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Effect of Ageing on Pitch Pattern Sequence Test

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Introduction

In the past, people instinctively associated hearing difficulties with problems of the ear or the auditory nerve. However, a number of people with apparent listening problems have been found to have hearing thresholds within the normal limits. One of the causes of the problems that a group of people experiences is believed to be a deficit in their processing ability of auditory information even with normal hearing threshold findings (Jerger & Musiek, 2000). Much research has thus been conducted in this area called as central auditory processing disorder (CAPD). Evidence shows that temporal processing, the ability of the auditory system to follow fluctuations of sound and resolve them into meaningful messages, is an underlying and key component of central auditory function (Bornstein & Musiek,1984; Lister, Roberts, Shackelford, & Rogers, 2006; Pinheiro & Musiek, 1985). Audiologists are now more aware of the issue, and its diagnosis in school-aged children has especially drawn a great deal of attention as CAPD may significantly affect children's learning (Whitelaw, 2008).

All functions of the central auditory nervous system are somehow influenced by time. In this system, the pattern of neural activity is mediated by temporal information with an accuracy of microseconds. Speech and language comprehension, the most complex function of the human central nervous system, depends on the ability to deal with sound sequences.

Auditory Temporal Processing

Auditory temporal processing is defined as the perception of the temporal characteristics of a sound or the alteration of durational characteristics within a restricted or defined time - interval. Auditory skills in temporal processing include temporal resolution, temporal masking, temporal integration and temporal ordering. Temporal processing is the fundamental component of most auditory processing abilities. Any deficiency in this area can lead to auditory processing disorder. Temporal ordering the arrangement of sequence in time. Temporal ordering ability to sound stimuli is one of the most important functions of the central auditory nervous system. Assessment of auditory processing involving temporal ordering tasks uses behavioural measures to analyze the central auditory system. This ability allows the listener to discriminate based on ordering and sequencing of auditory stimuli.

Impact of Ageing

Ageing is a biological process. There are a number of pathophysiological changes that occur due to ageing in the auditory system which can cause an adverse effect on the person's communication as well as his quality of life. It is well known that both peripheral and central auditory physiology changes with age (Willot, 1991). It is stated that older individuals will be having greater temporal ordering thresholds than that of younger individuals. Thus, this ability is compromised in older adults compared with younger adults (Bukard & Sims, 2001). Ageing can bring a decline in the ability of temporal ordering, which may be related to the reduction of effective communication.

Tests to assess temporal processing

Pitch pattern sequence test (PPST), Duration pattern test (DPT), Psychoacoustic pattern discrimination test (Bellis, 1996) are some of the tests which assess the temporal processing. Pitch pattern sequence test developed by Pinheiro in1977 for both children and adult assess listener's pattern perception and temporal sequencing abilities (Bellis 1996). The test consists of pattern sequences of 3 tone bursts: two of one frequency and one of another. The subject has to respond by repeating the sequences of the tone presented. The subject has to hum and say it verbally and point or tap to high - low objects. PPST is useful in detecting disorders affecting cerebral hemisphere (Pinheiro & Musiek, 1985). Along with corpus callosal dysfunction (Musiek, Pinheiro & Wilson, 1980). When patients with disruptions in the interhemispheric transfer of auditory information are asked to hum the pattern rather than verbally describe it, they show improvement in performance (Musiek, 1986).

Ageing and CAPD tests

One of the challenges faced by audiologists when administering CAPD tests and consulting test normative data is the issue of age effects. Neijenhuis and colleagues (2002) investigated the influence of age to the test scores of the Dutch test battery for CAPD and confirmed significant age effects, meaning that the age of the subjects must be taken into account when interpreting these scores. They specially pointed out that an age effect is particularly prominent in children, with the children's percentile scores being different in each age group, suggesting that their auditory processes are still developing and are not completed at the age of twelve (Neijenhuis, Snik, Priester, van Kordenoordt, & van den Broek, 2002). Bellis (2003) presented age-specific normative data on several CAPD tests, and the figures also demonstrated age effects in both verbal and non-verbal tests performed on school-aged children. Although the study by Neijenhuis et al. (2002) did not show age effects in the Pitch Pattern Sequence (PPS) test, the author remarked that the results might have been caused by ceiling effects and/or the wide variability in scores.

