Some Aspects of Temporal Processing Deficits in Individual with Learning Disability

Registration no: 05AUD009
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MANSAGANGOTHRI, MYSORE-570006
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DEDICATED TO MY

DEAR PARENTS,

BROTHERS, TEACHERS

AND ALL MIGHTY

CERTIFICATE

This is to certify that this dissertation entitled **"Some Aspects of Temporal Processing Deficits in Individual with Learning Disability"** is a bonafide work in part fulfillment for the degree of Master of science (Audiology) of the student Registration no: 05AUD009. This has been carried under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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DECLARATION

This is to certify that this master's dissertation entitled **"Some Aspects of Temporal Processing Deficits in Individual with Learning Disability"** is the result of my own study and has not been submitted earlier to any other university for that award of any degree or diploma.

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CHAPTER 1

INTRODUCTION

Learning disability is a disorder in the psychological processes involved in understanding or using language, spoken or written, which may manifest in an imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations. Exclusions from this group is based upon organic deficits including visual, hearing, motor or economic disadvantage (Public Law-94, 1992). Thus learning disability can be termed a syndrome possessing a cluster of symptoms and different deficits can underlie learning disability. Prevalence estimates of this disability have been found to range from 3% to 10% (Snowling 2000). Prevalence rates can vary across languages (Kujala & Naatanen, 2001). Prevalence rate in India varies from 3 to 10% (Ramaa, 2000).

/ The causes of learning disability are unknown and often poorly defined. The debate on the nature of origin of learning disability as well as factors underlying it has been going on for decades resulting however in no clear agreement (Kujala & Naatanen, 2001). There are wide varieties of theories that attempt to account cause for dyslexia. Snowling (1998) classifies the theories that have received most attention into two general approaches. First is domain specific view, which posits that the dyslexia arise from deficits in systems that are specifically linguistic. Here the deficits are traced to be present in phonological processing and memory. On the other hand, may claim that deficits in underlying nonlinguistic sensory mechanisms are the core deficits in the disorder such as visual and auditory processing.

Children with learning disability have auditory processing disorder has been experimentally investigated by many studies. But, whether these auditory processing deficits are seen only in association with language disorder or as a causal factor is yet to be explored (Rosen, 2003). Though a majority of studies in the literature report that a subgroup of children with learning disability have auditory processing disorder. Tallal, (1980) described a deficit in dyslexics involving processing of brief, rapidly changing auditory stimuli. The characteristic, brief and rapid spectral changes support the role of temporal processing in speech perception deficits of dyslexics. This basic temporal processing impairment underlies their inability to integrate sensory information that conveys in rapid succession in the central nervous system.

Natural speech is a complex signal which has variation in frequency, amplitude with respect to time. Rosen (1992), said these are the three main temporal features of speech and named it has envelope, periodicity and fine structure. A number of investigators demonstrated that nearly perfect consonant identification and sentence intelligibility could be achieved with speech stimuli processed only with temporal modulation cues which is as low as 50Hz. (Shannon et al., 1995; Xu et al., 2005; Durllman et al., 1994). Since TMTF signal involves envelope, periodicity and fine structure, TMTF assessment would help us in understanding ability of individual in perceiving the amplitude variation in continuous speech.

Human auditory system has the capacity to resolve the faster and slower changer in the amplitude, frequency with respect to time. (Separate 'fast' and 'slow' auditory system). Any defects in the development of these two 'fast' and 'slow' auditory system may be related to rapid processing deficits, which is common to specific language impairment or individuals with language learning disability (Steve & Miller, 1995). Tallal, et al., (1996) reported that, individuals with learning disability specifically dyslexics are impaired in processing the rapidly varying signals, which may effect their speech perception ability in the presence of noisy situation.

Drullman et al., (1999) based on his study on normal he said that the TMTF perception varies with different modulation frequency and lower modulation frequency has its role in identification and higher modulation frequency in discrimination of the signal.

Need for the study:

TMTF has undergone an extensive research in various populations. Viemester, (1979); Bacon and Viemester (1985); conducted TMTF on normal population and showed that, for normal-hearing listeners, sensitivity to SAM is relatively independent of modulation frequency up to 50-60Hz, and decreases progressively at higher modulation frequencies. For low modulation frequencies (16Hz), detection is limited by the amplitude resolution of the auditory system, rather than its temporal resolution. As the modulation frequency increases beyond 16Hz, temporal resolution starts to have an effect and SAM detection threshold increases. Drullman et al., (1999) and Zeng et al., (1999), conducted study using different modulation rates on normal individuals and showed the severe reduction in sentence intelligibility by degrading the consonant identification when amplitude envelope is low pass filtered. However, unlike other psycho-physical studies TMTF is also affected by developmental changes. Robbers and Lister (2004), in the study concluded that the psycho-physical function varies with the developmental changes and is applicable to other psycho-physical tests. This was supported by Lynne, Werner, and Gray (1998). Hence the obtained normative data may not be applied to all the population. So attempt has been made in the present study to obtain norms for the comparison.

TMTF has been used as tool to assess the temporal processing ability in individual with learning disability. Tallal et al.,(2000) and Lorenzi (2000) assessed TMTF in dyslexics children at two modulation frequencies 2Hz andl28Hz. Based on there study they said that, dyslexics exhibits the impaired ability to perceive the faster modulation may leading to poor speech perception in noise.

Rocheron et al., (2000) investigated the ability to process temporal envelope cues in dyslexic's children by measuring detection thresholds of sinusoidal amplitude modulation thresholds (SAM). Each threshold was measured at slow rates and faster rates at 4Hz and 128Hz respectively. Overall SAM thresholds were higher in dyslexics than in normal at both rates. These findings are consistent with Tallal's hypothesis according to which the speech reading deficits in 35% of dyslexics may be caused by impaired temporal processing which plan an important role in speech perception.

Zeng, Kong, Michalewski and Starr (2005) studied TMTF at different rates and obtained different patterns in auditory neuropathy in comparison with normal. To the best of our knowledge, the TMTF approach never been applied to the individual with learning disability in Indian context and its not checked at different rates. The purpose of the present study will be therefore, to perform systematic study using different modulation rates in individuals with learning disability and also to see age related changes in TMTF perception. Hence an attempt was made to see the temporal processing ability of learning disability at different modulation frequencies.

Noordhock and Drullman (1997), Houtgast and Steeken, (1985), and Miller (1994), reported poor speech perception in noise by individual with normal hearing and cochlear hearing loss is mainly attributed to degradation caused by noise in processing the low modulation frequency of the speech signal. From the literature it can be understood that poor speech perception may be caused when impaired processing of the temporal modulation in the speech signal. It has been reported in the literature that dyslexic and individuals with language delay have poor perception in presence of noise (Ajith & Vanaja, 2004). Hence, present study was conducted to investigate phoneme perception ability of different LD in presence of noise and correlate with TMTF thresholds.

AIM OF THE STUDY:

Thus this study has been taken up with the aim to know

1. TMTF function across different frequency modulation rates in individual with learning disability hearing normally and individual with normal hearing without learning disability.
2. Age related changes in TMTF perception at different modulation rates in individual with normal hearing without learning disability and individuals with learning disability having normal hearing
3. Comparison of phoneme recognition scores in the presence of noise between the normal hearing individual and individual with learning disability.
4. The correlation between TMTF perception and phoneme recognition scores in the presence of for individuals with learning disability.

