; Cameron, Dillon, & Newall, 2006; Jerger, Speaks, & Trammell, 1968; Katz & Smith, 1991; Yathiraj, 1999); and to quantify the communicative abilities of individuals with hearing loss. Testing speech in the presence of noise has been reported to give an indication to clinicians regarding the rehabilitative approaches such as choosing appropriate amplification (Katz, 2009). Further, speech identification tests help in counseling since the outcome of these tests are more easily understood by patients than information about the degree of hearing loss (Mendel & Danhauer, 1997). Hence, testing with speech material has been found to be more clinically acceptable in assessment of persons with poor auditory abilities and in the selection or checking outcome of listening devices (Wilson & McArdle, 2005).

The speech stimuli that have been commonly used are phonemes, nonsense syllables, monosyllables, spondees, phrases, sentences and paragraphs (Dias, Devadas, & Rajashekhar, 2015; Tyler, 1994). Each type of the stimuli has their own advantages and disadvantages. However, stimuli that provide an indication of everyday communication have been considered to have an added advantage over other material (Tyler, 1994).

Although speech intelligibility testing with phonemes and words has been found to yield a good understanding of speech recognition skills, these tests were observed to miss the rapid nature of speech. Thus, speech recognition using sentence and paragraphs has been considered as a better choice of stimuli (Tyler, 1994).

Miller, Heise, and Lichten (1951) and Tyler (1994) have reported of several advantages of sentences over other stimuli. Sentences were found to yield a more realistic measure of communication; Give a more valid indication of intelligibility in everyday communication (Tyler, 1994); Eliciting better speech reception threshold as they have a much steeper intelligibility function when compared to single words; Useful in assessment of co-articulation as well as temporal aspects of speech; and as the stimuli are natural and meaningful, they have face validity (Miller et al., 1951).

Despite the advantages of sentence tests, these stimuli have been criticized as semantic redundancy has been noted to have an adverse effect on scoring. To overcome this disadvantage, synthetic speech has been recommended (Jerger et al., 1968). Synthetic test material such as the Synthetic sentence identification test by Jerger et al. (1968) make use of sentences that are not connected to prevent semantic information being conveyed. This was reported to allow for the assessment of intelligibility without the influence of context. However, due to the unnatural nature of the sentences they are likely to be difficult to perceive.

Another disadvantage of sentences is that the influence of familiarity once presented. Tyler (1994) noted that the identification of sentences may not be a true representation of speech intelligibility of an individual, as individuals may be able to guess the complete sentence after identifying a few words. However, despite the problems with the use of sentence tests, they continue to be used speech assessment as their advantages outweighs their disadvantages.

To overcome the disadvantages of typically used sentence tests, Hagerman (1982) developed the ‘Matrix sentence test’ that utilized sentences constructed from a closed set of alternatives. The sentences were developed to be grammatically and semantically correct, but with no redundancy. The word ‘matrix’ was used since the sentences were constructed from a fixed matrix of words. The sentence test was recommended to be presented in the presence of noise that matched the long term average spectrum of speech. While the original test developed by Hagerman was in Swedish, similar tests have been developed several other languages. These tests include the Polish Matrix Test (Ozimek, Warzybok, & Kutzner, 2010); German Matrix Test (Kollmeier et al., 2011); Spanish Matrix Test (Hochmuth et al., 2012); Turkish Matrix Test (Zokoll, Hochmuth, et al., 2012); French Matrix Test (Jansen et al., 2012); Italian Matrix Test (Hochmuth, Zokoll, Caroll, & Kollmeier, 2013; Puglisi et al., 2014); Finnish Matrix Test (Dietz, 2014); American-English Matrix Test (Zokoll, Wagener, et al., 2012) and Russian Matrix Test (Warzybok et al., 2015). As the matrix tests in different languages have similar construction, comparison of data across languages has been made possible.

Need for the Study

Perception of speech is influenced by the language a person is familiar with. As early as 1947, Hudgins, Hawkins, Karlin and Stevens suggested that speech testing should be conducted in the native language and dialect of an individual. Hence, tests in English, developed in other parts of the world cannot be used in India.

Although the matrix sentence test is available in several languages, it is not available in Indian-English. Additionally, no sentence tests are available for children in Indian-English. Such a test would be helpful in documenting the real-life performance of high-functioning children with hearing impairment. Hence, there is a need to develop such a test that does not have predictable sentences, yet follows the syntax and semantics of natural sentences.

Evaluating the identification abilities at threshold, as recommended in several of the matrix tests (Dietz, 2014; Fayazi, Modarresi, Zokoll, Hochmuth, & Kollmeier, 2013; Hochmuth et al., 2012; Hochmuth et al., 2013; Houben, Koopman, Luts, Wagener, van Wieringen, et al., 2014; Oygarden, 2013; Ozimek et al., 2010; Warzybok et al., 2015; Zokoll, Wagener, et al., 2012), does not give a true picture of the performance of an individual when hearing signals at normal conversational levels. Perception at threshold levels cannot be equated to perception at normal conversation level since speech perception is a non-linear function. Typically, speech is not heard at threshold levels. Hence, a test that gives a direct measure of perception of speech at normal conversational level is preferred.

Further, Grant and Walden (2013) noted that threshold level tests are not designed to measure the suprathreshold distortion, which are induced due to hearing loss. Hearing loss not only causes loss of sensitivity, but also distortion of speech at higher level due to abnormal loudness growth, impairment of frequency resolution and poor temporal resolution. These issues are not addressed in tests done at the threshold level.

Aim

The aim of the study was to develop and validate a Matrix Sentence Test in Indian-English to assess Speech Identification Scores.

Objective:

The objectives of the study are as follows:

1. To develop a Matrix sentence test in Indian-English,

2. To validate the test on normal hearing children,

3. To check the inter-list equivalence.

Chapter 2

Review of Literature

Speech intelligibility assessment is a vital component in the evaluation and the management of individuals having problems related to their hearing. Speech intelligibility has been assessed using speech stimuli either in quite or in the presence of noise, using identification or discrimination tasks (McArdle & Hnath-Chisolm, 2009). Difficulties in speech perception have been noted to have a debilitating impact on communication abilities of individuals. Speech based tests have been noted to provide a means to determine the quantum of difficulty individuals with such pathologies have (Wilson & McArdle, 2005). It is reported that the major goal of speech assessment is to quantify an individual's ability to communicate in everyday situation (Mendel, 2008). Speech material have not only been used for assessment of hearing ability, but also used to find other measures such as 'Most Comfortable Level' and 'Uncomfortable Level' or selection of hearing aids (Mendel & Danhauer, 1997).

It is reported in literature that the integrity of the auditory system can be assessed better with speech material than through non-speech based material. Speech material are found to be better as they are able to tap higher processing abilities unlike pure-tone audiometry. Speech identification has been assessed using a variety of material such as monosyllables, bisyllables, nonsense syllables and sentences (Tyler, 1994). Although recognition testing with words have been found to yield better understanding of recognition skills than sentences, these tests were observed to miss the rapid nature of natural speech. Thus, speech recognition using sentence and paragraphs, with consideration for contextual cues and language competencies, have been considered as a better choice of stimuli (Tyler, 1994).

2.1. Type of speech material used:

In literature a variety of stimuli have been developed and utilized. Authors in the past have advocated the use of various speech materials such as non-sense syllables, monosyllables, spondees, sentences and paragraphs. The section below provides a brief overview of the advantages and disadvantages of various speech stimuli used for speech identification testing and some of the tests using such stimuli.

2.1.1. Phoneme Tests:

Phoneme tests are designed to isolate a particular phoneme in words to identify phonemic errors present in the individual, which may not be assessed with traditional monosyllabic word testing. Phoneme testing are known to minimize lexical context and word familiarity effects (McArdle & Hnath-Chisolm, 2015). The use of isolated phoneme has been found to help in obtaining descriptive profile of a person's hearing loss that may be missed when testing with monosyllable (Mendel & Danhauer, 1997). The phoneme tests reported in literature are closed-set tests, in which isolated meaningful monosyllables are presented. The major disadvantage noted with phoneme tests are poor face validity and poor context effect (Tyler, 1994). Some of the monosyllable test for phoneme recognition are Multiple Choice Intelligibility Test (Black & Haagench, 1963), Rhyme test (Fairbanks, 1958).

2.1.2. Nonsense Syllable Tests:

The use of natural speech, even at the word level, has been found to always contain some cues that can affect the measure due to auditory closure. To overcome this disadvantage, Jerger et al. (1968) have proposed the use of nonsense syllables to test speech intelligibility. As such stimuli are meaningless syllables and not real words, they are considered abstract. The major advantage found in the use of nonsense syllable is the minimization of the effect of word familiarity and reduction of lexical constraints as seen in natural words (Jerger et al., 1968). A few tests utilizing nonsense syllables are Common Speech Discrimination Test for Indians (Mayadevi, 1974), The City University of New York Nonsense Syllable Test (CUNY-NST) by Resnick, Dubno, Hoffnung, and Levitt (1975) and Nonsense Syllable Test (NST) by Edgerton and Danhauer (1979). The tests have been recommended to be used either in closed-set or open-set response modes.

2.1.3. Monosyllabic word tests:

Monosyllabic word tests are noted to be the most frequently used stimuli in diagnostic audiology (Martin, Champlin, & Chambers, 1994). Monosyllabic words have been preferred due to their non-redundancy and meaningfulness. Also, monosyllables were considered not as confusing as nonsense syllables. However, it was noted that monosyllables, presented at a constant level, do not truly represent real communication (Carhart, 1965). Although these are the most frequently used stimuli, they have been criticized due their inability to predict social adequacy (Berger, 1971) .

Some of the monosyllabic word test reported in literature are PAL PB-50 word list (Egan, 1948 as cited in (Mendel & Danhauer, 1997), CID W-22 (Hirsh et al., 1952 as cited in (Mendel & Danhauer, 1997)), NU-6 ((Tillman & Carhart, 1966)as cited in (Mendel & Danhauer, 1997)), Mandarian Speech Test Materials-MSTMs (Han et al., 2009), Nonsense Monosyllabic Lists in Modern Greek (Trimmis, Vrettakos, Gouma, & Papadas, 2012), Speech Identification in Manipuri (Tanuza, 1984), Speech Identification Test in Bengali (Ghosh, 1986), Speech Identification Test in Gujarati (Mallikarjuna, 1990), Monosyllabic words in Indian-English for children (Rout, 1996), Picture Identification Test for Hindi Speaking Children (Chowdary, 2003), Speech Perception Test in Oriya (Smeeta, 2004), High Frequency English Speech Identification Test (Sudipta, 2006), and Hindi monosyllabic Speech Perception Test for children

(Bhimte & Rangasayee, 2015). Due to the drawbacks of monosyllabic words for speech recognition testing, Mendel & Danhauer (1997) have suggested to use these material with caution.