Need for the Study

Very few of the earlier studies have systematically examined changes in temporal ordering in three age groups (9-18yrs, 19-45yrs, and 46-65 yrs.). Considering the general trend of increased lifespan and high prevalence of central auditory processing difficulties, the present study has great social relevance. The subtle mechanisms involved in temporal ordering in different age groups need to be clearly understood. Further, the relationship between temporal ordering and effect of ageing has not been thoroughly investigated in the Indian context, most of the studies have been done in the Western scenario. Considering all these aspects, the present study was proposed.

Aim

- To identify the effect of ageing on pitch pattern sequence test in three age groups.

Method

The main focus of the study was to find the effect of ageing on temporal ordering skills across different age groups.

Proposed Setting

The study was conducted at the Department of Speech & Hearing, Marthoma College of Special Education, Kasaragod, between January 2017 and July 2017.

Participants

Ninety individuals in the age range of 9-18yrs, 19-45yrs & 46-65yrs satisfying below mentioned criteria participated in the study.

Inclusion Criteria

1) Subjects between 9- 18years, 19-45 years and 46-65 years of age.
2) An average of thresholds of 500Hz, 1000Hz, and 2000Hz of less than 15dBHL for air conduction and bone conduction.
3) Normal immittance audiometry.
4) No complaint and history of any neurological impairment.
5) Normal auditory processing as indicated by;
   a) Screening checklist for auditory processing (SCAP)Yathiraj & Mascarenhas (2003),
   b) Screening checklist for auditory processing for adults (SCAP-A) Vaidyanath & Yathiraj (2014).

Exclusion Criteria

1) Subjects with hypertension.
2) Subjects with diabetes.
3) Continuous noise exposure for prolonged periods.
4) Drug ototoxicity.
5) Recurrent ear infections.
6) Head or ear injury.
7) Acoustic trauma.

Test Administered

- Pitch Pattern Sequence Test (Shivani, 2003)

Other Instruments Used:

- Grason Stadler Incorporates (GSI) -61 clinical audiometer.
- GSI Tympstar immittance audiometer.

Test Procedure

The individuals were screened for auditory processing disorder by the Screening checklist for auditory processing (SCAP) (Yathiraj & Mascarenhas, 2003) for children and the Screening checklist for auditory processing for adults (SCAP-A) (Vaidyanath & Yathiraj, 2014).

The individuals were then administered with immitance audiometry. (GSI-Tympstar) for 'A' type tympanogram with reflexes present, and pure tone audiometry (GSI-61) for air conduction and bone conduction threshold of less than or equal to15 dBHL. The subjects selected according to the criteria were then administered with Pitch Pattern Sequence Test (PPST) (Shivani, 2003).

Pitch Pattern Sequence Test

The PPST is a test of auditory processing designed to measure temporal ordering. The PPST (Shivani, 2003) consisted of 30 test items and 21practice items (consisting of two-tone patterns and 5 three patterns). Each test item had the pattern of 3 tone bursts of 500msec duration each, separated by 300msec intervals between tones. The tone frequencies were 880Hz (Low) 1430 Hz (High). The tones are in 6 different combinations (HLH, LHL, HHL, LLH, HLL and LHH). The subjects were made to sit comfortably in the sound-treated room with headphones placed on his/her ears. Subjects were trained to discriminate between high and low tones with practice trials by demonstrating the verbal and humming tasks. The test items were presented through the audiometer using external input from a laptop with a patch cord connected to the audiometer.

Initially, the calibration tone was presented in the subject's ear through TDH-50P headphones and the audiometer was adjusted to show "0" reading. Each ear was tested under headphones at 40dB SL (Ref.1KHz threshold) with 30, 3-tone patterns presented to each ear separately. Two types of responses were taken. Subjects were asked to respond by humming responses when stimuli were presented first and then verbally for next presentation. The responses were recorded, and total numbers of correct responses were calculated. Score 1 was given for correct response and 0 for an incorrect response. Both humming and verbal responses were scored separately for each ear.