CHAPTER 2

REVIEW OF LITERATURE

Learning Disability is a generic term that refers to the heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual presumed to be due to central nervous system dysfunction. Even though a learning disability may occur concomitantly with other handicapping conditions (e.g. sensory impairment, retardation, social and emotional disturbances) or environmental influences (e.g. cultural differences, insufficient or inappropriate instructions, psychogenic factors), it is not the direct results of those conditions or influences.

When the various definitions of learning disabilities are considered, they have common elements, which are neurological dysfunction, uneven growth pattern, difficulty in academic and learning skills/tasks, discrepancy between achievement and potential reduced by the exclusion of other causes such as

- language development and language skills (listening, speaking, reading, writing, and spelling)
- social studies
- mathematics
- social skills
- motor skills (fine motor skills, as well as coordination)

- cognitive development and memory
- attention and organization
- test-taking

For practical purpose like diagnosis and classification, a stipulated definition needs to be operationalzed. The operational definition issued by the US Office of Education (USOE, 1976) is as follows.

A specific learning disability may be found if a child has a severe discrepancy between achievement and intellectual ability in one or more of several areas, oral expression, written expression, listening comprehension or reading comprehension, basic reading skills, mathematic calculation, mathematic reasoning, or spelling. A "severe discrepancy" is defined to exist when achievement in one or more of the areas falls at or below 50% of the Childs expected achievement level, when age and previous educational experiences are taken into consideration.

The operational definition suffered a fundamental flaw in that it did not bear a much resemblance to what was stipulated in the formal definition. Kavale and Forness, (1995), Semmel (1986), Adelman (1989) provided an example of what an operational interpretation of a learning disability should be.

- It must result in an ordered , sequenced decision-making process
- It must produce improved educational outcomes
- It must give attention to such dimensions as problem severity, pervasiveness and chronicity.

Auditory processing disorder (APD) in learning disability

Number of extremely encouraging experimental studies in the area of learning disabilities has been conducted. Studies have revealed that heterogeneity seen in learning disability in terms of characteristics causes associated deficits. Even though it is not known that whether it is a cause or just an associated deficit, results of various investigations have revealed that there is a sub group of children with learning disability having auditory processing deficits. The incidence of auditory processing disorder in children with dyslexics is estimated to be 40% (Ramus, 2003).

Jerger and Musiek, (2000), defined auditory processing disorder (APD) as a deficit in the processing of information that is specific to auditory modality. The problem may be exacerbated in unfavorable conditions and may be associated with difficulties in understanding speech, language development and learning. It includes disability in subtle sound difference discrimination that interferes with accurate perception of individual word and leads to confusion of conversation, difficulty in auditory figure-ground (presence of noise) and auditory lags or delays in speech processing (Silver, 1993).

Studies have documented that, at the behavioral level a sub group of children with dyslexia have primary disturbance in phonological process (Adlard & Hazar,1998). Deficit can be in any or all the three types of phonological processing skills which it includes phonological awareness, phonological memory and rate of access for phonological information (Ray, Demartino, Espesser & Habib ,2000). Studies have shown that children with dyslexia have poor speech discrimination ability that results in phonological processing deficits (Rosen & Manganari, 2001).

Manis, McBride-Chang, Seidenberg, Keating, Doi, Munson & Peterson (1997) administered phonological awareness and phoneme identification task to dyslexic children and compared the performance with that of chronological as well as reading level matched controls. Results showed less sharply defined categorical perception of VOT differences in children with dyslexia. Also, there performance was a good as that of reading Jevel age matched children but significantly poorer than that of chronological age matched children. In all the children, phonological awareness was directly related to the phonemic identification performance. These finding are also supported by Been and Zwartz (2003). Goswami et al, (2002) attributed the core difficulty to the deficits in the accurate specifications and neural representation of speech. They observed significant difference between dyslexics and normally reading children, in amplitude envelope onset detection. They proposed that a likely perceptual cause of this difficulty is a deficit in the perceptual experience of rhythmic timing.

Auditory temporal processing deficits hypothesis suggests that at least a sub group of children with reading disorder have a deficit in low level auditory temporal processing that affects the perception of short transational acoustic elements that provide important acoustic cues for phonemic contrast (TallaL, Miller, & Fitch, 1993).

Rey, Demartino, Espesser, and Habib, (2002) support the general temporal deficit theory of dyslexia. They investigated the impact of temporal alteration and the impact of complex syllabic structure on consonant order judgments. Thirteen phonological dyslexic children and ten control subjects matched for chronological age were compared on a temporal order judgement tasks. It was observed that the temporal order judgement performance was significantly poor in dyslexic than in controls. Moreover, in the "slowed speech" condition performance of dyslexics improved to reach that of the normal subjects, where as manipulating the phonological structure complexity provided no significant improvement. Finally, performance of dyslexics especially on slowed condition correlated with several tests of phonological processing.

Mody, Kennedy, and Brady, (1995) studied auditory processing or phonological coding in poor readers and two hypothesis have been proposed to account for their deficits: 1. a speech-specific failure in phonological representation, or 2. a general deficit in auditory "temporal processing ", such that they cannot easily perceive the rapid spectral changes of formant transition at stop-vowel syllables. Two groups of second grade children (20 good readers and 20 poor readers) matched for age and intelligence were selected. Results showed that group did not differ in syllable discrimination, discrimination of non-speech and sensitivity to brief transitional cues varying along a synthetic speech continuum. In conclusion deficits in speech perception among reading-impaired children are domain-specific and phonological rather than general and auditory in origin.

Auditory processing test results in individuals with learning disabilities.

The dichotic listening task is thought to assess the development of central auditory processing and lateralized language ability localized in the left temporal region. Originally conceived of by Broadbent (1956) as an experimental paradigm to investigate his mechanical memory model, the dichotic task has been validated repeatedly with clinical population. Since Orton (1937) first proposed that learning-disabled children suffer from delayed cerebral dominance for language; countless studies have sought to correlate deficient or delayed lateral or perceptual asymmetries with cognitive and academic disorders. Hynd , cohen, and Obrzul, (1983) studied the performance of normal and learning-disabled children on a dichotic listening task in which normal were matched to learning disabled children to sex, chronological age and handedness using 30 paired consonant-vowel (CV). Results showed that the learning-disabled children performed poor in the dichotic CV task and they reasoned out, the difference between normal and learning disability children on measures of auditory-linguistic competence are likely due to attentional deficiencies in learning-disabled children.

Roeser, Ross, Millay, Kathleen, Morrow and Juanita (1983) carried out two experiments using dichotic presentation of the consonant-vowel (CV) with temporal offsets of 30, 60, and 90 msec between channels. Data were analyzed for ear asymmetry (right ear advantage), double correct responses (auditory capacity), and the effects of temporal offsets (the lag effect). In experiment 1, 32 normal children (mean age at entry = 6 yrs 6 months) were evaluated once in each year over a 4-yr period. Results showed no significant change in ear laterality over the 4 yrs. However, there was a significant, age-related increase in auditory capacity. None of the subject groups showed a significant lag effect. In experiment 2, results from 17 children (mean age = 9.3 yrs) enrolled in a school for learning disability who were identified as having significant auditory processing problems were compared to age- and sex-matched normal controls. Results failed to show a significant group difference for ear asymmetry, auditory capacity, or the lag effect. Overall, findings indicate that the dichotic CV syllables test has limited prognostic value in identifying auditory processing dysfunction in children classified as having learning disability.

