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Development of Time-Compressed Speech Test for Children between 8 - 12 Years of Age in Telugu

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1.0. Introduction

Some children have normal hearing ability but have difficulty using information they hear in academic and social situations. These children may have a Central Auditory Processing Disorder. Myklebust (1954) was one of the first person, stated that "central hearing loss" contributes to children's language learning deficits. The term central auditory Processing disorder (CAPD) is used to describe functional impairment of the auditory system with respect to different skills. Central auditory processing (CAP) problems may underlie or interact with other difficulties including speech language impairment, attention disorder, learning disability or developmental disabilities (Tallal & Piercy 1974; Willeford 1980; Jerger, Martin & Jerger 1987).

Auditory Processing Disorder (APD) is deficits in information processing of audible stimuli but without hearing or intelligence deficits. It is the inability to attend to, discriminate, recognize or comprehend what is heard. Auditory processing deficits interfere directly with speech and language as well as all areas of learning, especially reading and spelling. Instruction in schools relay primarily on spoken language, so students with APD may have serious difficulty. APD often coexists with other disabilities, including speech and language disorders or delays, learning disabilities, dyslexia, attention deficit disorders, and social and/or emotional problems. APD are more pronounced when listening to distorted speech, or in poor acoustic environments such as listening in the presence of competing background noise (Bellis 1996).

Diagnosis of APD is essential for the implementation of appropriate therapeutic and/or remedial strategies. Formal diagnosis is accomplished through administration of a battery of tests. Each of these tests is designed to evaluate various behavioral processes required to process auditory information. Though information can be obtained as early as 5.5 to 6.5 years of age, the administration of the comprehensive central auditory pathway test battery is not performed until the age of 6.5 to 7 years or later to minimize any bias introduced by limited vocabulary and / or attention. In younger children, informal diagnosis is made utilizing behavioral information in conjunction with speech language measures (Willeford & Burleigh 1985; Bellis 1996).

The audiologist assesses the peripheral and central auditory systems using a test battery approach, which may include both behavioral and electrophysiological tests. Peripheral hearing tests determine if the child has a hearing loss and if so, the degree to which the loss is a factor in the child's learning problems. Assessment of the central auditory system determines the child's ability to respond under different conditions of auditory signal distortion and competition. It is based on the assumption that a child with an intact auditory system can tolerate mild distortions of speech and still understand it, while a child with an APD will encounter difficulty when the auditory system is stressed by signal distortion and competing messages (Keith 1995).

No single test of APD can be expected to challenge the variety of functions required by the central auditory nervous system (CANS) in different listening situations. Therefore, it is necessary to use a test battery approach (Dempsey 1983). Using a test battery approach, audiologist can determine if CAPD is present and, if so, the specific nature of these difficulties as well as the likely ramifications. They can then use this information to provide individualized management strategies as well as measure the success of interventions by post testing. APD is assessed through the use of special tests designed to assess the various auditory functions of the brain. However, before this type of testing begins, it is important that each person being tested receives a routine hearing test (Chermak & Musiek 1997). Tests of central auditory function have been categorized in a variety of ways. Baran & Musiek (1991) categorize behavioral central tests in the following sub-categories:

- Dichotic Tests (Musiek & Pinheiro 1985)
- Monaural Low-Redundancy Speech (Jerger & Jerger 1971)
- Temporal Processing Tests (Pinheiro 1977)
- Binaural Interaction Tests (Matzker 1959)

Children being assessed for APD would not necessarily be given a test from each of these categories. Rather, the audiologist would select a battery of tests which would depend upon a number of factors, including the age of the child, the specific auditory difficulties the child displays, the child's native language and cognitive status, and so forth (Willeford & Burleigh

1985). Due to the richness of the neural pathways in the auditory system and the redundancy of acoustic information in spoken language, a normal listener is able to recognize speech even when parts of the signal are missing. However, this ability is often compromised in the individual with APD.