2.1.4. Spondees / Bisyllabic word tests:

Spondees are considered important stimuli to obtain recognition and detection threshold. Recognition threshold are considered to be important as they provide the basis for other suprathreshold testing and also for cross checking pure-tone thresholds. Bisyllables have been preferred as not all languages have concrete monosyllabic words and they provide more cues for intelligibility (Hirsh, 1952). A few examples of spondees test are Mandarin Speech Test Material-MSTMs (Wang et al., 2007) and materials available is Indian language are Picture Test of Speech Perception in Malayalam (Mathew, 1996), Bisyllabic Word test in Speech Identification Test for Kannada Speaking Children (Vandana, 1998), High Frequency-Kannada Speech Identification Test (Mascarenhas & Yathiraj, 2002), Speech Perception Test in Oriya (Smeeta, 2004), and Bisyllabic wordlist in Telugu (Kumar & Mohanty, 2012).

2.1.5. Sentence tests:

Incorporation of sentences in speech identification has been found to aid in understanding the individuals' performance in everyday situation (Silverman & Hirsh, 1955). However, according to Mendel and Danhauer (1997) sentences or phrases can be understood if an individual identifies a few key words that convey the overall meaning, and the rest of the words in the sentence may not carry the same weightage as the key words. Thus, they concluded that sentences may quantify conversational speech perception but cannot assess analytical perception of speech.

Despite the problems with the sentence tests, they continue to be used in speech identification as their advantages outweigh their disadvantages. Use of sentences in testing speech intelligibility has been noted to accomplish the motive of speech testing (Silverman & Hirsh, 1955). Sentences have found to be more similar to a realistic situation, valid indicators of intelligibility, elicit more accurate and effective measure due to steeper intelligibility function compared to words, have contextual cues that give more predictive validity, can assess co-articulation as well as temporal aspect of speech (Geetha, Kumar, Manjula, & Pavan, 2014; Jerger et al., 1968; Nilsson, Soli, & Sullivan, 1993).

Many sentence speech tests have been developed in the past with the intention of assessing speech recognition / speech identification and site of lesion testing in cases with auditory processing disorder. Sentence tests have been used to obtain Speech Recognition Threshold where the lowest level where the material is correctly identified is recorded (Miller, 2013; Wilson & Margolis, 1983; Wilson & McArdle, 2005), or used to obtain speech identification at supra threshold levels, representing normal conversation (Humes, 2002; Miller, 2013; Wilson & McArdle, 2005). Additionally, sentence identification in the presence of noise has been evaluated by keeping the noise level constant and varying the sentence level to establish the lowest presentation level of the sentences where 50% of correct identification is targeted (Hagerman, 1982; Humes, 2002; Kalikow, Stevens, & Elliott, 1977; Plomp & Mimpen, 1979; Wong, Soli, Liu, Han, & Huang, 2007). Sentence tests have also been carried out in the presence of noise, by keeping the sentence level constant and varying the noise level to establish the highest level of noise at which 50% of the sentences can be identified (Hagerman, 1982). Such a procedure has been termed as SNR-50 by Killion and Niquette (2000). The supra threshold measure has been considered to be more sensitive to the auditory functioning than threshold measures by (Wilson & Margolis, 1983). Below in Table 2.1 some of sentence tests available in the literature are explained.

Table 2.1. List of sentences tests available in literature

Author	Test	Stimuli	Age group	Respons e	Scoring
Hudgins, Hawkins, and et al. (1947)	PAL Auditory test No 12	224 sentences in eight list, which are further sub-divided into seven lists containing four sentences each.	Adult	Open set verbal response	Answer to the question was scored
Silveman and Hirsh (1955)	Central Institute for the Deaf (CID) Everyday Sentences	10 list of 10 sentences in each list	6+ years	Open Set Verbal Response	Scored for correctly responded keywords
Kalikow, Stevens and Elliot (1977)	Speech Perception in Noise (SPIN)	10 list of 50 sentences	Adult	Open Set Verbal Response	Final keyword is scored.
Plomp (1986)	Speech Reception Threshold Testing using Sentence Stimuli	Ten list with 13 sentences in each list	Adult	Open set verbal response	
Cox, Alexander, and Gilmore (1987)	Connected Speech Test (CST)	48 passages with 10 sentences having 25 key words	Adults	Open Set Verbal Response	Keywords in the passage are scored

Nilsson, Soli and Sullivan (1994)	Hearing in Noise Test (HINT)	25 list of 10 sentences each and 36 practice sentences divided into three list	Different version for children (HINT-C) and adult (HINT)	Open Set Verbal Response	Word-by-word scoring was done.
Mascarenhas and Yathiraj (2002)	High Frequency-Kannada Speech Identification Test (HF-KSIT)	Words: Four world list with 25 words in each list Sentences: Four sentence list with 10 meaningful sentences	Adult with sloping hearing loss	Open Set Verbal Response	Words and Phoneme scoring was used for word subtest and keyword scoring for Sentence subtest.
Sudipta (2006)	High Frequency-English Speech Identification Test (HF-ESIT)	4 list of 10 sentence each	Adults	Written response	Key words correctly identified were scored
(Rahana, 2007)	High and Low Predictable English Sentences (EHLPS)	5 list of 10 sentences each	Adult (12+ years)	Open Set Verbal Response of the final target word	Scoring of high and low predictable words
Wong et al. (2007)	MHINT (Mandarian Hearing in Noise Test) in two versions-	24 list consisting 20 sentences each	Adults	Open Set Verbal Response	Percentage correct was scored.

	Mainland and Taiwan				
Neumann et al. (2012)	Oldenburg Sentence Test for Children	6 list of 14 sentences each	4-10 years	Open Set Verbal Response	All words in sentences were scored
Spahr et al. (2012)	AzBio Sentences	33 list of 20 sentences (Adult version) 16 list with 20 sentences (Paediatric version)	Both for adult and children different version	Open Set Verbal Response	Number of words correctly repeated were scored and percentage correct was calculated
Jain, Narne, Singh, Kumar, and Mekhala (2014)	Hindi Sentence Test for Speech Recognition in Noise	20 list of 10 sentence each	Adult	Open Set Verbal Response	Percentage correct scored by analysing the correct words.

From the review it can be seen that several tests have utilized sentences as stimuli for evaluating speech recognition / speech identification. It has been shown that sentences with predictable structure yielded better scores than unpredictable structured sentences (Hagerman, 1982). Another problem with the use of sentences is the length that has been considered to put cognitive strain on an individual (McArdle & Hnath-Chisolm, 2015). Further, it has been reported in literature that sentence tests are influenced by knowledge of linguistic factors and are more time consuming compared to word and phoneme tests (Tyler, 1994).

The Matrix test, the concept of which was originally developed by Hagerman in (1982), attempts to take advantage of the positive features of sentence tests mentioned earlier and tries to overcome the disadvantages. The major advantage of the Matrix sentence test, according to Hagerman (1982), is that it is difficult to memorize the sentences because of their lower redundancy that allows testing the same individual multiple times with different hearing aids in a single or in multiple sittings.

Further, the Matrix sentence test has been designed to generate sentences that are comparable across languages so as to have syntactically fixed yet semantically unpredictable sentences (Dreschler et al., 2006; Hagerman, 1982; Puglisi et al., 2014). This feature of the Matrix test enables the comparison of performance across different languages and different countries.

2.2. Matrix sentence test:

Due to its inherent advantages, the Matrix sentence test that was originally developed by Hagerman (1982), has been adopted to several languages. As per a HearCom project report in 2014, besides the Swedish Matrix sentence test the following 10 matrix sentence tests were available, developed by different groups: Polish Matrix Test (Ozimek et al., 2010); German Matrix Test (Kollmeier et al., 2011); Spanish Matrix Test (Hochmuth et al., 2012); Turkish Matrix Test (Zokoll, Hochmuth, et al., 2012); French Matrix Test (Jansen et al., 2012); Italian Matrix Test (Hochmuth et al., 2013; Puglisi et al., 2014); Finnish Matrix Test (Dietz, 2014); American-English Matrix Test (Zokoll, Wagener, et al., 2012) and Russian Matrix Test (Warzybok et al., 2015). These tests were developed as a part of a project titled 'The European HearCom Project' (Dreschler et al., 2006), which aimed to develop similar speech audiometry material across the European Union to bring uniformity in testing across the continent. According to the European HearCom project, the developed matrix tests could be used either in an open-set or a closed-set format. To obtain open-set responses verbal responses were required to be obtained and to obtain closed-set responses the participants were required to clicks on the correct words on a matrix provided. The responses were scored by calculating the number of correct responses. In the section below, the original Matrix test and those developed in different languages across different centres of the world are described.

The Matrix sentence test was initially described by Hagerman in 1982 when the 'Sentences for Testing Speech Intelligibility in Noise' was constructed in Swedish. This test was constructed with the main purpose of developing speech intelligibility material especially for evaluation of hearing aids in free field and discrimination (*sic*) under headphones. The aim was to produce different sentence lists with equal difficulty and reliable results.

The sentences for the tests were constructed using a base matrix which included five categories (name, verb, numerical, adjective, & object), each containing 10 words. The original test in Swedish had a total of 13 lists of sentences with noise. Several different lists were produced from one recording with the intention of them having the same content of sounds so that the lists would have equal difficulty. The recording of the sentences on a computer was done by a female speaker who was instructed to avoid transitions between words. Following this, each word was cut out. New lists were made by selecting words randomly from each of the 5 columns from the original list by a computer. The computer program also automatically mixed the sentences together to form new lists. Silence was introduced between words to make them sound more natural.

As the test was designed to evaluate speech discrimination (*sic*) in the presence of noise, noise was generated by periodic filtering the sounds of the original word list to make 7 periodic noises with periodicities between 10 to 30 Hz. The 7 periodic noises were mixed together to form a noise with no noticeable periodicity but having the exact spectral characteristic as the word lists. To make the noise not have a steady state, but to sound like cocktail-party noise, a low frequency amplitude modulation was introduced. The stereo recorded sentences were recorded in a mix tape, with a carrier tone at the beginning of each channel at -2 dB below the sentence level.

Using the developed Swedish Matrix test, Hagerman (1982) carried out a pilot study on 6 normal hearing subjects after which the words were regrouped to equalize difficulty. Following this, normative data were collected from 20 normal hearing adults. The open-set verbal responses of the participants indicated that the lists were equally difficult except for the first one. Hagerman opined that clients could memorize 50 words and guess the sentence, which accounted for 10% chance factor, since in different lists the words used were same.

