DEVELOPMENT OF NORMS ON DURATION PATTERN TEST

Register No. 02SH0008

An Independent Project submitted as part fulfillment for the first year M.Sc. (Speech and Hearing), Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING,

MYSORE - 570 006

JUNE, 2003

Dedicated to Aai & Baba

I feel like the luckiest person on earth having parents like you. You are the reason why I am here and what I am today.

Certificate

This is to certify that this Independent Project entitled **'DEVELOPMENT OF NORMS ON DURATION PATTERN TEST"** is the bonafide work in part fulfillment for the degree of Master of Science (Speech and Hearing) of the student with Register No. 02SH0008

Mysore
June, 2003

Director
All India Institute of
Speech and Hearing
Mysore - 570 006

Certificate

This is to certify that this Independent Project entitled **"DEVELOPMENT OF NORMS ON DURATION PATTERN TEST"** has been prepared under my supervision and guidance.

Mysore

June, 2003

Guide

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Declaration

This independent project entitled **"DEVELOPMENT OF NORMS ON DURATION PATTERN TEST"** is the result of my own study under the guidance of **Mrs.P. Manjula,** Lecturer in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier in any other University for any other Diploma or Degree.

Mysore

June, 2003

Register No. 02SH0008

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INTRODUCTION

Hearing involves different aspects of auditory processing such as detection, temporal processing, frequency processing and localization. Temporal processing refers to the time related cues in the auditory signal and it is critical for speech perception and perception of music (Hirsh, 1959). Performance on temporal patterning tasks, involving linguistic labeling of the non-speech stimuli, cannot be expected to reach adult values until neuromaturation of the neural structures, critical to the task particularly the corpus callosum, is complete.

The development of auditory temporal processing abilities appears to follow the course of neuromaturation, with skills improving as a function of age until approximately twelve years of age (Bellis, 1996). The effect of age on tests of temporal patterning may be influenced from studies on patients with corpus callosum involvement (Musiek; Pinheiro & Wilson, 1980; Musiek, Kibbe & Baran, 1984).

Temporal processing tasks include: temporal integration and temporal ordering. If the duration of the sound is decreased below a certain critical value, its intensity must be increased in order to continue to elicit a threshold response. This phenomenon is termed as temporal integration. Temporal ordering refers to the ability of the listener to recognize acoustic contours. Duration pattern test is a test for temporal ordering or temporal patterning. Temporal patterning involves discrimination of difference in auditory stimuli, sequencing of auditory stimuli, gestalt pattern perception and trace memory (Musiek & Chermak,1995). J

Efron (1963) opined that analysis of temporal order takes place primarily in the dominant hemisphere, specifically in the temporal lobe, and extending posteriorly to Wemike's area and the angular gyrus. The processes of temporal cues takes place throughout the Central Auditory Nervous System (CANS), however, the primary and associative auditory cortex appears to be particularly important for the process of temporal ordering.

Temporal processing is affected in temporal lobe and corpus callosum lesions. [Children with deficits in acoustic contour recognition and temporal patterning may exhibit difficulty recognizing and using prosodic aspects of speech. They may have difficulty extracting key words from a spoken message and may be unable to discriminate subtle differences in meaning brought about by changes in relative stress and intonation. These children may themselves be 'flat' readers or be somewhat monotonic in their own speech. Sequencing of critical elements within a message, as well as individual speech sounds within a word may be a problem. Cerebral lesions typically result in contralateral deficits as well as bilateral deficits on tests of temporal patterning (Bellis, 1996).

Discrimination of duration have not generally been used in central auditory assessment, though they can be of considerable help. This task represents processes that are the underpinnings of more complex auditory functions. Much research has been done on various types of auditory discrimination, little has been done using subjects with disorders of CANS. The psychoacoustic rigor involved in duration discrimination makes the testing too long and difficult to use clinically. Hence, at present, there is little clinically available data on duration discrimination. This is unfortunate because there is compelling data showing the difference limens being affected by CANS pathology.

There are several factors that affect the DPT results. These include age, gender, number of stimuli in the sequence to be discriminated, verbal versus humming response, etc.

***Need of the study**:*

Literature reports of regional differences in the normative for temporal tasks (Musiek, Baran & Pinheiro, 1990). Till date no normative data has been developed for DPT in India. Hence, developing norms would help us to include DPT in the test battery approach in the assessment of Auditory Processing Disorders (APD). In the present study, it was aimed to develop age related norms on Duration Pattern Test (DPT).