Dichotic Tests

Various dichotic speech listening tests are sensitive to central auditory nervous system dysfunction, and wide ranges of tasks are included in this category (Musiek & Pinheiro 1985). Clinically, two main types of dichotic speech tasks have emerged: binaural separation and binaural integration. In binaural separation, the subject is directed to listen to a target stimulus within the dichotic task. While in the binaural integration task, both signals in the dichotic paradigm must be recognized. Competing sentences and synthetic sentence identification with contra-lateral competing message (SSI-CCM) are commonly used binaural separation tests (Musiek & Pinheiro 1985). Dichotic digits, staggered spondaic words (SSW), dichotic consonant-vowels and dichotic sentence identification (DSI) are commonly used (binaural integration) dichotic tests (Bellis 1996; Musiek & Pinheiro 1985).

Monaural Low-Redundancy Speech (MLRS) Tests

In this speech signals have been degraded or are presented in some type of acoustic competition. Filtered, compressed, expanded, interrupted, and reverberated speech signals have all been used as central tests (Musiek & Baran 1987; Rintelmann 1985). In addition, speech signals that are in competition with other speech signals, noise, or are altered in intensity have been used in central assessment. Time compressed speech test is one such test, originally designed by Beasley, Schwimmer & Rintelmann (1972a) to evaluate monaural low redundancy. Time-compressed speech is generally described in terms of the percentage of temporal reduction, i.e. 30% time compressed speech means that the speech in which 30% of the signal has been removed in small units (Muller & Bright 1994). The test evaluates temporal processing which is critical to the perception of speech and music. Other frequently used low-redundancy monaural speech tests are low pass filtered speech test (Rintelmann 1985), the synthetic sentence identification with ipsilateral competing message (Jerger & Jerger 1971), the compressed speech with reverberation test (Bornstein & Musiek 1992) and the pediatric speech intelligibility test (Jerger, Jerger & Abrams 1983).

Temporal Processing Tests

Temporal processing tests measure the listener's ability to recognize the order or pattern of nonverbal auditory signals. Tones are presented to each ear using different time or pitch patterns, and the listener must either “hum” or verbally describe the pattern (Tallal 1985). There are three tests of temporal ordering used clinically: Frequency patterns or Pitch pattern sequence test (PPST) by Pinheiro & Ptacek (1971); Duration pattern test (DPT) by Pinheiro & Musiek (1985); and the Gap detection test (GDT) by Keith (2000).

Binaural Interaction Tests

This category includes a variety of tests. Their commonality is that the two ears (auditory systems) must interact (Chermak & Musiek 1997). Binaural interaction tests include Masking Level Difference (Schoeny & Talbott 1994), Interaural Timing Tasks (Levine, Gardner, Stuttlebeam & Fulterton 1993), Rapidly Alternating Speech Perception (Willeford 1977) and Binaural Fusion Test (Matzker 1959). Binaural interaction tests assess binaural fusion; the listener's ability to take incomplete information presented to each ear and fuses the information into an understandable signal.

1.1. Time-Compressed Speech Test as a Measure of CAPD

History of the development of time compressed speech test

One way to reduce the redundancy of a speech signal is to alter the temporal characteristics of the signal. The speaker can simply talk faster or recorded materials can be played back at a higher speed (Fletcher 1929). In order to overcome the problem of the frequency shifts associated with the fast or slow playback technique, a chop-splice procedure was employed. In this procedure, certain segments of the recorded signal were manually cut from the recording and the retained samples were spliced back together. This method permitted the experimenter to vary the temporal nature of the signal without undue distortion of the frequency characteristics of the signal as originally recorded. This method was laborious and time-consuming and hence, has been replaced by more efficient and technically advanced procedures. In order to overcome the problems associated with both the fast / slow playback and chop-splice techniques, an electro-mechanical time compressor or expander was developed (Fairbanks & Jaeger 1954).