2.2.1. Polish sentence matrix test (Ozimek et al., 2010).

The base matrix was constructed using words that were ranked as high frequency of occurrence in Polish dictionary, having one or two syllables, neutral in meaning in isolation and when combined with other words, grammatical correctness, and language specific phoneme distribution. Additionally, only verbs in the present tense and future simple tense were used as in the Polish language, in the past tense verb declension is determined by the gender of the subject. Further, a few numerals were also rejected since the declension of the adjective and noun was determined by the preceding noun. Some of the numbers were replaced by words such as ‘a lot of’ and ‘several’.

A total of 100 sentences were generated using the 50 base matrix words and it was recorded by a professional male speaker in a radio studio. The recorded material were cut at the zero crossing into 500 separate words. Two versions of the test were constructed, one to obtain open-set responses and other to obtain closed-set responses, with both having 10 lists with each list having 20 sentences.

The developed test was evaluated to find the test-retest reliability, effect different situations (supervised & unsupervised). Further, they evaluated the effect of measurement method (constant stimulus versus adaptive method), scoring method (word score versus sentence score), and the number of test items within a list (20-sentence in each lists was used for the adaptive procedure & 10-sentence in each lists was used for constant stimulus). The evaluation was carried out on 30 normal hearing individuals whose age was not mentioned.

The evaluation was done on four conditions as 1) with constant stimuli with word scoring, 2) constant stimuli with sentence scoring, 3) adaptive procedure with supervised response and 4) adaptive with unsupervised response. In constant stimuli mode noise was kept constant at 65 dB SPL, and speech was also kept at a constant level to maintain a fixed SNR. Whereas in the adaptive paradigm, noise was kept constant at 65 dB SPL and the speech level was changed adaptively with each response of the subject. Supervised condition involved obtaining open set responses, whereas in unsupervised condition closed set responses were obtained.

The measured outcomes were Speech Recognition Threshold with constant stimuli paradigm and S-50 with adaptive paradigm. All the measure were carried out in presence of noise. The result did not show any significant difference in the situation and method that was used for evaluation.

2.2.2. Spanish matrix sentence test (Hochmuth et al., 2012).

The base matrix was designed according to the sentence structure of the Swedish sentence test given by Hagerman in 1982 to contain name, verb, numeral, object, and adjective. Due to the gender dependent declination of the adjectives, only male objects were used to enable randomization of all words. The words for the base matrix were selected based on the frequency of occurrence, number of syllable in the words (equal), and grammatical correctness (male dependent declination).

After construction of the base matrix, 100 sentences were recorded that included most combinations of the adjacent words. The recording was done in a sound attenuated room by a female Spanish speaker. The words were sliced into individual words at the beginning of the next word to preserve co-articulatory cues. The words were then mixed randomly to make 35 base sentences. Sentences that did not have appropriate transitions were discarded. A Hann-window ramping of 15 msec was used as overlay for better transition. The final test consisted of 12 lists having 30 sentences each (triple-list) or 20 sentences in each list (double-list). Before actual testing, familiarization was done with two triple list sentences, first list was presented in quiet and second list at -4 dB SNR. Subjects included 13 normal hearing listener aged 21 to 27 with mean age of 24 years for the evaluation measurement.

Four experiment were carried out (optimization of speech material, testing in open set format, testing in closed set format & testing with Latin American subjects). Optimization was done to obtain homogenous SRT for each word of the sentence. It was carried out in Oldenburg Germany on 13 subjects in the age range of 21 to 27 years with mean age of 24 years. Twelve triple lists were administered and based on the responses, level adjustment was done. The sentences that had large variation were discarded from final list.

Next they evaluated open set responses in two region of Spain [Tenerife (N = 15) and Spanish Mainland Madrid (N = 18)]. The mean age these participants was 27 years (range 18 to 48 years). Six double lists were evaluated using an adaptive method. Also at fixed SNRs of -4, -5 and -9 dB, the homogeneity of the lists were measured. During all evaluations, noise was presented constantly at 65 dB SPL. No significant difference was observed between the results obtained at the two places. When pair-wise comparison was made using Bonferroni correction, there was significant difference between lists as; list 1 vs 6 and list 3 vs 2, 4, 6, & 7.

For evaluation closed set responses, ten normal hearing individuals were recruited and the responses were obtained with words in the matrix. The subjects were required to click the correct word sequence in the matrix box. A significant difference was observed between the response obtained with closed and open set responses.

To understand if the test developed can be used with other variation of Spanish language, it was administered in 12 Latin American subjects with mean age of 27.7 years (24 to 33 years) across the country. Six double lists were used for the evaluation in an open-set format. No significant difference was observed in the result obtained with Spanish and Latin American subjects.

The authors concluded that the developed Spanish matrix test is comparable to other matrix test in structure and also in terms of results obtained with Spanish subjects and Latin American subjects not differing, so it can be used with different variation of Spanish speaker. Also the test could be used in a closed set or in an open set format.

2.2.3. Turkish Matrix Sentence test(Zokoll, Hochmuth, et al., 2012)

The base matrix for the Turkish Matrix test was formed from 50 words that were categorized as name, numeral, adjective, object, and verb. The words were selected based on the frequency of occurrence in the Turkish language. The words in each category were pseudo-randomly selected to form 300 sentences that were grouped into 10 lists containing 30 sentences each. Optimization was done to obtain homogenous speech intelligibility for individual word. The evaluation was done in presence of noise, where noise was kept constant at 65 dB SPL and sentence level was varied to obtain fixed SNR of +5.5 dB to -22 dB SNR, in step of 2.5 dB.

The test was administered on 12 normal hearing individuals, who were exposed to Turkish language from childhood. Word scoring paradigm was implemented for scoring in open set response mode. The SRT obtained was -9.4 ± 2.6 dB SNR before optimization and after optimization it was-9.3 ± 0.8 dB SNR. The optimization resulted in steeper slope of the intelligibility function. The findings were comparable to the finding of matrix test in other languages.

2.2.4. The French Matrix Test (Jansen et al., 2012)

The base matrix of 10 names, verbs, numeral, object, and colours, was used to develop the French Matrix test. The words were selected based on the frequency of distribution of the words in French and also on the phonetic distribution of the spoken language. Recording of sentences was done in a sound treat room by a French female speaker. A total of 100 sentences were recorded from 50 words so that all words had co-articulation with the adjacent word. Equalization of the sentences was done for the root-mean-square value before cutting the sentences into individual words, while preserving the co-articulatory cues to the next word. After randomization of the words, a total of 50 lists with 10 sentences each were developed. After discarding the unnatural sounding sentences, 28 lists were finally obtained and noise was generated by superimposing 280 sentences several times, so as to present with LTASS of the sentences. The testing was carried out using two variations: first a constant stimuli with a noise level of 65 dB SPL and fixed sentence level resulting in fixed SNR for each list and second adaptive procedure with noise fixed at 65 dB SPL and sentence level was changed adaptively according to the response.

The utility of the test was established on 57 (17 males and 40 females) normal hearing listener. Out of the 57 listeners, 27 with a mean age of 26 years (range 20 to 54 years) were used for optimization of the developed sentences. The remaining 30 participants (mean age of 22, & age range of 20 to 29 years) were involved in the measurement of SRT.

Optimization was done by presenting the 280 sentences to the listeners with noise level being fixed noise at 65 dB SPL and the sentences varying between -18 to +6 dB SNR in 2 dB steps, but with each list being presented at a fixed SNR. For the establishment of norms, two groups of subjects were tested. In the first group, 20 participants were tested and word scores were calculated for their responses. Speech reception threshold was obtained for the 500 independent words by applying a logistic regression to obtain psychometric curve for these normal hearing listeners. The homogeneity of the words was ensured by the level of the words being adjusted to the mean speech reception threshold. In the second group, 10 listeners were presented with six double-lists using an adaptive 2 dB step, in which sentence scoring was utilized. The SNR was calculated by taking the average of last 16 sentences. The authors conclude that the lists developed were accurate and reliable, especially when using word scoring procedure. Also it was found that compared to other matrix tests as the Polish matrix test, the psychometric function curve was shallower.

2.2.5. Polish Paediatric Matrix Sentence (Ozimek, Kutzner, & Libiszewski, 2012).

The Polish Paediatric Matrix Sentence Test was evaluated on normal-hearing children and children with hearing impairment aged 3 to 6 years. The sentences were used from the Polish Matrix Test, and pictorial descriptive picture were developed. A picture pointing task was used as the response mode. Scoring was considered for both verbal responses and picture pointing. The pictures has 6 option which were similar to the sentences.

Testing was done in 181 preschool normal hearing children and 41 hearing impaired children, in each age group. The results showed that there was decrease in speech reception threshold in the normal hearing children with age. Also, it was found that hearing impaired children obtained SRT which was higher than those obtained by normal hearing children. It was found that children aged 3 to 6 years could be tested with the Polish paediatric matrix sentence test. The performance increases with age for both picture pointing and verbal response. In all the age groups, poorer scores were obtained for hearing impaired children compared to normal hearing. The authors also concluded that the Polish paediatric matrix sentence test, if combined with picture pointing could be a reliable tool for measuring speech intelligibility in the paediatric population.

2.2.6. American Matrix Sentence Test-USMatrix test (Zokoll, Wagener, et al., 2012)

The base matrix for the American Matrix Sentence Test was constructed with 50 words in 5 categories used in the original test. The sentences were recorded by a Native American English female speaker. Similar to the other matrix tests, the sentences were spliced into individual words and were re-concatenated into new sentences with preservation of natural prosody and co-articulation. Optimization of the sentence was carried out to check for the homogeneity of the sentences .The sentences were evaluated on 17 native listeners of American English, obtaining open-set responses with word scoring format. Later it was again administered on 31 American and 15 Canadian English listener to obtain normative information. All the tests were carried out at fixed noise level of 65 dB SPL with adaptive and constant stimuli paradigm for sentences. It was found that the lists were equivalent and the reference speech reception threshold values obtained for the American and Canadian listeners were comparable. It was also noted that the USMatrix test was a reliable, accurate and efficient speech test.

Rose (2013) also confirmed that the six lists of the USMatrix test were equivalent and any list could be used for testing purpose as there were no statistical difference observed across the lists. However, at a constant stimuli paradigm it was found that there was statistical difference between the scores obtained at -6 dB SNR, whereas there was no difference observed at -8.5 dB and -11 dB SNR. Hence, it was suggested to use the less favourable SNR to obtain the desired criteria of 50% score.