Significant relation between MRI measures of planum temporale area and dichotic processing of syllables in dyslexic children have been proposed by Hugdahl, Heiervang, Ersland, Lundervold, Steinmetz, Smievoll (2003). They investigated differences between dyslexic and normal reading children in asymmetry of the planum temporale area in the upper posterior part of the temporal lobe and dichotic listening performance to consonant-vowel syllables. An extension of previous studies on the girls and left-handers was carried out. There were 20 boys and 3 girls in the dyslexic group and 19 boys and 4 girls in the normal reading group. The age of the participants was 10-12 years for both groups. The planum temporale area was measured in sagittal magnetic resonance (MR) images. Mean left and right area and asymmetry index were compared between the groups. Dichotic presentations of consonant-vowel syllables made it possible to separately probe left and right hemisphere phonological function, and to correlate this with planum temporale area. The results showed a significantly larger left than right planum temporale area for both groups. However, while the right planum temporale area was similar for the dyslexic and control groups. The left planum temporale was significantly (one-tailed t-test) smaller in the dyslexic group. Both groups also showed a significant right ear advantage to the consonant-vowel syllables in the dichotic listening test. The relation between planum temporale and dichotic listening asymmetry showed a significant correlation for the dyslexic group, indicating a positive relation between brain structure and function in dyslexic children.

Speech-in-noise test.

Speech in the presence of noise is a method of reducing the redundancy of the speech signal is to imbed the signal in a background of noise (Chermak, Vonhof et al., (1989). Speech is a complex signal which has variation in its amplitude and frequency of the spectrum (temporal envelope). Presence of back ground noise will mask the variations in frequency and amplitude of the signal and the signal becomes less redundant to be processed. Normal processing auditory system will be able to pay selective attention to speech spectrum by ignoring the background noise where as an individual with auditory processing problem will fail to extract the information from the complex signal. Lorenzi et al (2000) obtained unprocessed speech signal and speech envelope noise identification and observed that individual with dyslexic's exhibit poor performance in processing the speech envelope in noise when compared to normal hearing subjects.

Gail D, Chermak, Marlys R. Vonhof, and Robert B. Bendel (1989) studied word identification performance in the presence of competing speech and noise in learning disabled children. Results revealed that the performance of learning disability children was poorer than that of the control subjects under each masking condition. Word identification score was poorest in the presence of speech noise for learning disability individuals and children with normal hearing. No difference in performance was seen as a function of linguistic content of the competing speech maskers. These results suggested that the learning disability subjects presents greater susceptibility to acoustic masking relative to control subjects and may support the view that auditory-language deficits observed in learning disability individuals may be secondary to an underlying acoustic-phonetic disorder rather than a phonological disorder. A similar result was observed by Raj Kumar (2005), Roshini (2006).

Evoked potentials in learning disability:

Evoked Potentials reported early and middle latency response in children with learning disability is equivocal. Normal evoked auditory brainstem responses are obtained for click stimuli in a investigations (Tal, roush & Johns, 1982). However a few investigatory have reported abnormal ABR in children with learning disability. Abnormalities observed were absent of waves (Greenblath, Bar & Zappulla, 1983) and delayed waves (Sohmer & Student, 1978). This was supported by studies that ABR responses are reported to be more useful than monoral responses tests in identification of auditory processing disorder (Gopal & Kowalski, 1999; Mason & Mellor, 1984).

Auditory long Latency Responses (ALLR)

A majority of the electrophysiological studies done on learning disability population have used ALLR to understand the auditory processing. Initial investigators compared the latency and amplitude of the peaks in children with learning disability to those of age match controls for responses elicited using clicks or tone burst. Results from a majority of studies revealed increase latencies (Satterfield, Schell, Backs & Hidaka, 1984; Byrung & Jaryilehto, 1985; Leppamann & Lytinrn, 1997; Guruprased, 1999; Dawson, Finely, Philips & Lewy, 1989) and reduced absolute amplitude (Pinkerton, Watson, & McClelland, 1989; Jirsa & Clontz, 1990; Leppamann & Lytinen, 1994) for PI, Nl, P2 and N2 waves in this population. But some studies revealed, normal (Radhika, 1997) and decreased latencies (Mason & Mellvor, 1984) have also been observed. Similarly Lincoln, Courehensne, Harms and Allen, (1995) reported increased amplitude and Jirsa (1992) reported normal absolute amplitudes in children with learning disability. Purdy, Kelly and Davies, (2002) reported earlier P1 in children with learning disability.

Sandeep and Vanaja, (2004) studied speech evoked and tonal stimuli ALLR respectively in children with learning disability and normal hearing subjects. Results revealed that ALLR wave forms mean latency were longer for children with learning disability when compared to those of normal children for /cha/ and tonal stimuli but there was not much mean obtained for /da/ stimuli. Based on their results they have concluded that there is a sub group of children who have auditory processing problems though it cannot be ascertained whether the auditory processing problem is a casual factor for learning disability or it is just an associated factor.

Mismatch Negativity (MMN)

MMN has become an emerging tool in studying the auditory processing in children with specific learning disability. MMN, originally described in 1975 by Naatanen and Colleagues (1978) is elicited by infrequent changes in a sequence of a repetitive auditory stimulus (Winkler, Tervanienu & Naatanen, 1997). This negative potential is usually seen as an increased negativity in the latency region following the peak Nl and P2, usually can be recorded from newborn peaking 100 to 300msec following stimulus onset. It can be elicited by frequency, intensity, duration, spatial or phonemic changes (Kraus, McGee, Micco, Sharma, Carrell & Nicol, 1993a). Hence, it can be helpful in early identification of children who are at risk of APD.

The results of behavioural studies have demonstrated that children with specific learning disability often demonstrate difficulty in discriminating rapid acoustic changes that occur in speech. Attemps have been made to investigate if there is a neurophysiological deficits which can explain this behavioural deficits. Kraus, McGee, Carrell, Zeeker, Nocol, and Koch, (1996) compared the performance of normal children and children with learning problems in behavioral discrimination tasks (/b a/ vs /wa/ and /da/ vs /ga/) as well as MMN for the same pairs. Results showed that the children with learning problem had deficit in discrimination of /da/ and /ga/ but showed intact performance in discriminating /ba/ and /wa/. It concluded that, these children have deficit in pre attentive processing auditory path way which leads to deficits in conscious perception of cues important for place of articulation. Further, Kraus et al, (1996) concluded that the perception of all spectro-temporal changes might not be impaired to the same extent. This may be because, two different contrasts may tap into separate and distinct neural mechanism or they may process at distant locations along auditory pathway. Similar findings were also reported by Marie Cheaur, Leppaner and Kraus, (2000).

Maurer, Bucher, Brem and Brandess (2003) investigated differences in frequency and phoneme mismatch negativity between kindergartners with and without risk for familial dyslexia. The results indicated that the mismatch response of children at risk was attenuated to frequency deviance and less left lateralized to phoneme deviance. Schulte-Korne, Deimel, Bartlig and Remschmidt (1998) examined MMN for tone and speech stimulus in dyslexic and normal children, while there were no groups for the speech stimuli. This finding lead to the conclusion that dyslexics have a specific speech processing deficit at the sensory level which could be used to identify children at risk at an early age. However, further investigations revealed that the deficit is not specific to speech stimuli.

Schulte-Korne, Deimel, Bartlig and Remschmidt (1999) recorded MMN for a complex tonal pattern, where the difference between standard and deviant stimuli was the temporal, not the frequency structure. Dyslexics had a significant smaller MMN in the time window of 225-600msec. these results indicate that dyslexics have a significant pre-attentive deficit in processing of rapid temporal pattern suggesting that it may be the temporal information embedded in speech sounds, rather than phonetic information per se, that resulted in the attenuated MMN found in dyslexics in previous studies. In support of this, Schulte-Korne, Deimel, Bartlig and Remschmidt (2001) found similar deficits in adult dyslexics. They found that the late component of the MMN elicited by passive speech perception was attenuated in dyslexic adults in comparision to a central group. But there was no group difference in MMN elicited by tonal stimuli.