REVIEW OF LITERATURE

Historically, tests of central auditory function have been categorized in a variety of ways. ASHA, (cited in Bellis, 1996), separated tests of central auditory function into two broad categories. Those that take away information from the signal and those that add information to the signal. Baran and Musiek (1991) categorized central tests as dichotic speech tests, temporal ordering tasks, monaural low redundancy speech tests and binaural interaction tests.

One of the temporal ordering tests is the Duration Pattern Test. The Duration Pattern Test (DPT) assesses the process of duration discrimination, temporal ordering and linguistic labeling. Pinheiro and Musiek described the Duration Pattern Test, in 1985. In Duration Pattern Test, the frequency of the tone is held constant (at lOOOHz) and the duration is the factor to be discriminated. Short and long tones are presented in sequences of two or three patterns and the listener is asked to describe the pattern heard verbally, E.g. short-long-short. The DPT assesses the processes of duration, discrimination, temporal ordering and linguistic labeling.

The review of literature on DPT is discussed under the following headings:

1. Duration Pattern Test
2. Factors affecting temporal processing tasks
3. Duration Pattern Test in various pathologies

1. *Duration Pattern Test: (DPT)*

As described by Musiek in 1994, the duration patterns are composed of three 1000 Hz tones and two 300 msec, intertone intervals. The tones in each duration pattern are either 250 msec or 500 msec in duration and are designated as short duration (S) and as long duration (L), respectively. Each tone is generated digitally and has 10 msec rise - fall times shaped with a cosine-square function. There are six possible combinations of the three -tone sequence (LLS, LSL, LSS, SLS, SLL and LLS). The CD contains 60 duration patterns (six patterns by 10 randomizations) that have approximately 6 sec interpattern intervals. It is critical when administering the test that the audiologist is sure, the patient understands the task. Practice items should be given in a face-to-face situation.

The DPT appears to be sensitive to cerebral lesions while remains unaffected by peripheral hearing loss (cochlear) as long as the stimuli are presented at a frequency and intensity that can be perceived by the listener (Musiek, Baran & Pinheiro, 1990). The test has a verbal portion. When the subjects are required to represent tonal sequence verbally, i.e., use words "short" and "long", individuals with corpus callosum lesions have significant difficulty. Hence, one can extrapolate these findings to postulate that the DPT would be an useful procedure for looking auditory integration when doing CAP testing. Musiek, Baran and Pinheiro, 1990, reported that this test is highly sensitive to cerebral lesions (86 %), while also has relatively high specificity rating, test - retest data on DPT have been shown to be reasonably good. (Humes, Coughlin & Talley; 1997).

Duration pattern test assesses integration across processing regions in the right hemisphere which is responsible for suprasegmental information and also spoken language perception which enables the processing of linguistic content, such as lexicon, semantic relations and syntax (Musiek & Lamb, 1994).

2. *Factors affecting temporal processing tasks:*

1. *Age:*

The scores on DPT improve with increase in age, with the neuromaturation of corpus callosum, upto to age of twelve years. The final portion of CANS to attain neuromaturation is the corpus callosum which is responsible for interaction between cerebral hemispheres. Hall and Grose, (1994) found that the peripheral mechanism responsible for encoding temporal aspects of the acoustic signal appeared to be well developed in young listeners. However, the ability of the CANS to extract and process temporal cues appeared to improve as a function of age. Performance on temporal patterning tasks which involves linguistic labeling of non-speech stimuli cannot be expected to reach adult form until neuromaturation of the neural structures, critical to the task, particularly the corpus callosum is complete. Adult values of DPT are not attained until 11 to 12 years of age. Thus, the development of temporal processing abilities appear to follow the course of neuromaturation with skills improving as a function of age, until approximately 12 years of age.

2. *Gender:*

There is no difference between the scores in males and females on DPT.

3. ***Presentation of the sequences (separate or continuously):***

Performance is better if the sequences are presented with a gap, not continuously. In fact, it is possible that the number of stimuli affect the manner of processing in a temporal ordering task.

4. ***Subject training:***

It is obvious that learning can affect results unless subjects are trained to certain criteria. The amount of training necessary depends on both the complexity of the stimuli and the difficulty of the psychophysical task. Waren, as cited in Musiek and Pinheiro (1985), felt that training of subjects was not necessary for sequences in which the components had a duration of atleast 200 msec, each, on some temporal ordering tasks. Efron (1963) pointed out that naive subjects perform significantly more poorly than trained normal subjects on certain temporal ordering tasks. Whether or not the subjects should be trained may depend on the type of data that is being collected. The normative data to be used as a basis for clinical procedures might best be established on a naive population, since time is not available for more than the most elementary training of patients in a clinical setting.