2.2.7. Italian Matrix Sentence Test (Hochmuth et al., 2013).

The base matrix was developed using 10 words in five categories (names, verbs, numerals, nouns, & adjectives). The words selected had two or three syllables and were chosen from the most frequently spoken words in Italian language. From the base matrix 100 sentences were recorded to incorporate all possible combination of two adjacent words. The recording was done by a native female Italian speaker having neutral and natural intonation. Masking noise was generated by superimposing the sentences generated 30 folds, to match the average speech spectrum.

Optimization was done in Germany (Oldenburg; N = 19) and evaluation was carried out in two centre in Italy (Ferrara; N = 21 & Torino; N = 15). All listener were Italian speaker with a mean age of 25 years, ranging between 16 to 37 years. The evaluation was carried out on 36 normal hearing listeners. It was done for both open-set responses and closed-set responses. The noise was presented at a constant level of 65 dB SPL, whereas the presentation level of the sentences was varied adaptively based on the response of the participant. There was no difference in the speech reception thresholds obtained at the two different centres. The mean speech reception threshold obtained with open-set responses was -6.7 ± 0.7 dB SNR and for closed-set responses it was -7.4 ± 0.8 dB SNR. This was found to be similar to that obtained on the Spanish Matrix Test by (Hochmuth et al., 2012). A final 12 base list with 10 sentence was constructed. The authors concluded that sentences may be combined together in different list from the base list to form multiple sentence lists with 20 to 30 sentences in each list.

2.2.8. Finnish Matrix Sentence test (Dietz, 2014)

This was the first sentence test in noise that was developed in Finnish language. The matrix was constructed based on the Hagerman model, and contained 10 names, 10 verbs, 10 numerals, 10 adjectives and 10 objects. The words chosen in the matrix were from two dictionaries and were commonly known by Finnish speakers as well as occurred frequently. The base matrix was recorded in a sound insulated room by a female news anchor, who was instructed to speak with natural effort, rate and intonation. The goodness of the recording was continuously evaluated by four listeners outside the recording room. A total of 100 sentences were recorded twice. The sentences were high pass filtered at 50 Hz to remove a low frequency hum in the recording and was equalized in term of their root mean square to adjust potential loudness differences during recording.

Subsequent to the recording, 300 sentences were constructed by splicing the recorded stimuli into individual words. These words were randomly mixing making sure to preserve co-articulatory cues. To maintain the transition, a constant cross fading between words was used. The sentences generated after randomization of the words were check again by five normal listeners. Finally, 30 lists of 10 sentences each were constructed. Noise was generated by superimposing the generated sentences to create a noise that had a frequency spectrum similar to that of the sentences.

Optimization was done in a similar manner as that described by Hochmuth et al. (2012) for the Spanish Matrix Test. Optimization was carried out on 21 subjects in the age range of 22 to 44 years with mean age of 30 years. The response mode utilized was open set presentation with word scoring. Following the optimization, the sentences were evaluated on 21 normal hearing listener aged 21 to 38 years (mean age of 23 years), who did not participate in the optimization. The presentation level of sentences was varied adaptively based on the response of the subject with noise level fixed at 65 dB SPL. The authors concluded that the Finnish matrix test was in par with the German, Danish, French and Spanish matrix tests. The test was found to have good test specific recognition function and intelligibility across subjects.

2.2.9. Dutch matrix sentence test (Houben, Koopman, Luts, Wagener, Wieringen, et al., 2014)

The Dutch matrix test was developed in 2014 by Houben et al. to assess speech intelligibility in noise. The groundwork for the Dutch Matrix test was initially reported in the 2006 HearCom report, along with three other languages as Swedish, German and English (Dreschler et al., 2006). The base matrix consisted of five categories (name, verb, numeral, adjective, & object) and for each category ten alternatives were chosen. The sentences were recorded by a 24 year old female, who spoke naturally to ensure the presence of co-articulatory cues. The sentences were checked to verify naturalness, grammar and articulation Out of 360 sentences, 13 were discarded as they contained artefacts and a total of 347 natural sounding sentences were retained for further analyses.

Homogeneity of each word was evaluated to find its intelligibility. For optimization, 10 normal hearing listeners were recruited in the age range of 19 to 26 years with a mean age of 24 years. For equalization of intelligibility, each word was either amplified or attenuated based on the SRT obtained, maximum changes was done till ±3 dB to avoid unnatural jump in intensity. After optimization of the sentences and prior to evaluating mean speech reception threshold, a few more sentences were discarded as they sounded unnatural. Finally, out of the 311 remaining sentences, 14 lists with 20 sentences each were constructed.

Normative data were collected in three different centres, one in Belgium and two in Netherland. All three centres met same standard (ANSI). The developed test was evaluated on 45 normal hearing adults (15 adult in each centre). The mean age of participants in the three centres was 26 years (range: 20 to 42 years), 22 years (19 to 25 years) and 24 years (19 to 44 years), respectively. Testing was done using a closed-set response mode. The results obtained showed that there was no significant difference in speech reception threshold obtained from the three centres. Also, the authors concluded that the speech reception threshold for the developed test in noise was -8.4 dB with an inter-list standard deviation of 0.2 dB.

2.2.10. Russian matrix sentence test (Warzybok et al., 2015)

The Russian matrix sentence test (RUMatrix) was also constructed from a base matrix having 10 names, 10 verbs, 10 numerals, 10 adjectives and 10 nouns. The words for the base matrix was extracted from a frequency dictionary of modern Russian from which only words that were highly frequent were selected. Further, only verbs in present and future tense were selected, as the past tense verb was dependent on the subject's gender. Recording was done by a female native speaker from Moscow for 100 sentences that were generated from the base matrix. The recording was done with the speaker using natural intonation with constant vocal effort and rate. The sentences were cut into individual words at the zero crossing of the waveform.

A total of 500 sentences were generated by randomly mixing the words from the five categories. The masking noise was generated by random 30 fold superimposition of all sentences. Optimization was carried out to obtain word specific speech reception threshold and S-50, based on which the root-mean-square value of words were readjusted to obtain word-specific speech reception threshold close to that of the mean value. Optimization was done on 14 native Russian listeners in the age range of 20 to 31 years (mean age of 25 years).

The final test contained 16 lists containing 10 sentences each, which were or 8 lists containing 20 sentences each. Evaluation measures were obtained from 63 normal hearing listeners with mean age of 25 years (range: 19 to 33 years) from three different setups (N = 32 in Oldenburg, N = 15 in St. Petersburg, & N = 16 in Hannover). Evaluation was carried out for both open-set and closed-set responses in the presence of noise at 65 dB SPL. Testing was done using an open-set format on 35 participants and using a closed-set format on 28 listeners. Another sub-group of 27 participants were tested to see if noise level had any effect on the measures, using a closed-set format.

The results obtained shows that the RUMatrix test was found to be comparable to other matrix tests that had been developed earlier. Closed-set format showed better thresholds compared to open-set responses. This was ascribed to the visual cues present during the closed-set testing, which would have enabled the participants to guess the stimuli. It was suggested that closed-set responses may be beneficial in conditions when the examiner is not fluent in the language. Further, it was found that there was an effect of noise level on the speech reception thresholds, but the authors recommended that further extensive research needs to be obtain to validate this result.

Apart from above mentioned matrix sentence test, matrix test has been developed in few other languages as Persian by Fayazi et al. (2013), and Norwegian by Oygarden (2013). These were presented at 11th EFAS Congress, 2013 held in Budapest.

2.3. Application of Matrix sentence test on clinical population

The utility of the matrix sentence test has been investigated on individuals having hearing impairment (Hey, Hocke, Hedderich, & Muller-Deile, 2014). Studies have tested speech perception using the test in the presence of noise and measured the lowest level at which 50% scores can be obtained in deviant population.

Investigation of the German version of the matrix sentence test on cochlear implant users was investigated by Hey et al. (2014) . The test was carried out in the presence of noise using an adaptive procedure. The study was carried out on 38 adult cochlear implantee using Cochlear Freedom or Cochlear Nucleus 5 CI system. The testing was done in two steps, first pre-test training in quiet using 30 sentences at 65 dB SPL. In the next step they were tested in the presence of noise where adaptive testing in noise was done using 30 sentences at 65 dB SPL. The level of the sentences was varied according to the response of the adult. The adaptive testing utilized Oldenburg speech spectrum shaped noise which was presented at a constant level of 65 dB SPL. The level of sentence was increased if less than two words were recognized correctly and decreased if two or more words were recognized correctly, with the aim to obtain 40% scores. Also, testing was done at different fixed SNR conditions. At each SNR, 10 sentence were presented to obtain plateau. The Oldenburg noise was presented at fixed 65 dB SPL and the signal was varied systematically at different SNRs (+5, +3, +2, +1, +0, -1, & -2 dB). In all 7 SNR condition with constant stimuli, 10 sentences each were presented to obtain discrimination function, which was calculated as the change in scores with different SNR.

The results of the first pre-test training in quiet with 30 sentences presented at 65 dB SPL, indicated that out of the 38 subjects, 29 got a score higher than 90% in quiet and 9 of them got scores between 78 to 90%. A significant correlation was seen between the different speech reception thresholds obtained using different adaptive conditions.

It was concluded that for adults using cochlear implants, both adaptive and constant SNR, testing paradigms could be used to assess speech perception. Further, it was observed that the performance of the participants using cochlear implants was comparable to that of normal hearing listeners. The author suggested that some modification may be required for the test to be used with poor performing cochlear implants users. Although it was recommended that Matrix test can be used effectively in implanted individuals using any of the tested paradigms, but considering time constraints, it was better to use an adaptive method. Additionally, instead of 50% convergence the use of 75% convergence was suggested.

Another study by Weissgerber, Baumann, Brand, and Neumann (2012) investigated the application of OlKiSa (German Oldenburg Sentence Test for Children) in children fitted with hearing aids and cochlear implants. A total of 119 children between the age of 4 to 10 years were selected for the study. The measurements done were SRT in quiet and slope of speech discrimination was calculated using point of SRT at SRT +2 dB and SRT -2 dB by use of linear regression, but it was found that this regression technique overestimated the speech discrimination.

Unaided SRT was compared across age groups as the hearing threshold were different across individuals. There was a marginal correlation between aided free field thresholds and aided SRT ($r = 0.35$, $p < 0.005$) and PTA strongly correlated with aided SRT ($r = 0.87$, $p < 0.005$). It was found that those with hearing impairment had poorer threshold and lower discrimination slope. Hence the authors concluded that OlKiSa can be used as a reliable test for assessment of speech perception in quite as well as in noise (based on previous studies). Also, it was concluded that speech perception can be assessed in children with higher sensitivity compared to single word testing, using sentence test such as OlKiSa.