Temporal Modulation Transfer Function (TMTF)

It is well know that the auditory system, like all sensory systems has limited temporal resolution and cannot follow temporal changes if the changes occur too rapidly. This can be studied using TMTF. Briefly, this approach involves measurement of "Modulation Transfer Function" (MTF), an empirical function which relates some measures of the ability to follow or resolve sinusoidal amplitude modulation to the frequency of that modulation. At basic level, an MTF based upon modulation threshold can be considered a quantities description of resolution. As the modulation frequency increases, the amplitude fluctuations become extremely smoothened and the observer thus requires greater amplitude change in order to resolve the fluctuations. A functions analogue to temporal MTFs (TMTF), although not so interpreted, was obtained by Riesz (1928), in an experiment preliminary to his classic study of auditory intensity discrimination. Beating sinusoids were used to produce gradual transitions in intensity and in the preliminary study the "differential thresholds" was measured as a function of beat frequency (Df) for a fixed intensity of one component. The thresholds obtained are sufficiently small that the envelope of waveform can be considered sinusoidal. Results showed threshold modulation depth in decibels and is plotted as an attenuation characteristic with modulation thresholds increasing downward. For Df greater than 4Hz, the amplitude modulation required for just-detectable beats increases at approximately 3dB/octave. This increase in modulation threshold is, of course, qualitatively consistent with limited temporal resolution or, in the frequency domain, with low pass filtering. For Df less than 4Hz, shows a 2 dB/octave increases in threshold with decreasing Df.

Zwicker (1952), using pure-tone carriers compared modulation thresholds for sinusoidal AM and FM. Results showed slightly (2-dB) decrease in threshold from 1 to 4Hz, followed by a 3dB/octave increase in thresholds up to modulation frequencies of approximately 60Hz. Above 60Hz, modulation threshold again decrease-in this high frequency region the subjects is almost certainly resolving the sidebands and is no longer basing decision on the amplitude fluctuations.

Temporal modulation transfer function upon modulation thresholds was studied by Viemester (1978), who measured modulation thresholds for sinusoidally amplitude modulated wideband noise as a function of modulation frequency on normal subjects. Their results clearly display a low-pass characteristic up to fairly high modulation frequency (i e., fm<800Hz). Modulation threshold is constant up to approximately 1 OHz; sensitivity is reduced by 3dB at approximately 50Hz; from this frequency to about 800Hz, sensitivity decreases at rates of 3-4 dB/octave. For fm>l KHz, modulation thresholds is constant up to atleast 4 KHz, the highest frequency tested. Over the high-frequency region (fm>l KHz) the observers reported that they were basing decision on loudness differences and that they usually could not detect the "roughness" or "buzziness" present lower values of fm. Similar findings was also found by Akeroyd and Patterson (1997), but TMTF discrimination and detection was studied from 4 to 400Hz.

Hall and Grose (1993), measured TMTF in listeners aged 4years to adults in order to characterize the development of temporal resolution in children. Four ages was tested, 4-5 years of age, 6-7 years of age, 9-10 years of age, and adults. Sensitivity to sinusoidal modulation of noise carrier was determined for modulation frequencies of 5, 20, 100, 150, and 200Hz. The data from all the listeners indicated decreasing sensitivity to modulation as a function of increasing frequency modulation. No age effects were observed for the derived time constants. However, sensitivity to the modulation was found to be reduced in the children 4-5 and 6-7 years of age, as compared to adults, and in children 4-5 of age as compared to children 9-10 years of age. The agreement of time constant across all age group was interpreted as indicating that the peripheral encoding of the temporal envelope is probably adult like in children aged 4 years and above; however, young children appear to be relatively inefficient in processing the information underlying modulation detection.

Bacon and Viemeister (1985), studied temporal modulation transfer function and obtained modulation thresholds for sinusoidally amplitude modulated broadband noise in normal hearing (6 subjects with age range 21 to 31 years) and hearing impaired subjects (6 subjects with age range 19 to 52 years) with varying degree of hearing loss. A result showed that in normal, sensitivity to modulation remains constant up to lOHz, but is reduced by 3 dB at 50Hz; beyond 50Hz, sensitivity decreases at a rate of 4-5 dB/octave. Hearing impaired subjects also showed similar performance that observed in the normal hearing listeners. The modulation thresholds at each fm, however, are typically higher for hearing impaired listeners. Also TMTF in hearing impaired is level dependent: sensitivity to modulation, particularly for modulation frequencies greater than lOOHz, decreased with decreasing the level. The TMTFs in the low pass condition were similar to the TMTFs obtained with broadband noise from the impaired listeners, suggesting that the impaired temporal processing in the hearing impaired is a result of a narrow effective, 'internal' band width. In general, a similar power law relationship between modulation threshold and increment threshold was found to exist for both the normal hearing and the hearing impaired listeners.

Temporal processing was also tested on auditory neuropathy population using TMTF. Zeng, Kong, Michalewski, and Starr (2004),studied modulation detection as a function of modulation frequency in 16 auditory neuropathy subjects and 4 normal controls. Results revealed that there was a significant difference between groups but no significant interactions between groups and modulation frequency. The normal controls showed a typical low-pass pattern, with peak sensitivity of -19.9 dB (10% modulation) and 3dB cut-off frequency of 258.1. The auditory neuropathy showed a lower peak sensitivity of -8.7dB (37% modulation) and lower cut-off frequency of 17.0Hz. The relatively poor fit in auditory neuropathy subjects was due to the band-pass characteristic in the data. This result suggests that auditory neuropathy subjects have difficulty in detecting both slow and fast temporal modulation.

Lorenzi, Wable, Morni, Derbert, Frachet and Belin (2000), studied auditory temporal envelope processing in a patient with Left-Hemisphere Damage. Task was detection of sinusoidally amplitude modulation applied to a white noise, as a function of modulation, also discrimination between two white noises amplitude modulated by the time-reversed temporally asymmetric envelopes and identify white noises amplitude modulated by the temporal envelope of speech stimuli. Compared to normal data, the results obtained with the brain-damaged patients showed: 1. increased thresholds for the detection of SAM; 2. increased thresholds for the discrimination of temporal asymmetry; and 3. a deficit in the identification of speech-envelope noise stimuli. Taken together, the results indicate a general impairment in auditory temporal acuity, which is now specified as a deficit in the coding of envelope rate and shape, and a deficit in the ability to use temporal envelope cues in speech processing. The results support the hypothesis that left-hemisphere damage is associated with impairment in time analysis, which may cause, in turn, speech intelligibility disorder.

In the language field TMTF, also has undergone research specifically in the field of specific Learning Disability. Lorenzi, Dumont and Fullgrade (2000), use of temporal Envelope Cues by Children with Developmental Dyslexia: In the study they evaluated the ability to process auditory temporal-envelope cues in group of 6 children with dyslexia (mean age: 10; 10 years; months). They measured temporal modulation transfer function, as a function of modulation frequency, fm (fm was 4, 16, 64, 256, & 1024Hz) the same tests were further conducted on normal children and adults. Results revealed that for both normal groups, TMTFs were low pass in shape and showed low between variability. TMTFs were band pass in 2 children, flat in 1 child, and low pass in the 3 others. Overall, SAM thresholds were higher in children with dyslexia than in normal children at fm= 4 and 1024Hz. Menell, Me Anally, Stein (1999), studied psychophysical sensitivity and physiological response to amplitude modulation in adult listeners. Mean age of normal and control groups was 25.8 and 27.6 respectively. The results showed that dyslexic participants had significantly higher thresholds for amplitude modulation than the control participants. As expected, there was a significant effect of modulation frequency. The interaction between modulation frequency and participant groups was not significant, conforming that the thresholds of dyslexic's participants were higher than those of the control participants over the entire range of modulation frequency.