Statistical Analysis

The data collected were subjected to analysis using SPSS (13.0). The mean and standard deviation values have been derived for all the participants across the three age groups. ANOVA was carried out to find the significant difference between each of the groups. As there was a significant difference Post hoc analysis using Bonferroni multiple comparisons was also carried out to find a significant difference between the three age groups.

Results

The study was focused to identify the effect of ageing on Pitch Pattern Sequence Test. Ninety individuals (180 ears) who met the criteria participated in the study. The performance of three age groups; 9-18yrs (Group-1), 19-45yrs (Group-2) and 46-65yrs (Group-3) on Pitch Pattern Test was compared. The obtained data was analyzed in SPSS (13.0) version. The data obtained were statistically analyzed using ANOVA and Bonferroni Paired t-test to find the significant difference between different age groups. The obtained results are explained in the following sections.

1) **Performance of the individuals in 3 groups as indicated by the verbal response.**
2) **Performance of the individuals in 3 groups for humming response.**
3) **Post hoc analysis using Bonferroni multiple comparisons.**
4) **Performance of verbal response in right ear and left ear across three age groups.**

5) **Performance of humming response in right ear and left ear across three age groups.**
6) **Performance of verbal and humming response of right ear across three age groups.**
7) **Performance of verbal and humming response of left ear across three age groups.**

Group	N	Mean	S.D	ANOVA F	P	
Verbal rt 9-18yrs 19-45yrs 46-65yrs Total	30 30 30 90	20.93 24.90 14.90 20.4	7.066 3.661 5.081 6.793	25.599	.000	HS
Verbal lt 9-18yrs 19-45yrs 46-65yrs Total	30 30 30 90	19.97 23.87 13.93 19.26	6.921 3.928 5.252 6.820	24.797	.000	HS

Table-1: Performance of the individuals in 3 groups as indicated by the verbal response.

Table-1 shows the performance of individuals in the three age groups for verbal response in right and left ears. The mean scores in right ear for 9-18 years (group 1) are 20.93, for 19 - 45 years (group 2) is 24.90, and 46 – 65 years (group 3) is14.90. The p-value is .000 indicating a highly significant difference between different age groups. Mean scores in left ear for 9-18 years (group 1) is19.97, for 19 - 45 years (group 2) is 23.87 and 46 – 65 years (group 3) is13.93. The mean values of various age groups are highly significant as indicated by the p-value which is .000.

Group	N	Mean	S.D	ANOVA F	P	
Humming rt 9-18yrs 19-45yrs 46-65yrs Total	30 30 30 90	23.00 25.60 15.30 21.30	5.849 3.420 5.286 6.588	34.967	.000	HS

Humming lt	9-18yrs 19-45yrs 46-65yrs Total	30 30 30 90	23.47 24.73 14.40 20.87	4.981 3.648 5.430 6.591	42.287	.000	HS

Table-2: Performance of the individuals in 3 groups for humming response.

Table -2 shows the performance of individuals in the three age groups for humming response in right and left ear. The mean scores in right ear for 9-18 years (group 1) is 23.00, for19 - 45 years (group 2) is 25.60, and 46 – 65 years (group 3) is15.30. The right ear humming responses are highly significant between different age groups (p< .05 level). Mean scores in left ear of 9-18 years (group 1) is 23.47,19 - 45 years (group 2) is 24.73, and 46 – 65 years (group 3) is 14.40. The means between three age groups are highly significant indicated by the p-value which is .000. As the data shows highly significance between the age groups a post hoc analysis was done using Bonferroni test. Table-3 shows the result.

Dependent Variable	(I)Group	(J)Group	Mean difference (I-J)	Std.Error	p	
Verbal rt	9-18yrs	19-45yrs 46-65yrs	-3.967 6.033	1.407 1.407	.018 .000	Sig HS
	19-45yrs	46-65yrs	10.000	1.407	.000	HS
Verbal lt	9-18yrs	19-45yrs 46-65yrs	-3.900 6.033	1.421 1.421	.022 .000	Sig HS
	19-45yrs	46-65yrs	- 9.933	1.421	- .000	- HS

Humming rt	9-18yrs	19-45yrs 46-65yrs	-2.600 7.700	1.281 1.281	.136 .000	NS HS
	19-45yrs	46-65yrs	- 10.300	1.281	- .000	- HS
Humming lt	9-18yrs	19-45yrs 46-65yrs	-1.267 9.067	1.226 1.226	.913 .000	NS HS
	19-45yrs	46-65yrs	- 10.333	1.226	- .000	- HS

Table-3: Post hoc analysis using Bonferroni multiple comparisons.