Using this device, investigators were able to record a signal and subsequently delete and retain samples of the signal automatically. Further, the retained samples were electro-mechanically "spliced" back together, such that the end procedure was a recorded version of the original recording, which was to some specific percentage shorter (compressed) or longer (expanded) than the original. Lee (1972) developed Varispeech device, a modification of the Fairbanks instrument, contained a small tape recorder and minicomputer and was the one most widely used for time-compressed speech. A drawback of both the Fairbanks and Lee devices was that the sampling was random so samples discarded could be with as well as between linguistic sections. Beasley & Freeman (1977) reported the use of software that could compress or expand the speech signal and currently several such soft wares are available.

Development of Time-compressed speech for clinical purposes

In the evaluation of central auditory dysfunction, the use of time-compressed speech has gained recognition as a simple, sensitive and valid clinical tool. Time-compressed /expanded speech has been used to detect subtle neurological lesions that may go unnoticed by use of standard pure tone and word identification measure of audition. Temporal alteration of speech stimuli in the form of time compression reduces the extrinsic temporal redundancy of the speech signal (Beasley & Maki 1976), thereby increasing the processing load on the temporal aspect of the auditory perceptual processor (DiSimoni 1974; Calearo & Lazzaroni 1957; Dequiros 1964) consequently employed time-compressed speech signals as a measure for evaluating lesions in the central auditory nervous system. They pointed out that the time compression reduced the external temporal redundancy of the normal speech signal, thereby increasing the difficulty of the processing task by the internally redundant central nervous system.

Beasley, Maki & Orchik (1976) were the first to report the clinical use of time-compressed speech with children. Normative data were provided for young children using two measures of speech discrimination, the PBK-50 (Haskins 1949) and the WIPI (Lerman, Ross & Mc Laughlin 1965). Subsequent investigation with the PBK-50 (Manning, Johnston & Beasley 1977) indicated reduced performance on a time-compressed speech discrimination task by children displaying auditory perceptual deficits when compared to previously published data with normally hearing children (Beasley, Maki & Orchik 1976). The data suggested that measures employing time-compressed speech might be useful in the study of auditory processing in children exhibiting various speech and language disorders. Luterman, Welsh & Melrose (1966); Sticht & Gray (1969) used time-compressed CID W-22 word lists and revealed differential results for young adult listeners compared to geriatric listeners, and sensorineural hearing-impaired listeners compared to normal listeners. This study showed a gradual decrease in the intelligibility of monosyllables corresponding to progressively greater percentages of time compression over the range of 30% to 60% with a dramatic reduction of intelligibility occurring at 70% time-compression.

A comparison of speech discrimination scores obtained with the Audited Versions of the NU-6 and the CID W-22 test materials indicated that these two measures yielded different results, particularly at the 30% and 60% levels of time compression. It is also commonly used in clinical application of time-compressed speech (Beasley & Freeman 1977). The difference between the discrimination scores obtained in this study indicated that the effect of the talker was also a significant variable in a time-altered speech discrimination task. May, Rastatter & Simmons (1984) used 30 tape-recorded sentences taken from the Carrow Auditory Visual Abilities Test, which were time-compressed by the Lexicon Varispeech II to 50%. Age related changes in auditory discrimination were investigated using this material. Each sentence offered one or more phonemic contrasts (manner or place of articulation, voicing frequency or some combination). It was found that the overall group mean performance was not different between 6 year olds (N: 14) and 8 year olds (N: 20) or, between 10 year olds (N: 16) and young adults (N: 15), but the two older groups were each significantly better than each of the two younger groups.

Gordon-Salant & Fitzgibbons (1999) investigated age related performance differences on a range of speech and non-speech measures involving temporal manipulation of acoustic signals and variations of stimulus complexity. The goal was to identify a subset of temporally mediated, measures that effectively distinguished the performance patterns of 10 younger (18-40 years) and 10 older (65-76 years) listeners with normal hearing sensitivity and with sensorineural hearing loss. The speech stimuli were undistorted speech, time compressed speech (50% and 60%), reverberant speech and combined time compressed (40%) and reverberant speech. All speech stimuli were presented both in quiet and in noise. Age related deficits were observed for all time-compressed speech conditions and some reverberant speech conditions, in both quiet and noise. Older participants exhibited poorer performance than younger participants on all conditions. The robust nature of the age effect with time compressed speech strongly indicates that aging imposes a limitation on the ability to process rapid speech segments.