The Polish Paediatric Matrix Sentence Test was evaluated on normal-hearing children and children with hearing impairment aged 3 to 6 years by Ozimek et al. (2012). Testing was done in 181 preschool normal hearing children and 41 hearing impaired children, in each age group. The results showed that as the age increased, SRT was better and the hearing impaired children had poorer SRT compared to the normal hearing children in all age groups. The authors concluded that the Polish paediatric matrix sentence test, if combined with picture pointing could be a reliable tool for measuring speech intelligibility in the paediatric population for both the population.

From the review it can be seen that a variety of stimuli have been used to evaluate speech intelligibility. Sentence tests were noted to be the stimuli that provided a close approximation of the difficulties faced by individuals in real life situations. Although sentences were found to have certain disadvantage, the advantages outweigh the disadvantages and continued to be preferred while assessing speech perception.. To overcome some of the difficulties of sentence tests, Matrix sentence tests have been recommended. These tests are available in a large number of European languages and studies have demonstrated their utility.

Chapter 3

Method

The study aimed to develop a matrix sentence test for English speaking children in India to evaluate speech intelligibility at a suprathreshold level, which mimics everyday situations. Evaluation of speech intelligibility was targeted instead of speech reception threshold, unlike the majority of the matrix tests reported in literature, in order to get an estimate of normal conversational speech. Additionally, since the test was designed for children, who are known to have more difficulty than adults in perceiving speech in the presence of noise, the study aimed to measure speech intelligibility in quiet. The study was conducted in two phase. The first stage involved the development of the 'Matrix Sentence Test in Indian-English (MST-IE)'. The second phase involved checking the validity of the developed sentence material in normal hearing young children aged 7 to 10 years by determining their speech identification scores.

3.1. **Participants**

Stage I of the study included 20 children, aged seven years, to check the familiarity of the words used to develop the matrix sentences. Content validity as well as a goodness test was carried out on 10 adults. Further, a goodness test was also done on 5 children aged 7 years to confirm the clarity of the recorded material. In the stage II, 30 children in the age range of 7 to 10 years, who did not participated in the stage I of the study, were recruited to check the intelligibility of the developed sentences. All the children included in this study for both stage I and II had no history of middle ear problems; no trauma to their head or ears; normal hearing indicated by the presence of pure-tone average thresholds of ≤ 15 dB HL in the frequencies between 250 Hz to 8000 Hz for air conduction and 250 Hz to 4000 Hz for bone conduction; normal middle ear functioning, confirmed by the presence of 'A' type tympanograms with reflexes present in both ears; normal speech and language development; exposure to English for at least 3 years; and no history of otological, neurological, or psychological problems.

3.2. Test Environment

Testing the familiarity of the test material, that was a part of Stage I, was carried out in distraction-free quite rooms. The audiological evaluations were carried out in a well illuminating, sound treated room having permissible noise levels (ANSI, 1999).

3.3. Instrumentation

The instruments used for the study included a calibrated two-channel audiometer with TDH-39 headphone with MX-14 ear cushion and Radioear B-71 bone vibrator, to determine the hearing sensitivity of the children. A calibrated immittance meter (GSI Tympstar) was used to assess tympanogram and acoustic reflex to confirm the presence of normal middle ear status. A computer with Adobe Audition (Version 3.0) was used to record and play the developed speech material.

3.4. Stage I: Development of material

Stage I entailed the development of the test material for use in the 'Matrix Sentence Test in Indian-English (MST-IE)', in the format given by Hagerman (1982). In the format described by Hagerman (1982), each sentence had a fix semantic structure that had a 'name', 'verb', 'number', 'adjective' and an 'object'. Each word category had 10 alternative words, making the total number of different words 50.

The words for the MST-IE were selected based on the vocabulary of 7 year old children. The English words were selected from second standard text books of schools having English as the medium of instruction and story books meant for the target age. Additionally, adults who were familiar with the vocabulary used by seven year old children also contributed to the list of words. Only words having one to two syllables were selected. Content validity of the initial 100 words was checked by asking three adults who dealt with seven year old children to report if the words were considered appropriate for the target age group and were used commonly.

Further, the familiarity of the 100 short-listed words was tested on 20 children aged seven year in a distraction free room. The children were instructed to indicate the meaning of the words, if they had heard of the words or had not heard the words. Based on their responses the words were classify as 'highly familiar', 'partially familiar' or 'unfamiliar'. Words that they knew the meaning of were categorized as 'highly familiar', while words that they had heard of but did not know the meaning were labeled as 'familiar'. Words that they did not know the meaning and had not heard of were grouped as 'unfamiliar'. Fifty words that 80 % of the children considered as 'highly familiar' were selected to make 10 sentences for the base matrix. The 50 words were selected included 10 names, 10 verbs, 10 numbers, 10 adjectives and 10 objects. One word was selected from each category to develop 10 grammatically correct sentences for recording.

The 10 sentences were recorded by a female speaker, who spoke Indian-English with a neutral accent. The recording was done in a sound-treated room using Adobe Audition (Version 3) at a sampling rate of 44100 Hz with 16 bit resolution. A directional microphone (AKG D-7) was place 10 cm away from mouth of the speaker during recording. The speaker was instructed to read all the sentences with similar vocal effort without much inflection in intonation.

The recorded sentences were sectioned to obtain individual words, ensuring that the sectioned words were not distorted. The sectioned words were concatenated to form 1640 unique sentences with fixed semantic structure using a Matlab code (Gnanateja & Bhattarai, 2014). Grammatically incorrect sentences were discarded.

The concatenated meaningful sentences were played to 10 adults who were fluent speakers of Indian-English to confirm that they were meaningful. The same 10 adults verified the clarity of the recorded material. Only the sentences that were considered grammatically correct and clear by all 10 adults were retained. Following the evaluation of the 10 adults, 730 sentences were short-listed. Additionally, a goodness test was performed on five children aged seven years to confirm if they were able to repeat all the recorded sentences. Since the five children were able to repeat all the sentences, no further modifications were made. A 1000 Hz calibration tone was inserted prior to the list. The average RMS of the 50 words of the base matrix was considered for generation of the calibration tone.

3.5. Stage II: Validation of test:

The developed sentence material were administered on 30 normal children aged seven to ten years who met the participant selection criteria. The stimuli were presented using a computer using Adobe Audition software (version 3). The output of computer was routed through the audiometer to TDH-39 headphones. The stimuli were presented at 40 dB SL (w.r.t PTA), to represent normal conversational level. The 1000 Hz calibrated tone was used to adjust the VU meter deflection.

The children were instructed to repeat the sentences heard through the headphone. Prior to the actual testing, the children were familiarized using the practice items. Half of the participants were tested in the left ear and other half were tested in the right ear to minimize an ear effect. The lists were presented in random order and the sentences were also presented randomly within the lists. Testing was carried out in multiple sessions depending upon the child’s interest and fatigue, with breaks provided between the sessions. Most children completed the testing in 2 to 3 sessions with breaks in between. A few of them, mainly from the second standards required 4 to 5 sessions.

The responses given by the child were noted and scored by the examiner. Each correctly repeated sentence was given a score of '1' and each incorrect sentence was given a score of '0'even if sentence were not entirely incorrect. Only those sentence which were correctly responded were selected for the final list.

From the 730 sentences that were presented to all the children, 500 that were correctly identified by all the children were selected. Using these 520 sentences, 50 lists were made that contained 10 sentences each as shown in Appendix 1. The lists were balanced in terms of the consonant distribution. The consonant variation across the lists was not more that ±2. The remaining 20 sentences were used as practice items. A 1000 Hz calibration tone was inserted prior to each of the lists having the average RMS of the 50 words of the base matrix. Further, to confirm the equality of the lists in terms of their amplitude, the root-mean-square (RMS) value of each sentence list was calculated. For each sentence list, three different amplitude parameter was calculated. These included average RMS amplitude, minimum RMS amplitude, and maximum RMS amplitude.

3.6. Analyses

The amplitude measures of the 50 different lists were subjected to statistical analyses to check for their equivalence. Besides descriptive statistics, a repeated measure ANOVA was measured.

Chapter 4

Results

The 50 perceptually equivalent sentence lists that were developed were subjected to further analyses to check they were also equivalent in terms of root mean square (RMS) amplitude. Descriptive and inferential statistical analyses were carried out using SPSS (Version 20).

Three different RMS amplitude measures were analysed (average, minimum, & maximum RMS amplitudes). Table 4.1 displays the mean and standard deviation of the average, minimum, and maximum RMS amplitudes for each of the 50 lists. From the table it can be seen that mean RMS values of each list containing 10 sentences, varied marginally. This occurred for all three amplitude measures that were calculated. However, the variations were relatively more for the minimum RMS amplitude and were relatively less for average RMS followed by maximum RMS. These variations can also be seen in Figure 4.1.

Table 4.1: Mean and standard deviation (SD) of the Average, Minimum and Maximum RMS amplitude for the 50 sentence lists.

List	Average RMS Amplitude		Minimum RMS Amplitude		Maximum RMS Amplitude	
	Mean	SD	Mean	SD	Mean	SD
1	-28.18	1.85	-96.41	15.02	-19.97	2.53
2	-29.39	0.70	-101.72	9.59	-20.91	0.69
3	-28.97	2.23	-103.89	15.45	-20.06	2.60
4	-28.59	1.69	-102.66	10.99	-20.34	2.29
5	-29.01	1.25	-96.76	14.16	-20.48	2.15
6	-28.47	2.44	-103.32	9.44	-20.02	2.92
7	-28.77	1.71	-103.08	5.04	-20.49	2.33
8	-28.51	2.84	-103.22	10.02	-20.05	2.98
9	-29.60	0.86	-102.54	9.24	-21.05	0.86
10	-28.75	1.93	-107.64	19.79	-20.43	2.21
11	-29.01	1.51	-101.39	9.40	-20.46	2.11
12	-29.24	0.58	-102.71	11.82	-20.92	1.13
13	-28.99	2.01	-103.34	7.60	-20.29	2.07
14	-29.27	1.67	-101.60		-20.69	1.43
15	-28.21	2.53	-99.19	16.76	-19.86	3.19
16	-29.29	0.68	-99.46	5.42	-20.93	0.93
17	-28.67	2.88	-103.71	10.81	-20.08	2.90