5. ***Stimuli for temporal ordering tasks:***

A. ***Type of stimuli:***

Different types of stimuli have been used by the investigators in their studies. Tones are one among them. If there is any difference among the signals in frequency, intensity or duration, the subject should be able to distinguish between them easily in isolation. Divenyi and Hirsh (1974) noted that a simple harmonic relationship among components of a sequence facilitated temporal ordering judgements.

B. ***Number ofcomponents:***

Sequences of stimuli have been composed of two, three, four or more components. The number of components in a sequence influences the difficulty of the psychophysical task. The task of ordering three elements is different from that of ordering only two elements or from that of ordering more than three elements. It is possible that the number of stimuli affect the manner of processing in a temporal ordering task.

C. ***Duration of components:***

The duration of the individual components in a sequence also affects perception of the sequence and the task of ordering it. Divenyi and Hirsh (1974) summarized duration requirements for the components of a contiguous sequence necessary for judgement of temporal order. For sequences of three components, each component needed a duration of 50 msec (Peters & Wood, 1973). If the subject had to judge which of two components came first, each component required a duration of 20 msec (Hirsh, 1959). The above data refer only to sequences with contiguous sounds and not taken into account sequences in which the individual components are separated by silent intervals.

D. ***Rate and manner of presentation:***

Very brief stimuli presented at a rapid rate are thought to be judged by spectral differences whereas longer components presented at a slower rate are usually perceived as individually different or separate sounds (Nickerson & Freeman, cited in Musiek & Pinheiro, 1985). Very rapid rates of presentation do not permit actual temporal ordering of the stimuli but it is used for other temporal ordering tasks that are simple and require less cognitive processing. The manner of presentation interacts with the rate of presentation.

Hirsh (1959) studied the effect of inter stimulus intervals (ISI) on the perception of temporal ordering using a variety of acoustic stimuli. He determined that an ISI of only 2 msec is required for the normal listener to perceive two sounds instead of only one; however, this ISI must be increased tenfold (approximately 17 msec) for the listener to report which of the two sounds came first with 75% accuracy. In addition, the judgement of temporal order appears to be independent of the acoustical nature of the sounds. Hirsh concluded that the judgement of temporal order does not occur at the ear, but rather represents a central auditory function and that in cases in which a listener requires more than 15 or 20 msec to perceive temporal order of two consecutive stimuli, the examiner should look for a possible central involvement. The duration of silent interval have been found to be important if recall is inaccurate, not even the simplest type of temporal order judgement can be made correctly. In some studies attention has been encouraged by having the subject himself initiate the stimulus so that he listened to it only when he felt he was ready to listen and attend to it. Subjects have also been rewarded for participation in studies, or according to their levels of performance, hence encouraging them. Training has been shown to improve recall also as the stimuli become more familiar, although overtraining might decrease attention to stimuli that are no longer novel. Miscik & colleagues (as cited in Musiek & Pinheiro, 1985) reported that retention of auditory sequences was a combined function of stimulus duration, interstimulus interval, and encoding techniques the subject used in temporal ordering.

E. ***Level of presentation of stimuli:***

Literature reports of no differences in results with changes in the presentation levels. Musiek (cited in Musiek & Pinheiro, 1995) found no significant difference in DPT scores with 20 dBHL and 50 dBHL presentation levels.

6. ***Other factors in temporal ordering:***

Instrumentation has varied from one research laboratory to another, and this must be taken into account, when studies of temporal ordering are compared. A few investigators have used loudspeakers for presentation of stimuli, although most have employed earphones. Some have tested subjects using tape loops, while others have generated the signals as they were presented. The intensity level or sensation level at which the auditory sequences are presented may also influence the results. This psychophysical variable has not been investigated adequately (Peters & Wood; 1973, Handel &Yoder, as cited in Musiek & Pinheiro, 1985).