1.2. The Effect of Time-Compressed Speech Scores on Clinical Population

There are some indications that the intelligibility of time-compressed words is severely attenuated in elderly persons having a sensorineural hearing loss, in persons with temporal lobe lesions, and in persons with diffuse cerebral pathology (Bocca & Calearo 1963). Time-compression has been used on different clinical population for diagnostic purposes. These include brain damage, auditory processing disorders, learning disability, and specific language impairment.

Baran, et al. (1985) evaluated the performance of twenty-seven subjects with surgically, radiologically or neurologically confirmed lesions of the central nervous system on time-compressed speech test. The subjects ranged in age from 12 to 59 years. Twenty-four subjects had normal hearing (25 dB HL or better) bilaterally at 500 to 4000 Hz. Three subjects demonstrated a mild hearing loss at a single frequency in one ear. Test stimuli were presented at 40 dB SPL with reference to their speech reception thresholds. The subjects were administered the NU-6 word list at 60% time-compression. Percent correct scores were derived for each ear and compared to norms previously established by Beasley, Schwimmer & Rintleman (1972b). Results revealed that in 67% of the subjects tested, performance in at least one ear fell below established norms. For subjects with abnormal thresholds, performance was abnormal in the 'better' ear, or in both ears in all three cases. These results suggested that the time-compressed speech test might be moderately useful in the identification of CNS lesions.

Watson, Stewart, Krause & Rastaller (1990) measured the ability of eight good and eight poor readers in grade 1 (age ranging from 6.7 to 7.4 years) to discriminate phonemic contrasts presented in 50% time-compressed sentential stimuli. Good readers exhibited a significantly higher overall mean performance than poor readers on the time compressed task. Effects of time compression on the perception of manner, place, voicing and frequency contrasts showed a similar pattern of errors for both groups of readers. Many people with developmental dyslexia have difficulty perceiving stop consonant contrast as effectively as other people and it has been suggested that this may be due to perceptual limitations of a temporal nature.

Stollman, Kapteyn & Slesswijik (1994) measured the effect of time compression and expansion of speech on speech perception in noise for a group of hearing impaired and a group of language impaired children relative to control groups of normal children and normal adults. The children's age ranged from 9-12 years, for all time scale modified conditions (37% expansion, 27%, 35%

and 48% compression), both hearing impaired and language impaired children had significantly higher speech recognition thresholds in noise than their normal peers, who performed almost equally as the adult control group. Time-expansion was shown to have a negligible effect on recognition for all groups when compared to the control condition i.e., 0% time compression. The difference in speech recognition between the control and the impaired groups was in general not significantly altered by the degree of time compression or expansion of speech, although a clear trend towards greater differences for increasing time compression was observed.

Karlsson & Rosehall (1995) evaluated the clinical validity of four different low-redundant speech tests using four groups of 83 patients with retro-cochlear or central auditory lesion. The speech tests used were interrupted speech (7 and 10 interruption/s), time-compressed speech (message compressed to 290 words/min) and filtered speech. A comparison between patients and age matched normal-hearing controls showed that the patients had significantly lower speech recognition score. The speech tests with the highest sensitivity were 7 interruptions / sec and time-compressed speech. Time-compressed speech was found to have the following sensitivity levels for different lesions: 67% (cerebelopontine angle tumors), 64% (brainstem lesions), 47% (vascular brainstem lesions) and 80% (temporal lobe lesions).

Anally, Hansen, Cornelisson & Stein (1997) predicted that perception of time compressed stimuli by listener with dyslexia might be improved by stretching them in time equivalent to speaking slowly. Conversely, their perception of the same stimuli thought to be made even worse by compressing them in time equivalent to speaking quickly. They tested 15-children with dyslexia on their ability to correctly identify consonant-vowel-consonant (CVC) stimuli that had been stretched or, compressed in the time domain. They also tested their perception of the same CVC stimuli after the formant transitions had been stretched or compressed in the frequency domain. The performance reduced with increase in compression but contrary to their prediction, they failed to find any systematic improvement in their performance with expansion. They concluded that simple manipulations in the time and frequency domains are unlikely to benefit the ability of people with dyslexia to discriminate between CVC containing stop consonants. Thus, time compressed words are found to be highly sensitive in identifying children with dyslexia.