Cont…

…Cont

18	-28.85	2.08	-101.39	4.62	-20.29	2.50
19	-29.32	1.05	-100.14	6.09	-20.95	1.18
20	-29.02	1.30	-105.54	12.40	-20.55	1.31
21	-29.31	0.72	-101.5	14.59	-20.60	1.01
22	-28.87	1.33	-104.60	10.00	-20.20	1.71
23	-29.22	0.82	-103.37	14.19	-20.90	0.97
24	-29.01	0.64	-99.65	8.54	-20.63	0.95
25	-29.28	0.67	-103.40	7.64	-20.65	0.79
26	-29.31	0.77	-106.33	12.49	-20.60	0.89
27	-29.12	0.78	-97.28	16.42	-20.74	0.62
28	-27.97	2.61	-102.75	10.15	-19.19	3.06
29	-29.38	0.43	-100.18	4.67	-20.83	0.98
30	-29.76	0.60	-108.28	12.46	-21.29	1.24
31	-29.34	0.63	-104.41	7.42	-20.85	0.92
32	-29.39	0.57	-99.96	6.08	-20.69	0.96
33	-29.62	1.03	-101.83	6.73	-21.31	1.33
34	-29.61	0.82	-100.20	3.62	-21.14	1.23
35	-29.03	2.08	-101.65	10.32	-20.25	2.53
36	-29.19	0.46	-104.30	10.92	-20.63	0.78
37	-28.43	2.83	-99.36	13.85	-19.69	2.88
38	-28.56	2.86	-104.43	9.77	-19.97	3.06
39	-29.16	0.69	-101.54	15.87	-20.83	0.90
40	-29.29	0.73	-100.56	7.74	-20.90	0.96
41	-29.17	0.76	-97.81	7.02	-20.83	1.21
42	-28.94	1.52	-101.79	7.16	-20.02	1.95
43	-28.20	2.24	-105.49	14.25	-19.70	2.97
44	-28.30	2.27	-97.17	14.59	-19.49	3.22
45	-28.02	2.41	-101.90	9.39	-19.18	3.11
46	-28.88	2.25	-101.94	6.06	-20.26	2.37
47	-29.06	1.92	-103.77	5.34	-20.47	2.56
48	-28.61	2.24	-104.56	8.54	-20.34	2.53
49	-28.30	3.18	-105.86	12.86	-19.48	3.48
50	-28.58	2.78	-106.18	11.01	-19.99	2.92

Note. The mean amplitude values given is for the 10 sentences of each list

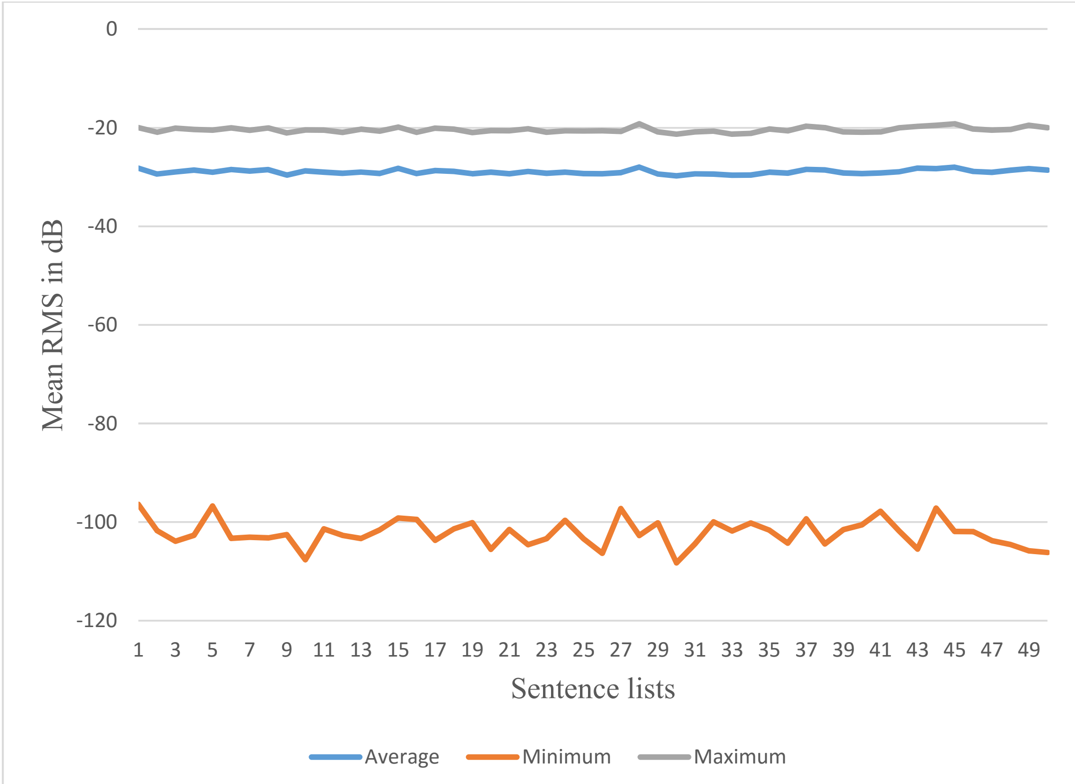

Figure 4:1: Minimum, Maximum and Average RMS amplitude of the 50 sentence lists.

Further, to confirm whether the variations across the lists were statically significant or not, the data were subjected to inferential statistics. Initially, normality of the data was checked with Shapiro Wilk's test of normality, which showed that the data had normal distribution ($p > 0.05$). Since the data were normally distributed, the equivalence of the lists was analyzed using three separate repeated measure ANOVA for each of the amplitude measures. It was found that there was no significant difference between the 50 sentence lists for the average RMS amplitude [$F (49) = 0.837$, $p = 0.78$], minimum RMS amplitude [$F (49) = 0.630$, $p= 0.98$] and for the maximum RMS amplitude [$F (49) = 0.702$, $p= 0.937$].

From the findings of the study, it can be inferred that the 50 sentence lists are not significantly different in all the three amplitude parameters that were evaluated. Thus, the sentence lists that were perceptually equivalent in children aged 7 to 10 years, were also equivalent in terms of amplitude.

Chapter 5

Discussion

The aim of the present study was to develop the matrix sentence test in Indian-English having multiple lists, following the principles and structure described by Hagerman (1982). The sentences were constructed from a base matrix containing 10 names, 10 verbs, 10 numerals, 10 objects, and 10 adjectives. The final 500 sentences were selected after eliminating sentences that were not intelligible to any of 30 children (aged 7 to 10 years) on whom they were tested, the sentence had fixed syntactic structures but were unpredictable.

5.1 Similarity and differences between developed and existing matrix sentence tests (Structure):

The developed test, that followed the principles and structure described by Hagerman (1982), was similar to the pattern followed in matrix sentence tests constructed in other languages Polish (Ozimek et al. (2010); Spanish (Hochmuth et al. (2012), American English (Zokoll, Wagener, et al. (2012), Finnish (Dietz (2014), and Dutch (Houben, Koopman, Luts, Wagener, van Wieringen, et al. (2014), Russian (Warzybok et al. (2015). However, in terms of the number of sentences / lists, the newly developed test that has 500 sentences divided into 50 list of 10 sentence each, is comparable to the matrix test developed as Polish (Ozimek et al., 2010) that has 600 sentence, and French (Jansen et al., 2012) that has 500 sentences. The matrix sentence test in Indian-English had considerably more sentences than those developed in Spanish (Hochmuth et al., 2012) that has 360 sentences, Turkish (Zokoll, Hochmuth, et al., 2012) having 300 sentences, Finnish (Dietz et al., 2014) with 140 sentences, Italian (Puglisi et al., 2014) with 120 sentences, Dutch (Houben, Koopman, Luts, Wagener, van Wieringen, et al., 2014) having 311 sentence, and Russian (Warzybok et al., 2015) with 160 sentences.

5.2 Similarity and differences between developed and existing matrix sentence tests (Participants):

While the majority of the Matrix tests that have been developed in different languages are designed for adults (Dietz, 2014; Hochmuth et al., 2012; Hochmuth et al., 2013; Houben, Koopman, Luts, Wagener, van Wieringen, et al., 2014; Ozimek et al., 2010; Warzybok et al., 2015; Zokoll, Wagener, et al., 2012), The Matrix test in Indian-English was developed for school-going children in the age range of 7 to 10 years. The few matrix tests reported in literature that were developed / adapted for children are the 'Polish Picture Matrix Sentence Test' for children aged 3 to 6 years. Since these tests were for much younger children they had been simplified to have a subject-verb-object pattern (Ozimek, Kutzner, & Libiszewski, 2012), and digit triplet test (Sofie et al., 2013). Further, the Polish test used a picture pointing and/or verbal responses, thus making the task simpler. Using this simplified test, they reported that they were able to test the children in the presence of noise. They concluded that the SRT for children became better with advancing age, with increase in verbal responses in the older children. They recommended the use of a closed-set response for children below 6 years of age. Since the current study was carried out on older children (7 to 10 years), open-set responses could be obtained with ease.

5.3 Influence of co-articulatory cues:

The sentences of the Matrix sentence test in Indian-English were developed using words spliced from sentences to obtain individual words that were later concatenated to form different other sentences. However, the co-articulatory cues of the original sentences were preserved by cutting words at the zero crossing at the start of the next word. Further, the individual words were normalized to make them equally loud to minimize the artifact as rapid changes in intensity. Thus, the reconstructed sentences had the co-articulatory cues of the original combination of words, with intensity variations reduced. Despite the 30 children hearing sentences that did not have the required co-articulatory cues, a large majority of the sentences were intelligible (520 out of 730 sentences) to them. The presence of other redundant cues in the sentences probably helped them correctly identify the sentences.

Similarly, earlier recorded matrix sentences (Dietz, 2014; Hochmuth et al., 2012; Hochmuth et al., 2013; Houben, Koopman, Luts, Wagener, van Wieringen, et al., 2014; Ozimek et al., 2010; Warzybok et al., 2015; Zokoll, Wagener, et al., 2012) have also utilized isolated words from base sentences that were concatenated to form new sentences. These studies also demonstrated that as long as some co-articulatory cues were present, though not necessarily of the word combinations used in the sentences, the sentences were found to sound natural and were intelligible.

5.4 Equality of lists:

Besides ensuring that all the lists were equal intelligible in quite to children age 7 to 9 year, the equality across the 50 lists was ascertained by them having equal number of syllables and distribution of consonants. To further confirm the equality of the sentences in terms of amplitude values, statistical analysis were carried out. It was demonstrated that there was no statistical difference between the 50 sentence lists in the 3 amplitude measures that were recorded (average, minimum, & maximum RMS amplitude). The equality in the amplitude of the sentence lists can be attributed to the fact that the isolated words were normalized before they were concatenated to form sentences. This would have ensured that the RMS amplitude values of the sentences were equal. Thus, it can be inferred that the sentences can be utilized to calculate speech reception thresholds as variations in the amplitude of the sentences will not interfere in thresholds that will be calculated.