The most recent study on learning disability using TMTF was done by Rocheron, Lorenzi, Fullgrabe, and Dumont (2002), who further investigated dyslexic children by measuring detection thresholds of sinusoidal amplitude-modulation (SAM) studied temporal envelope perception in dyslexic children and discrimination thresholds of SAM depth and SAM rate. Each threshold was measured at slow ands fast rates of 4 and 128Hz, respectively. Overall, SAM thresholds were higher in dyslexic than in controls at different rates. The strongest deficit was observed at 4Hz in the SAM detection task but a deficit was observed at 128Hz in the SAM tasks. Therefore, these results revealed that, in addition to reduced audibility of slow and fast envelope cues, some dyslexic children show poor encoding fidelity for these cues. Overall, these finding are consistent with Tallal's hypothesis (1993), according to which the speech and reading deficits in some dyslexics may be caused by impaired temporal processes.

Thus the review of literature shows that temporal processing might be affected in children with learning disability, which can be assessed by an psychophysical test Temporal Modulation Transfer Function where individual with learning disability showed poor response, and also the review of literature shows they also exhibit poor performance in adverse situation (noise). However, till now no correlation is attempted between TMTF performance and speech in noise test. Hence to see which test is most sensitive in identifying auditory processing deficits in learning disability which might intern help in predicting learning disability at early age. Hence the present study is conducted.

CHAPTER 3

METHOD

The study was conducted on two groups of subjects, control and clinical group in order to see how the temporal processing varies between these two groups and how does temporal processing change in late childhood and also to correlate between the speech perception ability in the presence of noise and temporal processing.

Subjects

Consisted of two groups

1. Control group
2. Clinical group

Control group

The control group consisted of 20 individual with normal hearing sensitivity without learning disability in the age range from 8 to 15 years. All were selected randomly from the school. All of them reported to have better scholastic performance and social activities based on the detailed information gathered from the parents and teachers.

Subject selection criteria:

1. All the subjects had pure tone thresholds within 15dBHL in all frequencies from 250Hz to 8 KHz to say all them had normal hearing as mentioned by ISO (1996)
2. Speech identification scores of more than 90% in quite condition
3. Speech identification scores in noise (OdB SNR) were better than 80% to rule out central auditory processing disorder.
4. All of them had immittance measure of 'A' type tympanogram with presence of acoustic reflexes which reflected normal middle ear functioning
5. No history of any other problems such as otological and neurological problems
6. The subjects were native speakers of kannada and English was the medium of instruction in the school.

Clinical group

Clinical group taken in the study consisted of 24 children with learning disability without hearing impairment in the age range of 8 to 15 years.

Subjects selection criteria

1. All the subjects had pure tone thresholds within 15dBHL, (ISO 1996) from 250Hz to 8000Hz in octave frequencies
2. Speech identification scores was better than 90% in quite condition
3. All of them had 'A'type tympanogram with reflexes present.

4. They were native speakers of kannada and English was the medium of instruction in the school.
5. All of them were free of retardation, autism, brain damage or any other psycho-physical dysfunction, which was ruled out by experienced psychologist and speech language pathologist and also by detailed case history taken from the parents and school teachers.
6. All of them were diagnosed to have learning disability by experienced speech language pathologist and psychologist based on the results obtained from the standardized test materials.

The clinical group and control group was further divided into subgroups based on their age

Subgroup 1: consisted of 7 normal hearing individuals without learning disability and 6 individual with learning disability with age range of 8 to 8 year 11 months

Subgroup 2: consisted of 3 normal hearing individuals without learning disability and 9 individual with learning disability of subjects with age range of 9 to 9 year 11 months

Subgroup 3: consisted of 8 normal hearing individuals without learning disability and 4 individual with learning disability number of subjects with age range of 10 years to 10 year 11 months

Subgroup 4: consisted of 3 normal hearing individuals without learning disability and 5 individual with learning disability with age range of 1 lyears to 11.11 months.

Instrumentation

The following instruments were used for the study

- o A computer with "speech editing software" was used to generate the TMTF signal.
- o A calibrated 2 channel diagnostic audiometer (orbiter 922) to check frequency specific hearing sensitivity, to route the TMTF signal to check the temporal processing ability and to obtain speech identification scores in quiet and in noise condition. Speech identification score in noise was obtained at OdB SNR
- o Immittance meter (GSI Tymp Star) to asses the middle ear status.

Procedure:

Subject selection

All the subjects from both the groups underwent hearing evaluation to rule out the hearing loss by routine clinical hearing evaluation. Pure tone audiometry was conducted using 10dB down and 5dB up modified Hughson-Westlake procedure [Carhart & Jerger l956] and the threshold were obtained at octaves frequencies from 250Hz to 8 kHz using clinical diagnostic audiometer (OB 922) under TDH 39 head phones.

Speech identification scores were obtained by conducting speech audiometry using clinical diagnostic audiometer (OB 922) under TDH 39 head phones for each ear independently. Phonetically balanced words developed by Maya Devi (1982) were presented monorally at 40dBSL or at most comfortable level and speech recognition score was calculated for 100 percentages.

Normal middle ear function was ruled out using GSI-Tympstar immittance audiometer. Each ear was tested separately by placing an air tight probe tip with 226Hz probe tone and responses were taken. Similarly stapedial acoustic reflexes were measured at 4 frequencies (500Hz, 1 kHz, 2 kHz, & 4 kHz). Reflex was considered to be presented when the amplitude was at least 0.03 ml.

All the subjects in the clinical group had poor scholastic performance in reading, writing, and calculation. These subjects were assessed by experienced speech-language pathologist and psychologist by using standardized tests materials. Learning Disability was diagnosed by using "Early Reading Skills" developed by Rae and Potter in 1981, which assess the ability in terms of Alphabet test, Visual discrimination, auditory discrimination, Phoneme-Grapheme discrimination, Structural analysis test and reading skills. (Scoring sheet of one subject is shown in annexure 1). Psychologist has diagnosed the child to have learning disability based on general assessment and detailed case history to obtain with reference to reading, writing, calculation, phoneme-grapheme analysis. All subjects were also undergone APD tests such as dichotic digit test, dichotic consonant vowel test and also speech in noise test. Majority of them showed poor scores in the APD tests administered. Those who fulfilled the selection criteria in the respective group have undergone the experiment.

Experiment was conducted in two phases, they were:

Phase 1: Administration of psycho-acoustical tests for estimating temporal modulation transfer function threshold.

Phase 2: Perception of speech material (phonemes/consonants) in the presence and absence of the noise.

Phase I

Test stimuli

The stimuli consisted of unmodulated and sinusoidally amplitude modulated (SAM) white noise of 500ms with a ramp of 10ms. The modulated signal was derived by multiplying the white noise by a dc-shifted sine wave. The depth of modulation was controlled by varying the amplitude of modulating sine wave. The expression given below to generate the modulated noise;

$$m\ (t) = [1 + m\ (\sin 2\pi\, fm\ t)] * n\ (t)$$

Where m is the modulation depth *(0<m<l)*, *fm* is the modulation frequency (2, 4, 8, 16, 32, 64, 128, 256, 512), and n (t) is the white noise. Stimuli were low pass filtered at 20 kHz. All the stimuli were generated using a 32 bit digital to analog converter at a sampling frequency of 44.1 kHz.