The overall review of literature shows a time compressed speech perception test provides information about auditory closure (refers to the ability of the normal listener to utilize intrinsic and extrinsic redundancy to fill in missing or distorted portions of auditory signal and recognize the whole message) and is sensitive to the cortical and sub-cortical regions. There is a need to develop the test in different language for the utility of the test in diagnosing auditory processing problems. In the pediatric population, research accelerated in the 1980s. Several tests have been developed for children to help identify the normal functioning of the auditory system (Keith & Jerger 1991). More commonly, central auditory testing in children is used to determine the functional auditory ability. It has been found that the test that was developed in the west cannot be directly used in India due to variation in accent. Hence, there is a need to develop tests appropriate for the Indian context.

1.3. Need for the Study

The time-compressed speech perception test is one test used for central auditory dysfunction evaluation. Norms for this test have been reported for the western population by Beasley, Schwimmer & Rintelmann (1972a) and Beasely, Forman & Rintelmann (1972b). Norms for this test were developed in India in English for children by Sujitha (2005) and in Kannada for children by Kumar (2006). No such study has been developed in Telugu language. Therefore, the present study has been taken up to develop and establish normative data for a time-compressed test in Telugu. This will help in the diagnosis of children with auditory perceptual problems, in children who speak this language.

1.4. Aims of the Study

The present study aimed to develop a time-compressed speech perception test for children between 8 – 12 years of age in Telugu with following objectives.

- To develop a time-compressed speech perception test in Telugu, for native speaker of the language.
- To investigate whether there is any ear difference on the scores of time-compressed words.
- To investigate whether the scores are different across gender.
- To investigate whether the scores are different across different ages.
- To develop normative data for the different age groups.
- To investigate whether the level of compression affects the scores obtained.

2.0. Method

2.1. Subjects

A total of forty children in the age range of 8 years to 9 years were taken to ensure that the test material was familiar to the children. Eighty normal children in the age range of 8 years to 12 years were taken for collecting normative data. These children were grouped into four different age groups; each group consists of 20 children (10 males and 10 females). The age groups were: 8 years to 9 years, 9 years to 10 years, 10 years to 11 years and 11 years to 12 years. All the children are native Telugu speakers, hearing thresholds within normal limits, good/average performers in school and having normal IQ.

2.2. Procedure

Stage I: Development of Material

A total of 100 phonetically balanced words divided into four lists were used as stimulus. Recording was done using a female speaker. The words were recorded in a Pentium 4 computer by using the PRAAT software with a 44100 Hz sampling frequency. Scaling of the words was done using the same software to ensure that the intensity of all words was brought to the same level. A four seconds inter-word interval was maintained. These words were time compressed using PRAAT software.

- List 1 is compressed to 0%
- List 2 is compressed to 20%
- List 3 is compressed to 40%
- List 4 is compressed to 60%

Stage II: Obtaining Normative Data

The stimuli were played on the CD player, the output of which was routed to the audiometer (Orbiter 922). The subjects heard the stimuli through headphones (TDH-39). The stimulus was presented at 40 dB SL monaurally. The subjects were instructed to repeat what they heard. Each subject heard all four lists at 0% compression (no compression) as well as at 20 %, 40% and 60% compression. The lists were randomized so that any sequence effect of the compression level did not contaminate the findings. Testing was done in a sound treated double room, with the ambient noise levels within permissible limits as recommended by ANSI (1989).

Stage III: Scoring

Each correct response was assigned a score of one, while a wrong response was given a score of zero. The scoring was done separate for the different levels of compression and for each ear separately. The raw scores were statistically analyzed. The responses were scored in terms of number of correct responses for different compression levels. The data obtained was subjected to statistical analysis using SPSS (version 10.0) software. The analysis was done to obtain information on the following:

1. Ear effect
2. Gender effect
3. Effect of level of compression with reference to age
4. Effect of compression across the ages.