5.5 Testing speech identification in quiet:

The Matrix tests developed in different languages have been designed to test speech intelligibility (Houben, Koopman, Luts, Wagener, van Wieringen, et al., 2014; Jansen et al., 2012; Ozimek et al., 2010) or speech reception threshold (Dietz, 2014; Hochmuth et al., 2012; Hochmuth et al., 2013; Houben, Koopman, Luts, Wagener, van Wieringen, et al., 2014; Jansen et al., 2012; Ozimek et al., 2010; Warzybok et al., 2015; Zokoll, Wagener, et al., 2012) in the presence of noise. However, the current developed was designed to test speech identification in quiet. Testing in quiet was preferred in the current study as it has been established that scores deteriorate in the presence of noise, which can result in the poor test-retest reliability of the test (Jansen et al., 2012). Further, children using cochlear implants were found to show poor performance when tested in the presence of noise (Hey et al., 2014). Utilization of the matrix test in children with hearing impairment may not yield the desired results due to a floor effect. Hence, it is recommended that the developed Matrix sentence test in Indian-English, be administered in quiet when used with children. This is also recommended since the format used for the development of the stimuli is similar to that used for adults, which could be readily done by normal hearing children above the age of 7 years. However, the utility of the test in the presence of noise needs to be investigated, before it is used in the format original recommended by the developers of the matrix test.

5.6 Use of constant stimulus level:

The matrix test developed in other languages have were administered using two paradigm as; constant stimuli and adaptive. In constant stimuli the noise level at 65 dB SPL and constant and at fixed speech level ten sentences are presented, this allows for testing at different fixed SNR. The other paradigm was adaptive, in which the noise level is kept constant at 65 dB SPL and each sentence presentation level were varied depending on the response obtained. For the current developed matrix test, presentation level was kept constant at 40 dB SL re PTA. The earlier version of matrix test were designed to obtain the threshold that is minimum SNR where 50% scores was obtained. But normal conversation is always at suprathreshold level and at high level, distortion can take place, which can degrade the signal. Hence testing at suprathreshold level mimics the normal conversation at higher then testing at threshold level. And as the presentation level increases, owing to distortion decrease in score were observed (Hagerman, 1982; Warzybok et al., 2015).

Based on the procedure used in the current study, it is recommended that the developed 'Matrix sentence test in Indian-English' be used as a supra-threshold test of speech identification for individuals above the age of 7 years. The test is recommended to be used only on those who have been exposed to English at least for 3 years. As the 50 lists of sentences were found to be equivalent, they can be used interchangeably. Having such a large number of equivalent sentence lists would be of considerable use when carrying out repeated tests, as done when selecting listening devices or programming of devices. For the use of the test in the presence of noise, further research needs to be done.

Chapter 6

Summary and Conclusion

The principle behind the ‘Matrix sentence test’ was provided by Hagerman (1982) while developing a Swedish sentence test. The test made use of sentences that were grammatically and semantically correct, but with reduced redundancy. Using the ideas of the original test, similar tests have been developed several other languages. The purpose of having similar tests was to bring about uniformity in testing to enable comparison across languages.

The primary aim of the current study was to develop a ‘Matrix Sentence Test in Indian-English (MST-IE)’ for children, that could be used for clinical assessment and management. The sentences were constructed from a base matrix of 50 words that had five categories of words (name, verb, numeral, adjective & objects). Using the base matrix, ten unique sentences were audio recorded. From the 50 words that were spliced from the recorded sentences, 730 grammatically correct and natural sounding sentences were generated.

Thirty children aged 7 to 10 years listened to the sentences through headphones and their open-set responses were noted. A score of one was given if the entire sentence was repeated correctly and zero if not entirely correct. Testing was carried out in multiple sessions with breaks to reduce the effect of fatigue.

From the 520 sentences that could be accurately repeated by the children, 500 were selected for developing the final sentence lists and 20 were used for practice. Fifty lists containing 10 sentences each were developed with all the lists having similar consonant distribution.

To check if the RMS amplitude of the sentences were equal, repeated measure ANOVA was carried out for 3 amplitude measures (average, minimum & maximum

RMS amplitude). The 3 separate ANOVAs indicated that there was no statistical difference between the 50 lists for all three amplitude measures. Hence, it can be concluded that the 50 lists can be used interchangeably when evaluating speech intelligibility of children aged 7 to 10 years who have had at least 3 years exposure to English.

Implications: The developed 'Matrix Sentence Test in Indian-English (MST-IE)' would be useful in the following ways:

- Provide information about the perceptual difficulties children are likely to face in a real life situation.
- Prevent familiarity of sentences effecting test findings due to the availability of multiple sentences.
- Will be useful in conditions when multiple conditions have to be evaluated such as when multiple manipulations of the controls of hearing aids are required.
- Although the test has been developed for children aged 7 to 10 years, it can be utilised on older children and adults.

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Appendix 1

Sentence list of the Matrix Sentence Test in Indian-English

List 1

1. Preeti saw some clean flowers
2. Rahul saw many big balls
3. Priya saw many big balls
4. Prema saw one green hat
5. Raama saw five new pens
6. Sita bought many big balls
7. Krishna washed five small socks
8. Raja washed twelve red bags
9. Chetan bought four red toys
10. Preeti wants four red bags

List 2

1. Raja wears some old socks
2. Priya breaks five red pens
3. Prema breaks ten old toys
4. Raama took ten good books
5. Sita wants many big balls
6. Krishna took one green hat
7. Chetan took three blue pens
8. Usha keeps some clean flowers
9. Krishna saw six old bags
10. Usha sings three old songs

List 3

1. Preeti saw one green hat
2. Raja saw four red balls
3. Priya saw some clean flowers
4. Sita saw five new pens
5. Krishna breaks five big toys
6. Chetan took five new books
7. Usha breaks five big toys
8. Preeti wants many big bags
9. Chetan washed some old socks
10. Usha sings ten old songs

List 4

1. Preeti washed six long dress
2. Rahul saw five new books
3. Raja saw many big toys
4. Priya saw four red balls
5. Prema wants one green hat
6. Raama bought some clean flowers
7. Sita washed some old socks
8. Krishna saw five new pens
9. Raja saw twelve small bags
10. Usha sings some old songs

List 5

1. Preeti bought some clean flowers
2. Rahul washed some old socks
3. Priya bought three blue pens
4. Prema bought one green hat
5. Raama bought five new books
6. Krishna saw many big toys
7. Chetan saw four red balls
8. Raja saw many big bags
9. Rahul bought ten good dress
10. Usha took twelve small toys

List 6

1. Preeti washed some old socks
2. Rahul saw one old hat
3. Priya got five new books
4. Prema got many big balls
5. Raama bought three blue pens
6. Krishna saw some clean flowers
7. Chetan saw many big toys
8. Rahul took one green hat
9. Raja saw four red bags
10. Sita took ten good songs

List 7

1. Preeti wants many big balls
2. Usha breaks twelve small toys
3. Priya breaks ten old toys
4. Prema got some clean flowers
5. Raama wants three blue pens
6. Sita took ten good books
7. Krishna bought five new books
8. Chetan saw four red bags
9. Raja wants three blue bags
10. Usha sings six old songs

List 8

1. Preeti got ten good dress
2. Rahul took ten good books
3. Raja got three blue pens
4. Priya bought many big balls
5. Prema washed some old socks
6. Krishna saw one green hat
7. Chetan saw some clean flowers
8. Usha took ten good bags
9. Sita sings twelve old songs
10. Rahul wants six old bags

List 9
1. Chetan bought five new books
2. Rahul took many big balls
3. Priya got four red toys
4. Prema washed some old socks
5. Raama breaks four old pens
6. Sita saw some clean flowers
7. Krishna took ten good books
8. Chetan wants twelve small bags
9. Raja wants twelve small bags
10. Priya keeps some clean flowers

List 10
1. Preeti bought ten good dress
2. Priya wants many big balls
3. Prema bought some clean flowers
4. Raama keeps three blue pens
5. Sita wears some old socks
6. Krishna saw twelve small toys
7. Chetan saw one green hat
8. Rahul saw three blue bags
9. Raja wants four red bags
10. Usha took six old songs

List 11
1. Preeti washed six long dress
2. Rahul took some clean flowers
3. Priya washed five small socks
4. Prema keeps five new books
5. Usha sings four old songs
6. Raama took twelve small toys
7. Sita took three blue pens
8. Krishna bought many big balls
9. Chetan bought one green hat
10. Usha wants six old songs

List 12
1. Rahul wants many big balls
2. Raja took one green hat
3. Priya took ten good books
4. Raama keeps some clean flowers
5. Chetan got three blue pens
6. Krishna bought four red toys
7. Chetan saw five new pens
8. Usha washed five small socks
9. Preeti took twelve small bags
10. Prema sings four old songs

List 13
1. Preeti saw ten good dress
2. Priya bought one green hat
3. Prema wears some old socks
4. Raama bought many big balls
5. Sita saw twelve small toys
6. Krishna wears some old socks
7. Usha got some clean flowers
8. Rahul wants four red bags
9. Raja sings five old songs
10. Sita breaks three blue pens

List 14
1. Rahul got one green hat
2. Raja saw some clean flowers
3. Priya got many big balls
4. Rahul saw many new balls
5. Rahul bought one green hat
6. Raja wants many big balls
7. Sita bought three blue pens
8. Preeti saw six old bags
9. Krishna keep twelve small bags
10. Chetan took ten good songs

List 15
1. Preeti got one green hat
2. Preeti washed one clean dress
3. Prema wears five small socks
4. Raama took some clean flowers
5. Sita keeps one green hats
6. Krishna got many big balls
7. Usha keeps twelve small toys
8. Priya saw six old bags
9. Rahul sings four old songs
10. Raja washed many big bags

List 16
1. Rahul wears one clean dress
2. Raja took many big balls
3. Priya took one green hats
4. Raama got three blue pens
5. Sita got five new books
6. Krishna got four red toys
7. Chetan wants some clean flowers
8. Usha wears some old socks
9. Preeti wants three blue bags
10. Prema sings five old songs

List 17

1. Preeti wants ten good dress
2. Raja washed some old socks
3. Priya took some clean flowers
4. Prema wants many big balls
5. Sita breaks twelve small toys
6. Krishna bought one green hat
7. Chetan took ten good books
8. Usha wears five small socks
9. Prema sings some old songs
10. Raama took ten good songs