7. *Temporal order judgements:*

The type of temporal order judgement the subject is asked to make influences results of studies in temporal sequencing (Warren and Obusek; cited in Pinheiro & Musiek, 1985). Some responses require higher cognitive processing than others. The most difficult type of processing judgement of temporal order appears to be a description of the sequence or actual ordering of the components by labeling them verbally or pointing to or pressing buttons in a sequence that matches the sequence heard, or repeating the actual order of the components of the sequence in some other form of response (Preusser, cited in Pinheiro & Musiek, 1985). The actual temporal ordering of components in a sequence apparently involves language processing when either verbal or manual responses are required of the subject.

8. *Attention and recall:*

Attention of a subject affects the recall of the sequence. Recall is a powerful variable in all types of judgements of temporal order, since the response must follow the stimulus after some brief period of time, whatever the psychophysical procedure used.

9. *The kind of task the subject must perform (verbal or hum):*

When the subjects perform the task verbally, i.e., use words 'short' and 'long', individuals with corpus callosum lesions have significant difficulty. Humming the pattern involves only the right hemisphere, hence, if a subject cannot orally report the patterns but hum them could mean that the right hemisphere is intact and the problem is either in the left hemisphere or the corpus callosum. (Musiek, Pinheiro, & Wilson, 1980; Musiek, Gollegly & Baran, 1984). The split brain patient can often correctly hum the patterns but are unable to verbally report them. This indicates the right hemisphere can recognize the patterns but cannot linguistically label them. Hence, both the hemispheres need to be involved for this task for the verbal report of the patterns. Bilateral deficits on DPT are seen in case of Learning Disabled cases.

3. *Duration Pattern Test in various pathologies:*

Theoretically and some experiments support the concept that both the hemispheres must interact to decode the pattern and orally report it (Musiek et al.; 1980 and 1984). Given that subjects with disorders often show bilateral deficits and normals show similar performance in both the ears, many clinicians opt for doing the test in a sound field. This shortens the test but this may also cause a few patients, with disorders that show only unilateral deficit on pattern perception, to be missed. Therefore, with patterns often revealing bilateral deficit, it is often difficult to determine which hemisphere is involved when verbal report is required.

Humming the patterns appears to require only the right hemisphere, hence, if a subject cannot orally report the patterns, but hum them could mean that the right hemisphere is intact and the problem is either in the left hemisphere or the corpus callosum (Musiek, Pinheiro & Wilson , 1980; Musiek, Gollegly & Baran, 1984) .

Severe bilateral deficits are seen in cases of audit©ry cortex involvement. According to a study done by Musiek, Baran and Pinheiro (1990), three groups of subjects were tested on a duration pattern recognition task. The groups included fifty normal hearing subjects, the second group included twenty four subjects who had been otologically diagnosed as cochlear hearing losses in one or both ears and negative neurologic histories. The third group of subjects included twenty one individuals with neurologically, radiologically and / or surgically confirmed Central Auditory Nervous system lesions involving, but not limited to, the auditory areas of the cerebrum. Results indicated no significant difference in pattern recognition between the normal subjects and subjects with cochlear hearing loss. However, the subjects with cerebral lesions performed significantly more poorly than either the normal subjects or those with cochlear hearing loss. In comparing pattern recognition performance for the ears ipsilateral and contralateral to the hemispheres, with lesion, no differences were noted. Rather, when a central lesion was present, both ears generally yielded abnormal scores. In a study done by Cranford, Stream, Rye and Slade (1982) on cats indicated that auditory cortex lesion had no effect on the cats ability to detect brief tones. They gave brief tone tests to seven patients with temporal lobe damage, and found similar behavioural dissociation. All the subjects exhibited normal detection thresholds in conjunction with substantially elevated frequency difference limen.

Performance on temporal patterning tests, such as DPT, typically is non - lateralizing, i.e., central, lesions tend to result in bilateral deficits, regardless of the site of lesion. Therefore, laterality information cannot be obtained by these tests. Thompson and Abel (1992) reported that the listener required a greater response time than did the other two groups. In all cases, listeners with lesions of the left temporal lobe tended to demonstrate greater performance deficits. Interhemispheric corpus callosum lesions resulted in bilateral deficits on tests of temporal patterning, i.e., on DPT, when the listener was required to respond verbally. Bilateral deficits on DPT have been reported (verbal) for patients with deep brain lesions, presumably affecting the Transcortical Auditory Pathway (Musiek, Baran & Pinheiro, 1990). Split brain patients typically demonstrated bilateral (for verbal report) on pattern perception tests, eventhough the assessment is a monaural procedure.