The above effects were analyzed using descriptive statistics, as well as three-way ANOVA. Post hoc analysis was carried out using Duncan's test, when required.

3.0. Results and Discussion

This study was carried out to develop time compressed speech test in Telugu for normal hearing children between the ages 8-12 years, and also to obtain norms of the perceptual scores of bi-syllabic phonetically balanced words for children in different age groups using the test with four compression levels (0%, 20%, 40%, and 60%).

3.1. Ear Effect

Table 1 shows mean and standard deviation values of the right ear and left ear at different compression levels. The ANOVA results indicated that there was no significant difference between left and right ear scores for all four age groups [F (1, 40) = 0.136, p > 0.05].

Age Group	Ear		Effect of Compression 0 %	Effect of Compression 20 %	Effect of Compression 40 %	Effect of Compression 60 %
8-9 Years	Right	Mean	22.80	21.70	18.70	16.60
		SD	0.632	0.675	1.337	0.699
	Left	Mean	22.60	21.70	18.70	16.70
		SD	0.516	0.675	1.337	0.675
9-10 Years	Right	Mean	23.30	21.10	18.80	16.90
		SD	0.483	1.101	0.789	0.738
	Left	Mean	23.40	21.10	18.80	17.00
		SD	0.516	1.101	0.789	0.816
10-11 Years	Right	Mean	24.80	22.60	19.90	17.60
		SD	0.422	0.516	0.568	0.699
	Left	Mean	24.70	22.90	19.80	17.80
		SD	0.483	0.568	0.632	0.789
11-12 Years	Right	Mean	24.80	23.80	21.70	19.10
		SD	0.422	0.632	0.823	0.738
	Left	Mean	24.70	23.50	21.00	19.00
		SD	0.675	0.707	0.667	0.816

Table 1 Mean and Standard Deviation (SD) for right and left ears across age groups for different levels of compression

It was observed that as the compression ratio's increases the performance in both the ears was reduced and as the age progresses performance in both the ears was improved. As there was no significant difference in both ears across the age groups and compression levels hence the hypotheses, there is no significant difference in right and left ears in eight to twelve years at 0%, 20%, 40% and 60% compression levels were accepted.

The results obtained from the present study are in agreement with the results of a study conducted on the western population by Beasley, Schwimmer & Rintleman (1972a), on Indian non-native English speakers by Sujitha (2005), and Kannada speaking children by Kumar (2007). They reported that there existed no difference between the right and left ear scores at different levels of time-compression. Beasley, Schwimmer & Rintleman (1972 a) postulated that in order to validly use the same test for both the right and left ears, performance of normal subjects would warrant that test results between ears be essentially equal.

3.2. Gender Effect

Table 2 shows mean and SD values of males and females at each compression level. The MANOVA results indicated that there was no significant difference between males and females for all four age groups at different compression ratio's [$F (1, 40) = 0.154, p > 0.05$].

Age Group	Sex		Effect of Compression 0 %	Effect of Compression 20 %	Effect of Compression 40 %	Effect of Compression 60 %
8-9 Years	Male	Mean	22.80	22.00	19.40	16.90
		SD	0.422	0.667	1.075	0.738
	Female	Mean	22.60	21.40	18.00	16.40
		SD	0.699	0.516	1.155	0.516
9-10 Years	Male	Mean	23.30	22.00	18.80	16.80
		SD	0.483	0.667	0.789	0.789
	Female	Mean	23.40	20.20	18.80	17.10
		SD	0.516	0.422	0.789	0.738
10-11 Years	Male	Mean	24.70	22.70	19.90	17.80
		SD	0.483	0.483	0.568	0.919
	Female	Mean	24.80	22.80	19.80	17.60
		SD	0.422	0.632	0.632	0.516
11-12 Years	Male	Mean	24.70	23.50	21.30	18.80
		SD	0.675	0.707	0.823	0.789
	Female	Mean	24.80	23.80	21.40	19.30
		SD	0.422	0.632	0.843	0.675

Table 2 Mean and Standard Deviation (SD) in male and female, across age groups for different levels of compression

It was observed that as the compression ratio increases performance in both the males and females were reduced and as the age progresses performance in both the ears were improved. As there was no significant difference in both males and females across the age groups and compression levels, the hypotheses stating that there is no significant difference in males and females in eight to twelve years at 0%, 20%, 40% and 60% compression levels were accepted.