Table-3 shows the post hoc analysis using Bonferroni paired t-test. When the comparisons were analyzed; between each age group within verbal responses in right ear, verbal responses in left ear, humming response in right ear and humming responses in left ear were compared with other age groups all comparisons indicated that the mean difference is statistically significant at 0.05 level, except for Humming responses in right ear and left ear when 9-18yrs were compared with 19-45yrs which were found to be not significant.

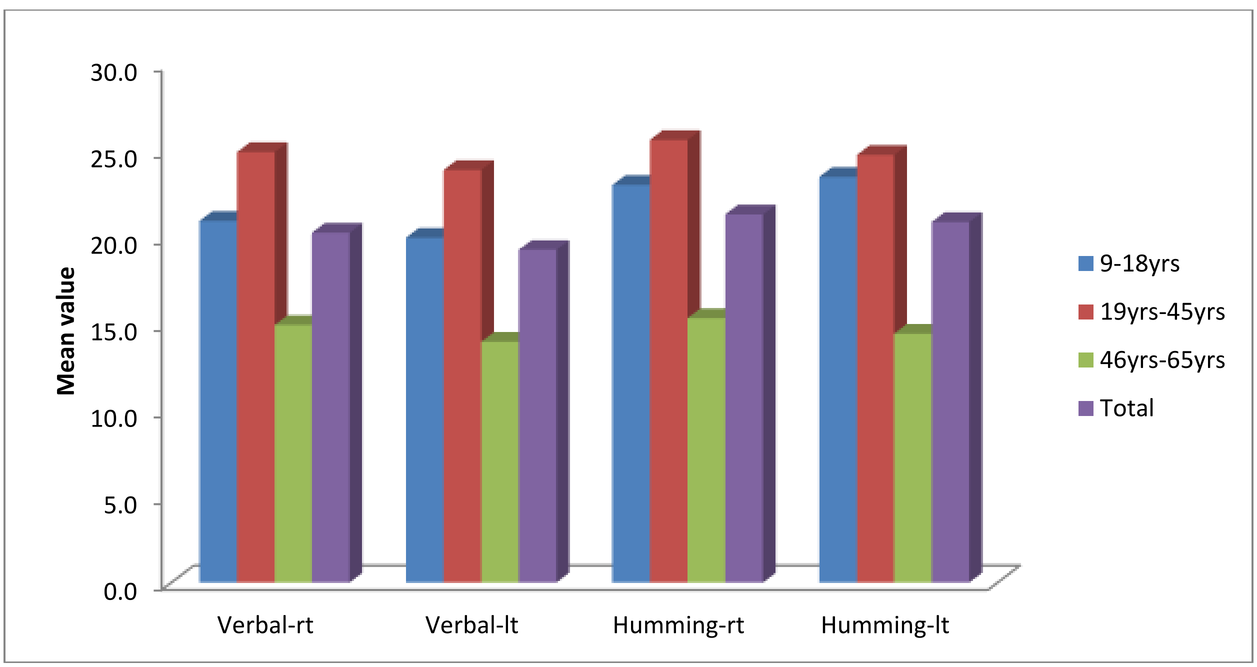

Figure-1: Mean of verbal and humming response for right and left ears across three age groups.

Figure-1 shows the verbal and humming scores in right and left ear across the three age groups. From the above bar diagram, it is clearly evident that the performance of 19-45yrs. is better compared with the other three groups. Performance of 9-18 yrs. is better than 46-65yrs, and 46-65yrs had least mean value as indicated by their performance. The humming response and verbal response had a similar pattern of results obtained. Also, from the graph, it is clear that the humming response was better compared to verbal scores in the 3 age groups.