The final portion of the CANS to attain neuromaturation in the corpus callosum which is responsible for interaction between cerebral hemispheres. Theoretically, it is found that a neuromaturational delay will result in findings, on tests of Central Auditory Function, that are similar to corpus callosum involvement. Poor performance is seen on tests of temporal patterning, i.e., DPT, although, the performance on these tests may improve when the listener is asked to hum the responses, thus removing the linguistic labeling component (Musiek, Kibbe & Baran, 1984).

Associated deficit primarily features an underlying inability to apply the rules of language to incoming acoustic information. Performance on DPT is often good. Output - organization deficit is a deficit in the ability to sequence, plan and organize responses. Performance on DPT is likely to be poor, because all of these tests require to report multiple elements.

Musiek and Lamb (1994) used the terms cortical and hemispheric to differentiate between the two types of cerebral lesion. Cortical refers to the grey matter of the brain alone where as hemispheric refers to lesions that affect both the white and grey matter. With similar performance in both the ears, many audiologists opt for doing the test in a sound field. This shortens the test but this may also cause a few patients, with disorders that show only unilateral deficit on pattern perception, to be missed. Therefore, with patients often revealing bilateral deficits, it is often difficult to determine which hemisphere is involved when verbal report is required.

Advantages of DPT:

- It has good sensitivity and specificity (86 %) with reference to auditory cerebral and cochlear dysfunction (Musiek, Baran & Pinheiro ,1990)
- In regard to sensitivity, specificity or both, this procedure atleast is as good as several other tests of Central Auditory Dysfunction.
- This test does not use speech as a stimulus and therefore, is not limited in its application by the language of the subject or examiner.
- Thus, it can be used to assess children and individuals with limited or impaired language skills.
- Another clinically important factor is that the Auditory Duration Pattern Test, generally requires only minutes or less to administer and score.
- It is significantly useful for individuals with peripheral hearing loss, as it is relatively easy to control for frequency distortion effects, as only one frequency is employed.
- DPT can be useful as a screening test for Central Auditory Dysfunction.

Disadvantages of DPT:

- If the duration pattern test is presented monaurally or in a sound field, it is common to obtain binaural deficits on DPT, eventhough the lesion may be in only one hemisphere (Musiek & Pinheiro, 1987) or isolated to corpus callosum.

- It tells us about the lesion in the cerebrum but doesn't provide laterality information.

METHOD

Subjects'.

A total of fifty subjects were taken in five groups. Table 1 depicts the distribution of subjects in these five groups -

Table 1: Distribution of subjects in different age groups.

Age Range	*Group*	*No. of Subjects*
8.1 to 9.0 years	I	10
9.1 to 10.0 years	II	10
10.1 to ll.Oyears	III	10
11.1 to 12.0 years	IV	10
18.1 to 35.0 years	V	10

Equal number of males and females in each age group were considered.

Subject selection criteria:

- No known history of hearing loss

  No history of chronic otologic problem.

  No neurological problems or trauma

- Average or above average intellectual functioning.

  Pure tone thresholds less than or equal to 20 dBHL, in both the ears, in the audiometric frequency range of 250 Hz to 8 kHz for AC and 250 Hz to 4 kHz for BC.

- A checklist was used to rule out any indications of Auditory Processing Dysfunction (Appendix).

Equipm ent/ Material:

A personal computer with sound generator software to develop DPT.

- A calibrated diagnostic audiometer, GSI-61, with Telephonies TDH50P headphones.

- Philips DVD 729 K player, with CD on DPT.

A calibrated GSI 33 (V2) immitance meter.

Test Environment:

The test was carried out in an acoustically treated two - room air conditioned suite with ambient noise levels within permissible limits (re: ANSI 1991, as cited in Wilber,1994).

Procedure:

The study was carried out in two phases.

1) Recording of DPT on CD
2) Collection of age-related norms on DPT.

Phase 1:

The sound generator software in the personal computer was used to generate 1 kHz tone of short (250 msec.) and long (500 msec.) durations. Using the short (S) and long (L) duration tones, six different combinations of three tone sequences were constructed. These sequences had atleast one of the three tones different from the other two. The three tones were separated by 250 msec gap. This resulted in the following six sequences:

1. Long - Long - Short (LLS)
2. Long - Short - Long (LSL)
3. Long - Short - Short (LSS)
4. Short - Short - Long (SSL)
5. Short - Long - Short (SLS)
6. Short - Long - Long (SLL)

The thirty stimuli of the above six patterns were considered as test items and six of them as practice items. These practice (6 nos.) and test items (30 nos.) were recorded on a CD along with a calibrated tone (1 kHz).