Procedure adapted to establish TMTF threshold:

Instruction: Subjects were instructed to discriminate the presence of SAM applied to a white noise carrier. On each trail, a standard and a target stimulus were successively presented in random order to the listener. The standard consisted of white noise n (t). In the target, a white noise carrier was sinusoidally amplitude modulated at a given modulation frequency.

Procedure adopted: SAM- detection thresholds were obtained using an adaptive two-interval, two-alternative forced-choice (21, 2AFC) procedure (Levitt, 1971) that estimates the modulation depth, 'm'. During one of the two 500ms observation intervals, continues wideband noise was sinusoidally modulated. The observer was to discriminate amplitude modulated noise and unmodulated noise. The step size and threshold were based on the modulation depths in decibels (Am=20 log m). The amplitude of the modulation was varied according to the following role: 'Am' decreased 3 dB following a correct response and 'Am' increased 3 dB following an incorrect response to obtain the threshold.

Criteria to estimate threshold: The lowest 'Am' at which modulation is detected is considered as threshold. The worst threshold that can be measured is 0 dB, which corresponds to modulation depth of 1 (100% modulated noise).

The testing was conducted in sound treated room where noise level was within permissible limits (ANSI-1996). All the stimuli were presented at 40 dB SL. The stimuli were played in a computer and routed through an audiometer (OB-922) and presented through a loud speaker which was placed 1 meter distance at an angle of 0 degree azimuth. The presentation level was changed in all the subjects at least at one modulation frequency and modulation detection threshold was rechecked to ensure that subjects were not using loudness judgments.

Phase II

The second phase of the study includes phoneme perception in the presence and absence of noise.

Stimulus:

Speech stimuli used in the present study was taken from the phonetically balanced word list developed by Maya devi in 1982 to obtain speech identification score.

Procedure

Instruction: subjects were instructed to repeat the phoneme which was heard by them.

Speech material was presented live through the orbiter 922 clinical audiometer. Stimuli were presented at 40 dB SL or at comfortable level through the headphones. The VU meter deflection of the audiometer was monitored to ensure that it .deflected to 0 while presenting the stimuli.

Open set phoneme recognition paradigm was used in which listener had to listen to each phoneme tokens and had to say back in a proper order in quiet condition. Further more, same speech stimulus is presented monoraly in the presence of speech noise at OdB SNR. Order of the presentation of the test material was randomized between the conditions for the same subjects to avoid practice affect. Then the correct response obtained was calculated for 100%.

Analysis:

A sinusoidal Amplitude Modulation threshold was obtained at 4, 16, 32, 64 and 128Hz frequency for individuals with learning disability and normal subjects. Independent sample "t", repeated measures of analysis of variance was administered to assess the significant difference in threshold and speech identification scores in noise between the groups. Pearson product movement correlation was obtained between TMTF threshold and SPIN scores. Similarly obtained TMTF data of both groups were analyzed using mixed measure of analysis variance to see the developmental changes in TMTF performance across different age groups.

The obtained speech recognition score was compared to that of control group to see variation in score from normal to clinical population and in presence and absence of noise.

Figure 1. Presents the average TMTF thresholds along with standard deviations at different modulation rates for individual with normal hearing without learning disability and individuals with learning disability without hearing loss.

Modulation thresholds for individuals with learning disability (represented by circle) and normal hearing subjects (represented by squares) are plotted in figure. The ordinate represents the modulation depth/sensitivity which is expressed in 20 log m, where as abscissa represents modulation frequency. It is clear from the figure that normal hearing subjects display a typical low-pass characteristic i.e. there hearing is most sensitive to slow modulation signal but becomes less sensitive as the modulation frequency increases having peak sensitivity at 16Hz. A similar trend of typical low-pass characteristic was also displayed in individuals with learning disability subjects; however, they show much broader response pattern and having peak sensitivity at 4Hz.

A repeated measure of analysis of variance was performed to assess the significant difference in mean scores between two groups at all modulation frequencies. The analysis showed a significant main effect between groups [F (1,100=7.65, $P<0.01$], and also showed no significant interaction between groups and modulation frequencies [p (4,100) =1.18, $P<0.01$]. The Scheffe's Post Hoc analysis of variance was carried out by considering the data of both normal and learning disability groups as no significant interaction between groups and modulation frequency. The results indicate significant difference between TMTF threshold at 128Hz modulation frequency from 4Hz, 16Hz, and 32Hz TMTF thresholds, however, no significant difference between 64Hz and 128Hz thresholds for both the groups.

Table 1: Post Hoc statistical values of different modulation frequencies for individual with learning disability and individual with normal hearing.

	Modulation Frequency	Number of subjects	Subtest	
			2	1
Scheffe's Post Hoc	4.00	21	-10.57	-
	16.00	21	-10.14	-
	32.00	21	-9.57	-
	64.00	21	-7.92	-7.92
	128.00	21	-	-5.78
	Sig	-	.146*	.338*

*p<0.01

The normal hearing subjects had, on average, significantly lower thresholds, that means to say they require lesser modulation to perceive the signal. Overall, SAM-detection thresholds were relatively constant up to 16Hz, but they reduce at 32Hz, beyond 32Hz, SAM-detection decrease gradually as the modulation frequency increases. Hall and Grose, (1994); Akeroyd and Patterson, (1997); Bacon and Viemester, (1985); Rodenburg, (1997) also observed the similar changes in their study. This may be because individuals with normal hearing show significantly larger physiological response to Am with respect to variation in signal which will be in synchrony of neural fibers to modulation (McAnally &Stein, 1997). However, on comparison of normal hearing subjects to that of individuals with learning disability, individuals with learning disability had, on average, significantly higher thresholds to amplitude modulation depth than did the normal hearing subject. The difference in TMTF performance between two groups is because individuals with learning disability show significantly smaller physiological responses to amplitude modulation than individual with normal hearing since they requires more synchronous firing of nervous system (McAnally & Stein, 1997 & Rocheron et a1, 2002). In conclusion modulation threshold can be considered a quantities description of resolution. As the modulation frequency increases, the amplitude fluctuations become extremely smoothened and the observer thus requires greater amplitude change in order to resolve the fluctuations (Viemester, 1979). Hence there was increase in TMTF threshold with increase in modulation rates in both the groups.

However, previous studies on normal hearing subjects done by various authors showed SAM-detection thresholds are relatively constant up to l6Hz, but they are reduced by 3dB at 64Hz, beyond 64Hz SAM-detection thresholds decrease at about-3dB/octave (Takahashi & Bacon, 1992). Poor performance by individuals with learning disability is likely to reflect a true defect in Am sensitivity rather than their difficulty in performing the task as shown by previous authors (McAnally & Stein, 1997) where they did electrophysiological study in which dyslexic children also had significantly smaller physiological response to Am than control group subjects where they concluded that this may be because of loss of synchrony of neural response to modulation.

The TMTF for individuals with learning disability was similar to that previously described by (McAnally & Stein, (1999); Lorenzi, Dumont & Fullgrabe, (2000); Rocheron, Lorenzi, & Dumont, (2002), however, the thresholds obtained in our study was much higher at each modulation frequency. This variation in the thresholds may be accounted to the procedural difference used to elicit the response whether it's an identification or discrimination task (Lorenzi, Dumont, & Fullgrabe, 2000).

B. Age related changes in TMTF perception in normal hearing subjects and individuals with learning disability.

Table 2: Mean TMTF thresholds at each frequency along with standard deviation for each subgroup.