Group	N	Mean	S.D	Mean difference	S.D of difference	t value	p	
9-18yrs Verbal-rt Verbal-lt	30 30	20.93 19.97	7.066 6.921	.967	2.566	2.06	.048	Sig
19-45yrsVerbal-rt Verbal-lt	30 30	24.90 23.87	3.661 3.928	1.033	3.316	1.71	.099	NS
46-65yrsVerbal-rt Verbal-lt	30 30	14.90 13.93	5.081 5.252	.967	2.251	2.35	.026	Sig
Total Verbal-rt Verbal-lt	90 90	20.24 19.26	6.793 6.820	.989	2.717	3.453	.001	HS

Table-4: Performance of verbal response in right ear and left ear across three age groups.

Table-4 shows the performance of verbal response in right ear and left ear in three age groups. Group-1 and Group-3 showed a significant difference between right ear and left ear responses, whereas Group-2 showed no significant difference in responses between ears. But when comparing the mean values of 3 age groups it indicates better performance by the right ear signifying a right ear advantage.

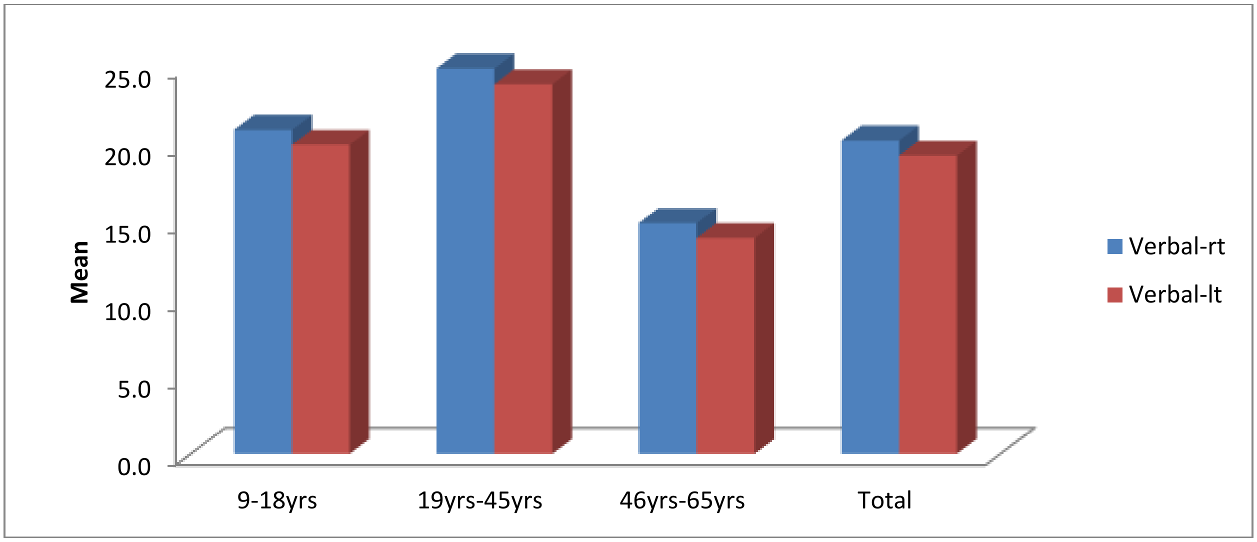

Figure-2: Mean of verbal scores in right and left ear in 3 age groups.

Figure-2 shows the mean value of right and left ear scores for verbal response across the three age groups. From the figure the mean value of the three age groups the right ear showed better results than the left ear.

Group		N	Mean	S.D	Mean difference	S.D of difference	t value	p	
9-18yrs	Humming-rt Humming-lt	30 30	23.00 23.47	5.849 4.981	-.467	2.285	1.12	.273	NS
19-45yrs	Humming-rt Humming-lt	30 30	25.60 24.73	3.420 3.648	.867	3.037	1.56	.129	NS
46-65yrs	Humming-rt Humming-lt	30 30	15.30 14.40	5.286 5.430	.900	2.325	2.12	.043	Sig
Total	Humming-rt Humming-lt	90 90	21.30 20.87	6.588 6.591	.433	2.623	1.568	.121	NS

Table-5: Performance of humming response in right ear and left ear across three age groups.

Table-5 shows the performance of humming response in right ear and left ear across three age groups. Group-1 and Group-2 showed no significant difference between right and left ears but Group-3 showed a significant difference between both ears. On comparing all the three groups there is no significant difference between right and left ear across the three age groups.