Phase 2:

Pure tone thresholds were obtained for the subjects at audiometric frequencies from 250 Hz to 8 kHz for AC and from 250 Hz to 4 kHz for BC and it was made sure, that the thresholds were within 20 dBHL for both AC and BC. This data served for selection of subjects. The subjects were also screened by using GSI 33 imittance meter to rule out middle ear problem. A checklist was also used to rule out central auditory processing problems.

Each subject was seated comfortably in the patient room. The DPT, recorded on a CD, was routed through the headphones of GSI 61 audiometer, to each ear separately. The presentation level of the test was 40 dBSL (re:PTA). The subjects were given practice trials of about six sequences before the test actually started. The subject was instructed as "you are going to hear to a sequence of three tones of varying durations (short & long). You should verbally report the pattern of the long and short duration tones in the sequence." For the practice items, the subject was demonstrated how to respond. Later the test items were administered.

The number of correct verbal responses of the thirty samples were then converted to percentage and tabulated, for each ear, for each subject, in each age group. Reversals of the responses were not considered correct. The tabulated data was then statistically analysed.

RESULTS AND DISCUSSION

Descriptive statistics of SPSS (Statistical Package for Social Science, 7.5) a computer software, was used to obtain the mean, range and standard deviation (SD). Independent t-test was administered to study the significant difference between the right and left ears, and, among the various age groups.

According to the results of the present study, there was no significant difference between the ears (right & left) at 0.05 level of significance, in different age groups (Table 2). The original study on Duration Pattern Test by Musiek (1994) also showed similar finding. Another study by Musiek, Baran and Pinheiro (1990) also concluded that there was no significant difference among the right and left ears at 0.05 level of significance. Thus, the results of the present study is in consonance with the study by Musiek, (1994) and Musiek, Baran and Pinheiro (1990). As there was no significant difference between right and left ears, the percent scores were combined to form one group, i.e; with N = 20 in each age group.

Table 2: The mean, range, SD, t values of the two ears (Right and Left) on DPT scores (in %) in different age groups.

AGE	*8years*		*9 years*		*10 years*		*11 years*		*12 years*		*Adults*	
	Right (N=5)	*Left (N=5)*	*Right (N=5)*	*Left (N=5)*	*Right (N=5)*	*Left' (N=5)*	*Right*	*Left (N=5)*	*Right (N=5)*	*Left (N=5)*	*Right (N=5)*	*Left (N=5)*
M	20.72	20.2	39.78	45.46	60.91	55.66	69.8	69.5	79.85	76.45	95.49	98.26
Range	10-43.3	13-30	25-66.6	20-80	43.3-80	40-70	66.6-76.6	66.6-76.6	70-90.3	70-90	93.3-97.3	94-100
SD	9.76	5.63	14.05	19.57	12.22	9.02	3.0	2.74	9.18	7.38	1.38	2.33
	0.071		1.29		1.11		9.90949-03		0.10		0.065	
S/NS	NS		NS		NS		NS		NS		NS	

df=18 NS-not significant S-significant

Table 3: The mean, range, and standard deviation (SD) of the Duration Pattern scores (in %) across different age groups.

Age group	*8 years*	*9 years*	*10 years*	*11 years*	*12 years*	*Adults*
Mean (N=20)	20.46	42.64	58.28	69.65	78.20	96.81
Range (N=20)	10-43.3	20-80	40-80	66.6-76.6	70-93.3	93.3-100
S.D (N=20)	7.76	16.83	10.80	2.80	8.30	2.34

From Table 3, it is observed that the mean percentage scores on DPT increases with increasing age. Also there is a gradual reduction in variation, as per the range and SD values, with increase in age, except for 9 years group. For the purpose of developing the norms, a score of "mean ± 2 SD" were derived for different age groups at 95% confidence levels. The cut- off scores for different age groups, in percentage, are depicted in Table 4

Table 4: The lower and upper cut-off percentage scores on DPT, in different age groups.

AGE	*LOWER CUT-OFF SCORE (IN%)*	*UPPER CUT- OFF SCORE (IN%)*
8 Years	4.94	35.98
9 Years	8.98	76.3
10 Years	36.68	79.88
11 Years	64.05	75.25
12 Years	61.6	94.8
Adults	92.13	100

The obtained percentage of scores in the present study also shows a gradual increase in the score from 8 years to 12 years of age. According to the study by (Musiek, 1994) the normative values by using the compact disc version of the test, a cut- off of 73% for young normal hearing adults was obtained. The lower cut- off scores obtained in the present study is 92.13%, and the higher cut- off score obtained is 100%.