Age	rate	Normal Subjects TMTF					Learning Disability Subjects TMTF				
		4Hz	16Hz	32Hz	64Hz	128HZ	4Hz	16Hz	32Hz	64Hz	128Hz
8-8.11 N=7, LD=6	M	-17.5	-17.0	-13.28	-12.0	-9.8	-3.5	-3.5	-6.0	-6.5	-3.5
	SD	2.07	2.4	1.6	2.4	8.2	6.1	6.1	0	1.2	5.1
9-9.11 N=3, LD=9	M	-17.0	15.0	-14.0	-4.0	-9.0	-8.0	-7.6	-7.3	-6.5	-3.6
	SD	1.7	3.0	3.4	3.0	8.0	1.5	1.5	1.5	1.2	1.3
10-10.11 N=8, LD=4	M	-15.85	-12.85	-11.14	-10.71	-9.42	-8.25	-6.75	-6.0	-4.5	-4.5
	SD	2.1	2.7	3.1	2.2	5.6	1.5	1.5	2.4	1.7	1.7
11-11.11 N=3, LD=5	M	13.50	13.50	-12.00	-10.5	-4.50	-7.80	-7.20	-6.6	-4.82	-3.60
	SD	1.7	1.7	1.7	1.6	5.1	1.6	1.6	1.3	1.6	1.3

N- Number of subjects in normal group

LD- Number of subjects in learning disability group

M-Mean

SD- Standard Deviation

It is evident from the above table as the age increases TMTF thresholds decreases. However, the decrease in TMTF threshold observed is not across the age. This pattern was observed in both normal hearing and learning disability group.

Table 3: Post Hoc analysis to see age related changes in TMTF thresholds across modulation frequencies in normal hearing subjects and individual with learning disability.

Age	Learning Disability		Normal Hearing	
	N	Subjects	N	Subjects
8.00	6	-5.400	6	-11.700
9.00	9	-6.446	9	-11.866
10.00	4	-6.000	4	-14.250
11.00	5	-6.000	2	-12.300
Sig		0.537+		0.160+

+ Not significant

In the present study psychophysical test TMTF perception was compared using mixed analysis of variance to see developmental changes in TMTF modulation depth performance. Analysis showed that there was no significant difference within subgroup of either control or clinical groups at each frequency. The significant difference is not seen in this study is because the age range selected in the present study was much higher and temporal processing maturation might have been complete by 12 years of age, but it depends on what type of temporal processing task are involved (Chermak et al 1989). .

Hall and Grose, (1994), measured TMTF in listeners aged 4years to adults in order to characterize the development of temporal resolution in children. Four ages was tested, 4-5 years of age, 6-7 years of age, 9-10 years of age, and adults. Sensitivity to sinusoidal modulation of noise carrier was determined for modulation frequencies of 5, 20, 100, 150, and 200Hz. The agreement of time constant across all age group was interpreted as indicating that the peripheral encoding of the temporal envelope is probably adult like in children aged 4 years and above; however, young children appear to be relatively inefficient in processing the information underlying modulation detection. Some studies reported that developmental changes occur till 12 years of age (Chermak et al 1989), but it depends on the type of task involved. In this study similar trend is not seen because of selected age range is from 8 to 15 years. Hence, TMTF maturation might have completed much earlier and reached adult like response

C. Comparison of speech perception ability in the presence of noise between the normal hearing subjects and individual with learning disability.

The speech perception scores obtained at 0 dB SNR in normal was better than the scores obtained in individual with learning disability. However, within group there was no significant ear differences observed in both the groups. As it was found at 0.01 level of significance, there was no significant left and right ear differences in performances in both the groups, hence, the scores was combined to compare the performance between normal hearing subjects and individuals with learning disability. Analysis was done using paired sample't' test correlation to know the significance difference if any between ears between groups.

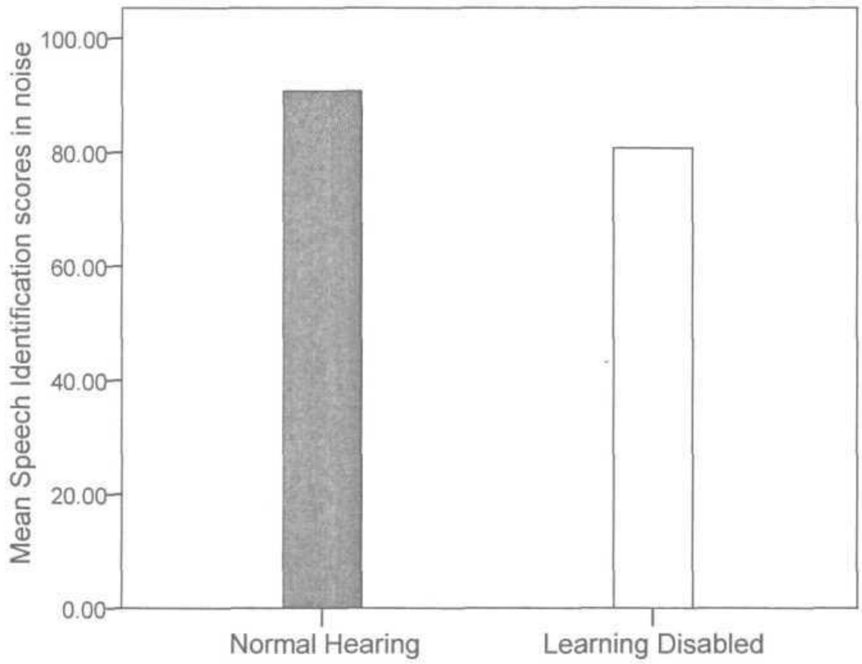

Figure 2: Speech in noise performance obtained from normal hearing subjects and individual with learning disability

Independent samples't' test analysis showed that, there was significant difference in the performance between groups right ear [t=3.07, PO.01] and left ear [t=3.2, PO.01] level of significance. Similar kind of performance also obtained by earlier studies by Raj Kumar, (2005) who compared the performance between normal and learning disabled children using behavioral and physiological test and found that, the individual with learning disability showed poor performance in the presence of noise when compared to normal hearing subjects.. However, in present study few individuals with learning disability had showed equal performance to that of normal subjects. This may be because all individuals with learning disability may not exhibit auditory processing problem. This can be supported by earlier studies by Ferre and Wilber, (1986), and Shivshanker & Gururaj, (1993). They reported that an individual with learning disability shows poor performance in CAPD tests including speech in noise test. Lorenzi et al (2000) obtained unprocessed speech signal and speech envelope noise signal identification and observed that individual with dyslexic's exhibit poor performance in processing the speech envelope noise when compared to normal hearing subjects.

Speech in the presence of noise is a method of reducing the redundancy of the speech signal, is to imbed the signal in a background of noise (Chermak, Vonhof et al., (1989). Speech is a complex signal which has variation in its amplitude and frequency of the spectrum (temporal envelope), presence of back ground noise will mask of the variations in frequency and amplitude of the signal and the signal becomes less redundant to be processed. Normal processing auditory system will be able to act selectively to speech spectrum by ignoring the background noise where as an individual with auditory processing problem will fail to extract the information from the complex signal. Thus, this might have resulted in poor speech recognition score in the presence of noise for learning disability group.

C. Correlation between TMTF perception and phoneme recognition in the presence of noise obtained from individual with learning disability.