Similar findings have been reported in a study conducted by Konkle, Beasley & Bess (1977). They found that within age groups there were essentially no differences between the performance of male and female subjects under the different time compression and sensation level conditions. This proved that the central aging process took place equally in both males and females. Sujitha (2005) & Kumar (2006) also reported that there was no difference in gender at different compression levels in children aged 7-12 years while evaluated the subjects using compression levels of 0%, 40%, 50% and 60%. Thus, the results of the present study are in agreement with earlier studies, indicating that there exists no significant difference between the performance of males and females across ages at different levels of compression. Hence, separate norms are not required for males and females.

3.3. Effect of Level of Compression with Reference to Age

Table 3 shows mean and SD values across age groups for different levels of compression and Table 4 shows values of significance difference for different compression within age groups.

Age Group		Effect of Compression 0 %	Effect of Compression 20 %	Effect of Compression 40 %	Effect of Compression 60 %
8-9 Yrs	Mean	22.70	21.70	18.70	16.65
	SD	0.571	0.657	1.302	0.671
9-10 Yrs	Mean	23.35	21.10	18.80	16.95
	S D	0.489	1.071	0.768	0.759
10-11 Yrs	Mean	24.75	22.75	19.85	17.70
	SD	0.444	0.550	0.587	0.733
11-12 Yrs	Mean	24.75	23.65	21.35	19.05
	SD	0.550	0.671	0.813	0.759

Table 3 Mean and Standard Deviation (SD) across age groups for different levels of compression

It can be observed that the performance for time-compressed words reduced with increase in the level of compression for all the age groups. In order to find out if there was a significant difference for different levels of compression in a particular age group, repeated measures of ANOVA was done (Table 4). At all the ages, there was a significant difference ($p < 0.001$) across the compression levels. Hence there was a significant difference between across the age groups and across the compression levels, hypotheses there is no significant difference between the age groups across the compression levels were rejected.

Age	F (df) Value	Significance (p-value)
8-9 Years	$F(3,33) = 8.306$	<0.001
9-10 Years	$F(3, 33) = 8.582$	<0.001
10-11 Years	$F(3, 33) = 7.923$	<0.001
11-12 Years	$F(3, 33) = 2.073$	<0.001

Table 4 Significance difference for different compression within age groups

The data indicated that for individual clients, there was generally increase in scores with age, as the age progresses performance also increased. Sujitha (2005) also reported that there was significant difference in performance across the age groups. As the age increases from eight to twelve scores were also improved.

3.4. Effect of Compression Across Ages

Table 5 shows mean and SD values across ages with increase in the level of compression and Figure 1 shows 95% confidence interval (CI) mean scores for different compression ratio's across the age groups.

Age Group		Effect of Compression 0 %	Effect of Compression 20 %	Effect of Compression 40 %	Effect of Compression 60 %
8-9 Yrs	Mean	22.70	21.70	18.70	16.65
	SD	0.571	0.657	1.302	0.671
9-10 Yrs	Mean	23.35	21.10	18.80	16.95
	SD	0.489	1.071	0.768	0.759
10-11 Yrs	Mean	24.75	22.75	19.85	17.70
	SD	0.444	0.550	0.587	0.733
11-12 Yrs	Mean	24.75	23.65	21.35	19.05
	SD	0.550	0.671	0.813	0.759

Table 5 Mean and Standard Deviation (SD) across age groups for different levels of compression

It is observed that there is significant difference between the compression ratio's within an age group and it is also clear that as the age progresses there is improvement in performance. Research by Beasley, Bratt & Rintelmann 1980) has also shown that in young adults, with increase in compression levels, the scores varied very marginally up to 60% compression. De Chicchis, Orchik & Tecca (1981) also noted that significant variations in scores are obtained in time-compression tests depending on the material used. They noticed the variation at 30% and 60% compression levels.