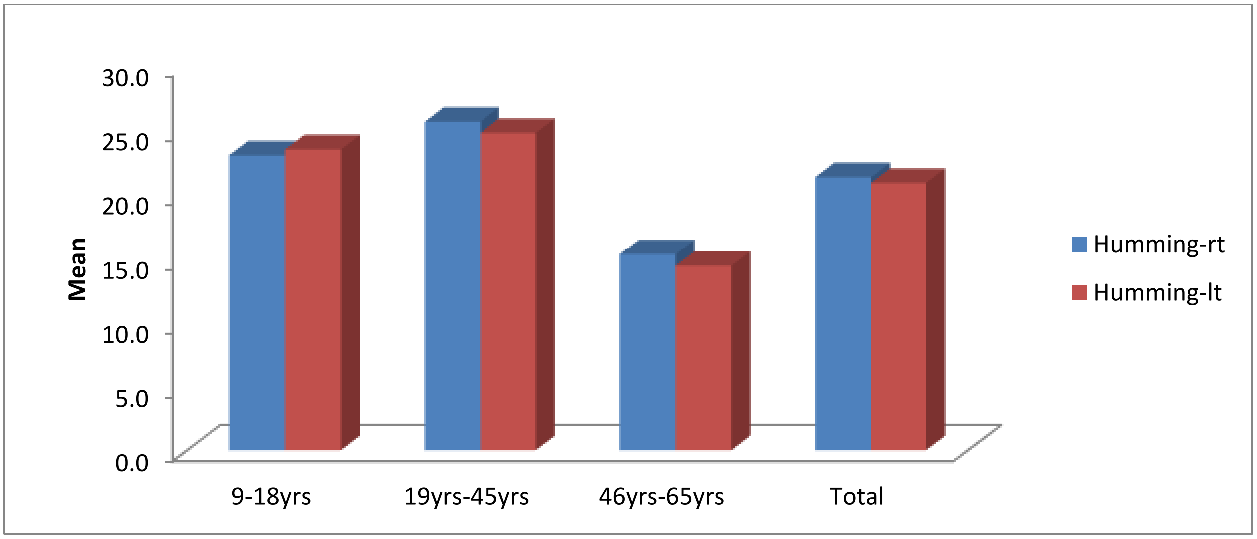

Figure-3: Mean of humming scores in right and left ear in 3 age groups.

Figure-3 shows the mean of humming scores in right and left ear in 3 age groups. The right ear performance is better compared with the left ear scores as indicated by the mean values.

Group		N	Mean	S.D	Mean difference	S.D of difference	t value	p	
9-18yrs	Verbal -rt Humming-rt	30 30	20.93 23.00	7.066 5.849	-2.067	2.196	5.15	.000	HS
19-45yrs	Verbal-rt Humming-rt	30 30	24.90 25.60	3.661 3.420	-.700	1.291	2.97	.006	HS
46-65yrs	Verbal-rt Humming-rt	30 30	14.90 15.30	5.081 5.286	-.400	1.003	2.18	.037	Sig
Total	Verbal-rt Humming-rt	90 90	20.24 21.30	6.793 6.588	-1.056	1.725	5.806	.000	HS

Table-6: Performance of Verbal and humming response of right ear across three age groups.

Table-6 shows the performance of Verbal and humming response of right ear across three age groups. The Significant difference was obtained between the age groups: Group-1, Group-2, and Group-3.