Table 4: shows the TMTF thresholds across all modulation frequency and speech in noise scores obtained in individual with learning disability

Number of subjects	TMTF thresholds					Speech-in-noise	
	4Hz	16Hz	32Hz ^	64Hz	128Hz	right	left
1	-9	-6	-9	-6	-3	60	70
2	-6	-6	-6	-6	-3	80	90
3	-9	-9	-9	-6	-3	90	80
4	-9	-9	-9	-6	-6	80	70
5	-9	-9	-6	-6	-6	70	90
6	-6	-6	-6	-3	-3	90	80
7	-9	-6	-9	-6	-6	70	60
8	-9	-6	-6	-6	-3	100	80
9	-3	-6	-6	-9	-9	80	70
10	-9	-6	-6	-6	6	90	100
11	-9	9	-6	-6	-3	90	100
12	-9	-6	-6	-6	-6	70	80
13	-9	-9	-6	-6	-3	90	100
14	-9	-6	-9	-3	-3	60	70
15	-6	-6	-6	-6	-3	60	60
16	-9	-9	-9	-6	-6	90	100
17	-9	-6	-6	-6	-3	100	90
18	-6	-6	-6	-3	-3	100	100
19	-9	-9	-6	-6	-3	60	70
20	-6	-6	-6	-6	-6	80	70
21	-9	-9	-6	-6	-6	70	60
22	-6	-6	-6	-6	-3	70	80
23	-6	-9	-6	-3	-3	90	90
24	-9	-6	-3	-3	-3	60	60

In the present study to see the correlation between SPIN scores and TMTF thresholds, peak sensitivity was calculated for the lowest threshold across modulation frequency, which intern correlated with SPIN scores in individuals with learning disability. To obtain correlation between these two variables Pearson's product moment correlation method is used to analyze the data. The obtained analyses showed there is a significant correlation between these two variables ($r = -0.39$, $P<0.01$) level of significance. However, few subjects showed better performance in SPIN scores equal to that of normal. This may be because Speech in noise test is a least sensitive and less reliable tool in assessing auditory processing deficits (Chermak, Vonhof, & Bendael, (1989); Dayal, Tarantino, & Swisher, (1996); Heilman, Hammer, & wilder, (1973); Morales-Gercia & Poole, (1972); Olsen, Noffsinger, & Kurdziel, (1975); Sinha, (1959). Obtained results reveal that TMTF is a sensitive test in assessing temporal processing ability than when compared to the speech in noise test to differentiate processing problem may be auditory based rather than linguistic based. However, until now there is no study as been reported regarding correlation between TMTF and speech perception in the presence of noise.

CHAPTER 5

SUMMARY AND CONCLUSION

Learning disability is a disorder in the psychological processes involved in understanding or using language, spoken or written, which may manifest in an imperfect ability to listen, think, speak, read, write, spell or do mathematical calculations. Exclusions from this group are based upon organic deficits including visual, hearing, motor or economic disadvantage (Public Law-94, 1992). Thus learning disability can be termed a syndrome possessing a cluster of symptoms and different deficits can underlie learning disability. Prevalence estimates of this disability have been found to range from 3% to 10% (Snowling 2000). Prevalence rates can vary across languages (Kujala & Naatanen, 2001). Prevalence rate in India varies from 3 to 10% (Ramaa, 2000).

Individuals 'with Learning disability exhibit wide varieties of problems one among those is temporal processing deficits, which in tern leads to inability to perceive an amplitude modulation signal. This aspect can be assessed using temporal modulation transfer function. TMTF has been used as tool to assess the temporal processing ability in individual with learning disability. Tallal et al., (2000) and Lorenzi (2000), Rocheron et al., (2000) reported that individuals with learning disability shows poor temporal processing ability using TMTF.

The study was conducted on two groups of subjects, control and experimental group 20 individual with normal hearing without learning disability and 24 individual with learning disability without hearing loss in order to see how the temporal processing varies between these two groups and how does temporal processing change in late childhood and also to correlate between the speech perception ability in the presence of noise and temporal processing.

The experiment was conducted in two phases. In the present study performance of normal hearing subjects and individual with learning disability on Temporal Modulation Transfer Function were done on 54 children aged between 8 to 15 years. The performance of 20 normal hearing subjects, and 24 individuals with learning disability on TMTF was compared statistically using repeated measures of ANOVA.

The results showed that there exists a significant difference between normal hearing subjects and individual with learning disability in modulation detection task. All the individuals with learning disability in the study showed poor performance this accounts in present study 100% of population showed abnormality in TMTF. This finding of the present study are in line with the findings of the earlier studies of Lorenzi et al, (2000); Lorenzi et al , (2002); Me Anally et al, (1999) gives us an insight into processing defects in individuals with learning disability, hence and TMTF can be most sensitive test in assessing the temporal aspects in the speech perception.

In the present study the TMTF performance data was also analyzed to account for developmental changes in the modulation detection tasks within different subgroups and between groups. The data was analyzed using independent "t' test. The obtained results revealed that there was no significant difference within subgroups as the age range selected was much higher. These findings of the present study are in line with the findings of the earlier studies of Hall and Grose, (1994) where they dint see any developmental changes above 8 years of age.

The present study TMTF was also correlated with the speech perception ability in individuals with learning disability in the presence of monoral noise using Pearson's correlation method. The obtained data revealed that there is a significant correlation between TMTF and speech perception in the presence of noise. However, some subjects revealed no significant differences which give us information that SPIN is not a sensitive tool in assessing auditory processing deficits when compared to that of TMTF. From this we can account that, TMTF can be a useful tool in diagnosing whether the learning disability is auditory based or linguistic based.

Finally in the present study speech in noise performance was compared between individual with learning disability. The obtained results are in line with the findings of earlier studies of Shivshankar, (2003), Roshini Pillai, (2006), Raj Kumar, (2005), Kumar et al, (2004) showed significant difference in performance between normal hearing subjects and individual with learning disability. This shows that over all individuals with learning disability shows poor performance in adverse listening situation when compared to normal hearing individuals.

Conclusion:

From the above discussion it can be concluded that learning disability required higher modulation depth to perceive the modular than the normal group. The peak sensitivity for normal individual is higher than learning disability individual. SPIN scores are likely poorer for learning disability than normal group. Thus, suggesting temporal processing deficit in learning disability. TMTF could be better test to assess temporal processing than SPIN. Data obtained for normal group at different modulation rate can be used as a normative data (as shown in fig 1).

Clinical implication:

1. TMTF is an effective, non invasive, quick and sensitive tool which helps in diagnosis of learning disability.
2. TMTF performance in combination with SPIN scores gives a better idea about whether the processing problem is linguistic based or an auditory based problem.
3. TMTF perception indirectly assesses how well an individual can perceive speech.
4. Early indication to diagnosis at risk of learning disability.
5. Also can be used in rehabilitation.

Future Directions:

1. To administer TMTF on linguistic based learning disability and combination of both to see difference in TMTF and for differential diagnosis.
2. Classification of learning dishabilles into sub groups using TMTF.
3. TMTF can be administering on slow learners to differentially diagnosis them into learning disability.

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ANNEXURE 1
EARLY READING SKILLS
A score sheet to assess the learning disability

	Max Score	Patients Score	Grade
Alphabet Test 1. Identification Level			
Upper Case	26	25	
Lower Case	26	24	
2. Recall Level			
Upper Case	26	19	
Lower Case	26	20	
Visual Discrimination			
Level 1	16	10	
Level 2	17	11	
Auditory discrimination	30	25	
Phoneme-Grapheme Correspondence tes			
Part 1 A	30	25	
B	30	24	
Part 2 A	18	16	
B	15	13	
C	20	15	
D: Long Vowel	10	07	
Short Vowel	10	08	
Structural Analysis test			
Level 1	10	10	
Level 2	27	03	
Level 3	10	01	
Oral Reading	16		level 3