The performance on temporal patterning tasks include, linguistic labeling of non-speech stimuli. This it is not expected to reach adult values until neuromaturation of the neural structures, critical to the task, particularly the corpus callosum, is complete. Literature reports that the development of temporal processing abilities appears to follow the course of neuromaturation with skills improving as a function of age until approximately 12 years of age (Bellis, 1996). The scores obtained in the present study are better than that observed by Musiek, (1994) and it could be due to several factors which affect temporal processing tasks.

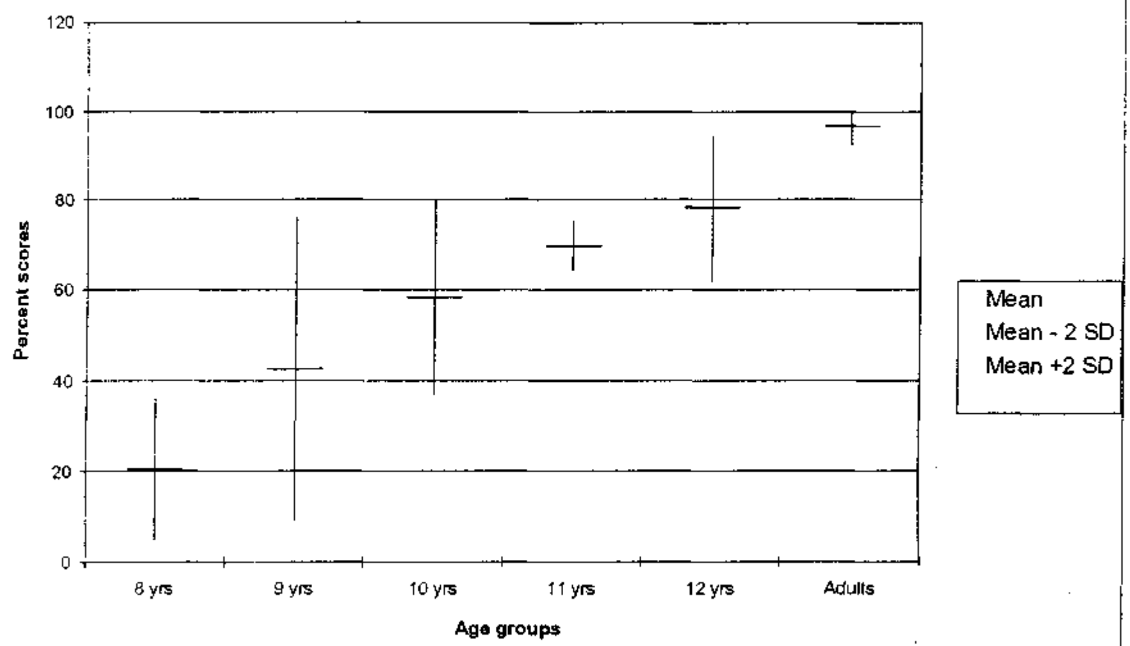

Fig1:Mean percent correct scores ± 2 SD for DPT in different age groups

Figure 1 shows the "mean", "mean -2 SD", "mean + 2 SD". The figure shows a gradual increase in the mean scores with the increase in age. It also shows that the variance among the scores gradually decrease with the age, except at 9 years age group where the variability among the scores is a little more than could have noticed. This is because of the skewness in the data caused by one subject who performed poorly than expected in this age group. The variation in different age groups is most in the 9 yrs followed by 10, 12, 8, 11 years and adults.

Table 5: The mean, SD, t values across different age groups.

AGE	*M*	*SD*	*t*	*S/NS*
8 years (N=20)	20.46	7.76	5.47**	S
9 years (N=20)	42.64	16.83		
9 years (N=20)	42.64	16.83	3.53**	**S**
10 years (N=20)	58.28	10.80		
10 years (N=20)	58.28	10.80	4.67**	**S**
11 years (N=20)	69.65	2.80		
11 years (N=20)	69.65	2.80	4.57**	**S**
12 years (N=20)	78.20	8.30		
12 years (N=20)	78.20	8.30	9.93**	**S**
Adults (N=20)	96.87	2.34		

df=38 **P<0.01 *P<0.05

NS-not significant S-significant

The t score indicates significant difference across different age groups from 8 years to 12 years. The results showed significant difference among the scores across the age groups, at 0.01 level of significance. This supports the statement that the scores improve with the neuromaturation of the cortical structures,till the completion of the corpus callosum, up to the age of 12 years (Bellis, 1996). Also, there is a significant difference between the 12 years, the highest age group among children, and the adults. Testing higher age groups might reveal when the scores on DPT reach the adult values.