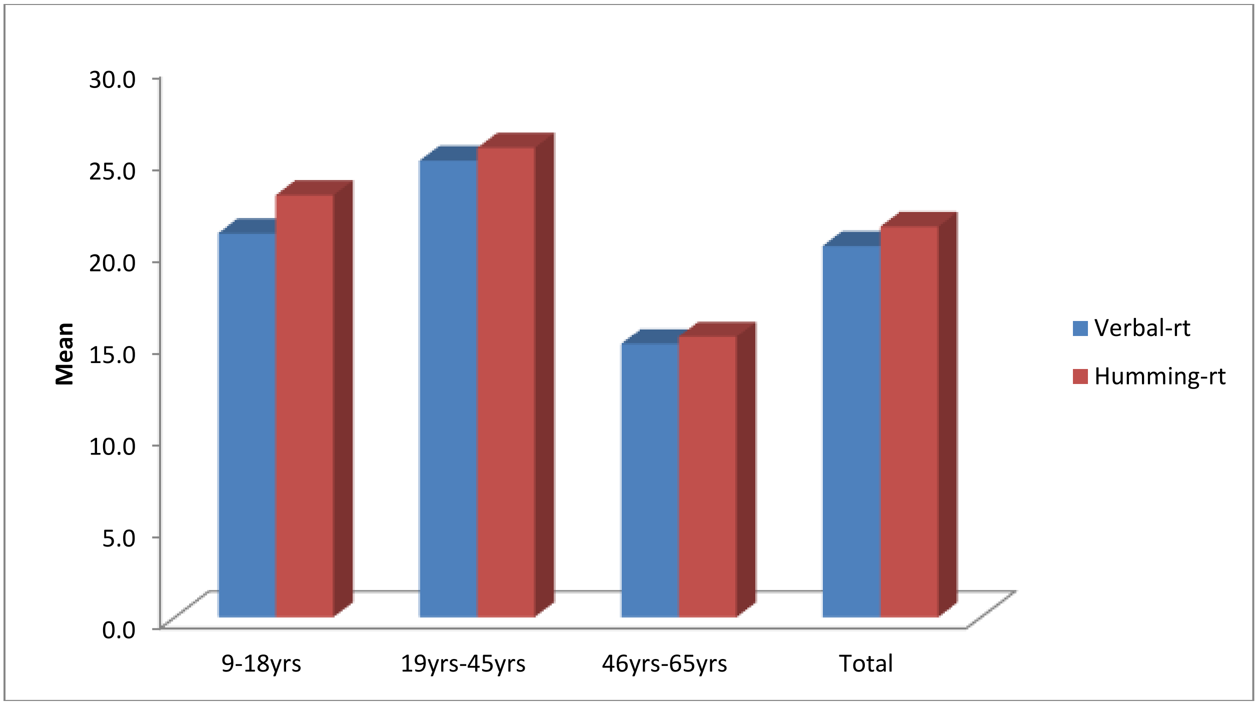

Figure-4: Mean of the verbal and humming response of right ear.

Figure-4 indicates the mean of the verbal and humming response of right ear. The humming scores were better compared with the verbal scores across the three age groups.

Group		N	Mean	S.D	Mean difference	S.D of difference	t value	p	
9-18yrs	Verbal -lt Humming-lt	30 30	19.97 23.47	6.921 4.981	-3.500	2.957	6.48	.000	HS
19-45yrs	Verbal-lt Humming-lt	30 30	23.87 24.73	3.928 3.648	-.867	1.306	3.63	.001	HS
46-65yrs	Verbal-lt Humming-lt	30 30	13.93 14.40	5.252 5.430	-.467	.629	4.06	.000	HS
Total	Verbal-lt Humming-lt	90 90	19.26 20.87	6.820 6.591	-1.611	2.316	6.599	.000	HS

Table-7: Performance of Verbal and humming response of left ear across three age groups.

Table-7 shows the performance of verbal and humming response of left ear across three age groups. Group-1, Group-2, and Group-3 showed a high significant difference between the verbal and humming response of left ear across three age groups.