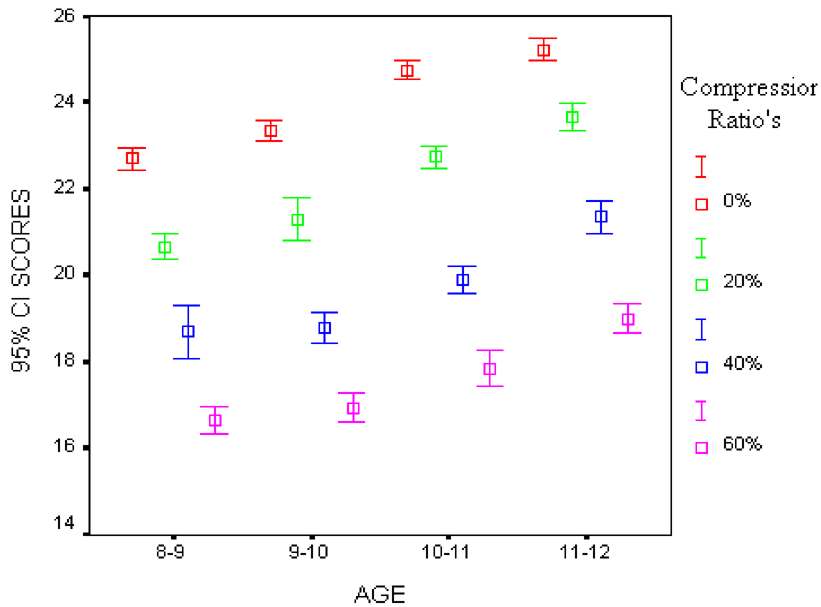

Figure 1: 95% confidence interval (CI) mean scores for different compression ratio's across the age groups

It is observed that there is significant difference between the compression ratio's within an age group and it is also clear that as the age progresses there is improvement in performance. Research by Beasley, Bratt & Rintelmann (1980) has also shown that in young adults, with increase in compression levels, the scores varied very marginally up to 60% compression. De Chicchis, Orchik & Tecca (1981) also noted that significant variations in scores are obtained in time-compression tests depending on the material used. They noticed the variation at 30% and 60% compression levels.

4.0. Summary and Conclusion

Time compressed speech test is a test for assessing APD, which is a monaural low redundancy speech test. This test provides information about auditory closure and is sensitive to cortical and sub-cortical regions. In literature it has been found that the test that was developed in West cannot be directly used in India due to variation in accent. Hence there is a need to develop tests appropriate for the Indian context. The present study aimed at developing a time compressed speech test in Telugu for normal hearing Telugu speaking children. The study also aimed at obtaining perceptual norms of bi-syllabic phonetically balanced words in different age groups of 8-12 years using the test with four compression levels (0%, 20%, 40% and 60%). The results revealed as follows.

- There was no significant difference in right and left ear scores for the monotically presented time compressed Telugu speech stimuli.
- There was no significant difference in the performance scores of males and females across the ages at different levels of compression.

- With increase in compression level the scores generally dropped. However, the effect of compression at each of the age groups was not identical.
- There was a significant decrease in performance observed with increase in the level of compression.

The findings of the present study on Indian population are consistent with findings obtained on Western population and similar to non-native speakers English speakers and Kannada speaking children.

5.0. Clinical Implications of the Study

- The test can be used for clinical purposes for assessing Telugu speaking children with the complaint of temporal processing.
- The obtained scores can be compared with the norms with reference to age groups to find out deviation in the perceptual abilities.
- When there is lack of time, test can be administered at 0% and 60% compression levels as a quick screening.

6.0. Future Research

- Study can be carried out on children with learning disabilities to evaluate the efficacy of the developed test material.
- Study can be carried out on children with the compliant of temporal processing to evaluate the perceptual abilities.

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