SUMMARY AND CONCLUSION

The auditory processing involves different aspects of hearing such as detection, frequency processing, temporal processing and localization. There are various tests to assess temporal processing and DPT is one of them. The development of temporal processing appears to follow the course of neuromaturation with skills improving as a function of age until approximately 12 years of age (Bellis,1996).

Literature reports of regional differences in the normative for temporal tasks, (Musiek, Baran & Pinheiro, 1990). As there is no normative data for DPT in India, the present study was undertaken. The objective of the present study was to measure performance of subjects on DPT, in different age groups, so as to establish norms.

A total of fifty subjects were taken in five groups. Ten subjects in each age group of eight, nine, ten, eleven and twelve years were considered. Ten adults between the age of 18 and 35 years were taken for comparison. Equal number of male and female subjects were considered in each age group. The subjects had no otologic and neurological problem. The pure tone thresholds were less than or equal to 20 dBHL in both ears in the audiometric frequency range of 250 Hz to 8 kHz for AC and 250 Hz to 4 kHz for BC.

The equipment used were a personal computer with sound generator software to generate tones to develop DPT. A calibrated diagnostic GSI 61 audiometer with Telephonics TDH50P headphones, Philips DVD 729K player with CD on DPT and GSI 33(V2) immitance meter. The test was carried out in an air conditioned acoustically treated two room suite with ambient noise levels within permissible limits (re: ANSI 1991, as cited in Wilber, 1994)

The DPT consisted of a 1 kHz tone with two durations short (S) and long (L) i.e; of 250 msec & 500 msec respectively. 36 sequences were constructed. Each stimulus sequence consisted of three tones presented in succession, with an interstimulus of 250 msec. Atleast one of the three tones in the sequence differed from the other two resulting in six sequences, E.g LSS, SSL, SLS, LSL, SLL, LLS. Six practice and thirty test sequences (totally 36) were recorded on a CD along with a c alibration tone (1 kHz).

The DPT was administered through the earphones (R/L) of the diagnostic audiometer to each ear of the subject. The presentation level was at 40 dBSL (re: PTA). Correct identification scores of stimuli sequences were recorded in percentage. Responses for each ear, for each subject, were then tabulated in percentage. Appropriate statistical analysis was carried out to derive mean, standard deviation, range and t values.

There was no significant ear difference among the two ears (R/L) at 0.05 level of significance. Further, there was a significant difference found among different age groups at 0.01 level of significance, with the scores improving with the age. The mean percentage score on DPT was 20.46 for 8 years (lower cut-off being 4.94 & upper cut-off being 35.98), 42.64 for 9 years (lower cut-off being 8.98 & upper cut-off being 76.3), 58.28 for 10 years (lower cut-off being 36.68 & upper cut-off being 79.88), 69.65 for 11 years (lower cut-off being 64.05 & upper cut-off being 75.25), 78.20 for 12 years (lower cut-off being 61.6 & upper cut-off being 94.8) and 96.81 for adults (lower cut off being 92.13 & upper cut-off being 100)

The norms developed would be useful to compare data obtained on clinical population. The comparison of the normative data with the clinical population has implications in management also.

Suggestions for further research:

i) Studies on normative data can be carried out, in children greater than 12 years of age to see when the scores reach the adult scores.

ii) A normative data on DPT with verbal vs hum response could be carried out.

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APPENDIX

CHECKLIST FOR SCREENING AUDITORY PROCESSING DISORDER

Place a check mark before each item that is considered to be a concern by you.

1. Has short attention span.
2. Easily distracted by background sounds.
3. Problems with sound discrimination.
4. Trouble in recalling any sequence heard.
5. Forgets what is said in a few minutes.
6. Misunderstands verbal instructions.
7. Takes long time to answer questions regarding familiar concepts.
8. Performance is below age in one or more subjects.
9. Problems in understanding when somebody speaks fast.
10. Reverses numbers, words, tones etc.