List 18

1. Preeti wears six old dress
2. Prema keeps many big balls
3. Raama washed five small socks
4. Sita got one green hat
5. Sita breaks ten old toys
6. Chetan wears some old socks
7. Krishna wants one green hat
8. Usha got three blue pens
9. Priya saw many big bags
10. Rahul sings four old songs

List 19

1. Rahul washed five small socks
2. Raja washed one clean dress
3. Priya took twelve small toys
4. Raama wants five new books
5. Sita took one green hat
6. Krishna wants four red toys
7. Chetan got many big balls
8. Usha took some clean flowers
9. Preeti keeps twelve small bags
10. Prema sings many old songs

List 20

1. Rahul saw one good dress
2. Raja bought some clean flowers
3. Priya wears some old socks
4. Raama saw one green hat
5. Sita keeps three blue pens
6. Krishna took twelve small toys
7. Chetan took many big balls
8. Usha saw three blue books
9. Preeti saw many big bags
10. Prema want six old songs

List 21

1. Rahul bought ten good dress
2. Raja got some clean flowers
3. Priya wears five small socks
4. Raama bought one green hat
5. Sita breaks five red pens
6. Krishna wants twelve small toys
7. Chetan wants many big balls
8. Usha took ten good books
9. Preeti saw four red bag
10. Prema keeps six old songs

List 22

1. Rahul got ten good dress
2. Preeti took ten good books
3. Raja wants some clean bags
4. Raama got one green hat
5. Sita got four red toys
6. Krishna breaks many big toys
7. Chetan keeps many big balls
8. Usha bought some clean flowers
9. Preeti saw some clean bags
10. Prema sings three old songs

List 23

1. Rahul wants four red toys
2. Raja took ten good books
3. Priya got some clean flowers
4. Raama wants one green hat
5. Krishna breaks three long toys
6. Chetan bought many big balls
7. Usha wants three blue pens
8. Preeti saw five new bags
9. Prema took six old songs
10. Sita sings four old songs

List 24

1. Rahul bought many big balls
2. Raja keeps three blue pens
3. Priya wants some clean flowers
4. Raama keeps one green hat
5. Sita saw four red balls
6. Krishna breaks ten old toys
7. Chetan breaks four old pens
8. Usha saw twelve small toys
9. Preeti bought many big bags
10. Prema sings ten old songs

List 25

1. Rahul got many big balls
2. Raja breaks four old pens
3. Chetan saw twelve small toys
4. Raama took one green hat
5. Sita keeps some clean flowers
6. Krishna got twelve small toys
7. Chetan wears five small socks
8. Usha keeps three blue pens
9. Preeti bought four red bags
10. Prema took ten good songs

List 26

1. Raja wants five new books
2. Priya wants one green hat
3. Raama saw four red balls
4. Sita wants four red toys
5. Chetan saw six old bags
6. Chetan breaks five red pens
7. Usha saw some clean flowers
8. Preeti bought three blue bags
9. Sita wants six old songs
10. Usha wants twelve small toys

List 27

1. Raja wants three blue pens
2. Rahul keeps twelve small toys
3. Priya saw one green hat
4. Prema took three blue pens
5. Raama wants many big balls
6. Sita took some clean flowers
7. Krishna washed some old socks
8. Usha keeps four red toys
9. Chetan wants four red bags
10. Prema sings four old songs

List 28

1. Preeti got some clean flowers
2. Preeti wears one clean dress
3. Rahul saw twelve small toys
4. Priya got one green hat
5. Prema took ten good books
6. Raama keeps many big balls
7. Krishna wears five small socks
8. Preeti bought five new bags
9. Prema washed some old bags
10. Prema sings six old songs

List 29

1. Rahul keeps one green hat
2. Raja keeps many big balls
3. Priya breaks many big toys
4. Prema wants some clean flowers
5. Raama keeps five new books
6. Krishna breaks three blue pens
7. Preeti washed many big bags
8. Krishna bought twelve small toys
9. Rahul keeps four red bags
10. Usha took ten good songs

List 30

1. Rahul bought four red toys
2. Raja got ,any big balls
3. Priya wants five new books
4. Prema took five new books
5. Raama wears five small socks
6. Krishna bought some clean flowers
7. Preeti washed some old bags
8. Chetan saw twelve small bags
9. Sita keeps six old songs
10. Usha wants five new songs

List 31

1. Rahul wants twelve small toys
2. Raja took some clean flowers
3. Priya breaks three long toys
4. Prema keeps four red toys
5. Raama took three blue pens
6. Krishna wants many big balls
7. Usha sings ten good songs
8. Preeti washed three green bags
9. Chetan bought many big bags
10. Sita took six old songs

List 32

1. Prema bought twelve small toys
2. Raama got many big balls
3. Usha got five new books
4. Prema wants four red toys
5. Raama wears some old socks
6. Krishna got some clean flowers
7. Preeti took some clean bags
8. Priya bought four red bags
9. Sita sings four old songs
10. Usha wants some clean flowers

List 33

1. Rahul got some clean flowers
2. Raja wears five small socks
3. Priya saw many big toys
4. Prema wants four red flowers
5. Raama saw five new pens
6. Priya keeps one green hat
7. Krishna got one green hat
8. Usha took four red toys
9. Preeti washed twelve red bags
10. Sita sings five old songs

List 34

1. Rahul wants one green hat
2. Raja keeps some clean flowers
3. Priya keeps twelve small toys
4. Prema took four red toys
5. Krishna saw five clean flowers
6. Sita sings many old songs
7. Chetan took five new books
8. Usha took many big balls
9. Preeti took four red bags
10. Krishna saw some clean flowers

List 35

1. Preeti wears six long dress
2. Raja wears five red socks
3. Raja took five new books
4. Prema saw some clean flowers
5. Sita breaks five big toys
6. Chetan wants some clean flowers
7. Usha keeps one green hat
8. Rahul saw four small bags
9. Usha got three blue pens
10. Sita sings six old songs

List 36

1. Chetan took four red toys
2. Prema got one green hat
3. Sita keeps many big balls
4. Sita keeps four red toys
5. Chetan wants five new flowers
6. Sita keeps twelve small toys
7. Preeti keeps four red bags
8. Preeti wants some clean bags
9. Rahul saw four red bags
10. Sita sings some old songs

List 37

1. Preeti got ten good dress
2. Rahul took ten good books
3. Raja got three blue pens
4. Raja keeps one green hats
5. Prema took five clean flowers
6. Raama washed some old socks
7. Sita took many big balls
8. Usha breaks many big toys
9. Preeti wants six old bags
10. Sita sings ten old songs

List 38

1. Pretty got ten good dress
2. Raja washed five small socks
3. Prema took one clean hat
4. Raama bought three blue pens
5. Sita breaks three long toys
6. Chetan bought five new books
7. Chetan wants some clean flowers
8. Usha keeps many big balls
9. Preeti keeps six old bags
10. Sita sings three old songs

List 39

1. Rahul wears one clean dress
2. Raja saw one green hat
3. Raja took many big balls
4. Prema saw some clean toys
5. Raama got three blue pens
6. Sita got five new books
7. Sita wants some clean flowers
8. Usha wants four red bags
9. Raja wants some clean flowers
10. Priya sings three old songs

List 40

1. Rahul wears one clean dress
2. Raja got one green hat
3. Prema took some clean flowers
4. Raama wears some old socks
5. Raama took three blue pens
6. Sita got five new books
7. Sita wants twelve small toys
8. Usha got many big balls
9. Preeti keeps five new bags
10. Priya sings six old song.

List 41

1. Raja got four red toys
2. Raja tool one green hat
3. Priya took ten good books
4. Prema keeps some clean flowers
5. Sita breaks three blue pens
6. Usha washed five small socks
7. Preeti keeps three blue bags
8. Priya sings some old songs
9. Usha wants many big balls
10. Chetan saw five new pens

List 42

1. Preeti washed six long dress
2. Raja saw twelve small toys
3. Priya washed five small socks
4. Prema breaks many big toys
5. Prema keeps five new books
6. Sita got some clean flowers
7. Sita took three blue pens
8. Usha bought one green hat
9. Preeti bought twelve small bags
10. Chetan sings ten old songs

List 43

1. Preeti bought ten good dress
2. Priya wants many big balls
3. Preeti wants some clean flowers
4. Priya keeps six old bags
5. Raama washed some old bags
6. Sita bought twelve small toys
7. Sita wears some old socks
8. Usha got twelve small toys
9. Rahul bought four red bags
10. Chetan sings five old songs

List 44

1. Preeti wears six long dress
2. Preeti took some clean flowers
3. Raja bought one green hat
4. Prema took many big balls
5. Sita got twelve small toys
6. Chetan wears some old socks
7. Usha got four red toys
8. Rahul washed some old bags
9. Chetan sings three old songs
10. Usha for three blue pens

List 45

1. Preeti wears some old socks
2. Prema breaks twelve small toys
3. Sita wants one green hat
4. Chetan took ten good books
5. Preeti wears six long dress
6. Usha bought four red toys
7. Usha got three blue pens
8. Usha took many green balls
9. Rahul washed ten blue bags
10. Chetan sings some old songs

List 46

1. Preeti keeps ten good dress
2. Prema breaks three long toys
3. Raama saw some clean flowers
4. Raama got three blue pens
5. Sita saw one green hat
6. Sita got many big balls
7. Sita got five new books
8. Usha bought twelve small toys
9. Rahul keeps three blue bags
10. Chetan sings four old songs

List 47

1. Preeti wears five small socks
2. Raja saw some clean flowers
3. Raja wants one green hat
4. Raama took ten big books
5. Sita bought four red toys
6. Prema keeps one green hat
7. Sita bought three blue pens
8. Krishna wears some old socks
9. Usha bought many big balls
10. Rahul washed twelve red bags

List 48

1. Preeti wears one clean dress
2. Prema took ten good books
3. Raama wants some clean flowers
4. Raama keeps three blue pens
5. Sita saw many big toys
6. Krishna wears five small socks
7. Usha saw one green hat
8. Chetan saw many big bags
9. Rahul washed five small bags
10. Chetan sings many old songs

List 49

1. Preeti got ten good dress
2. Raja saw four red balls
3. Raama got some clean flowers
4. Sita bought one green hat
5. Krishna saw five new pens
6. Preeti keeps many big balls
7. Chetan washed some old socks
8. Usha saw many big toys
9. Rahul bought three blue bags
10. Usha sings five old songs

List 50

1. Preeti got ten good dress
2. Rahul took ten good books
3. Raja wants four red toys
4. Raama saw five big pens
5. Sita bought some cleans flowers
6. Krishna saw one green hat
7. Raama washed some old socks
8. Usha saw four red balls
9. Rahul keeps twelve small bags
10. Usha keeps six old songs