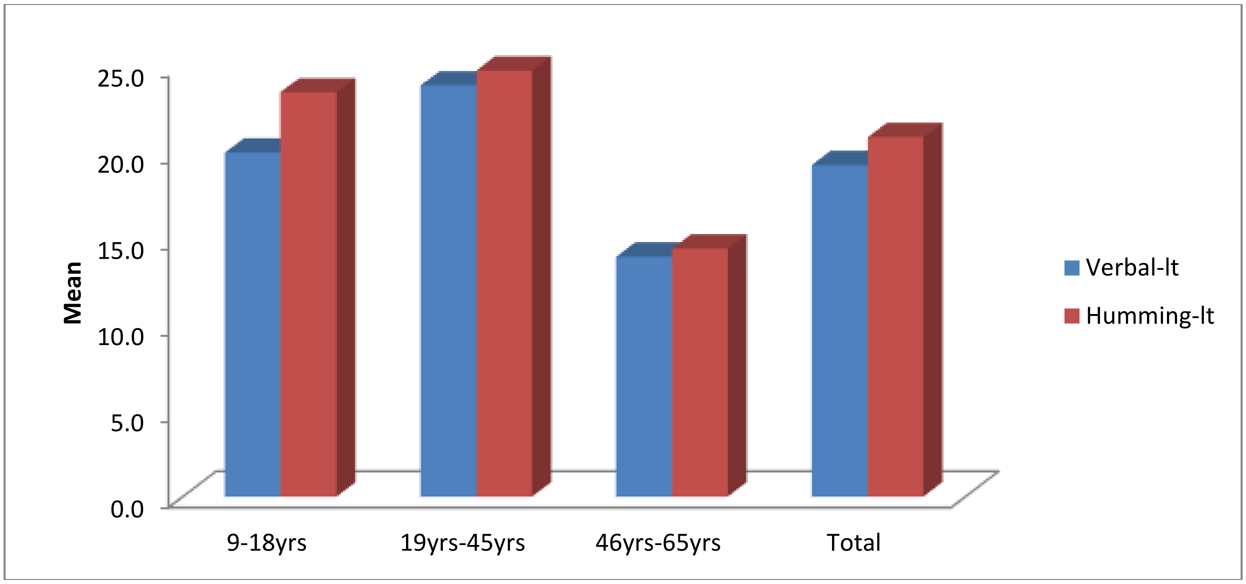

Figure-5: Mean of verbal and humming response in left ear.

Figure-5 indicates the mean of verbal and humming response in left ear. The humming scores were better compared with the verbal scores across the three age groups.

Discussion

Ageing is a natural phenomenon; age-related changes mainly start from the 5th decade of life (Koopmann, 1991). The principal pathological associated with acquired changes in the peripheral auditory system include changes in the cochlea. The cochlear contribution to ageing is likely embedded in the loss of sensory cells, strial degeneration along with associated changes in the endocochlear potential-EP and the loss of spiral ganglion neurons (Mills, Schmiedt, Schulte & Dubno, 2006; Ohlemiller, 2004; Schuknecht, 1955).

Apart from these conditions, there is also a neural loss at every nucleus of the central auditory nervous system (CANS) with ageing (Willott, 1991). Units in the CANS specifically code signal onsets, duration, and offsets; hence, age-related changes in the CANS further implicate reduced coding of incoming temporal information in signals, leading to distorted perception and slowed neural processing. Additional age-related changes that occur in the CANS relate to reduced inhibitory mechanisms. Individuals above the age of 50yrs are estimated to have problems in speech understanding in demanding communication situations are reported by older people with hearing loss as well as those with normal hearing.

The results of the present study showed a significant difference in scores between the three age groups. The scores increased with increase in age but showed a decline after the age of 45 years. The table-1and table-2 showed the performance of 9-18 years, 19–45 years, and 46-65 years and indicated that the performance gets poorer with the increase in age. The results were supported by different authors providing explanations on age-related declines in the temporal processing [Trainor & Trehub (1989); Fitzgibbon, Salant & Friedman (2006); Mukari, Umat & Othman (2010); Russo, Ives, Goy, Fuller & Patterson (2012); Fitzgibbons & Salant (2015); Bellis & Wilber (2001); Ludlow, Cudahy, & Bassich (1982); Fitzgibbons & Gordon (2004);

Jang, Lee & Yoo (2008)]. As people get aged, neural degeneration as well as structural changes occurs throughout the auditory system, therefore, their scores also get reduced.

The results also showed a significant difference between humming and verbal scores indicating humming response is better than the verbal response. The same findings were obtained for Jang, Lee & Yoo (2008) and Frederigue-Lopes, Bevilacqua, Sameshima & Costa (2010). It supports the facts that the temporal sequencing of auditory patterns requires processing by both hemispheres of the brain, i.e., the left hemisphere for serial ordering of the response and right hemisphere for the recognition of the pattern Gestalt, since the right hemisphere has been found to be dominant for pattern recognition (Nebes, 1971).

Results of the current study also indicated a significant difference between the right ear scores and the left ear scores across the three age groups. This was supported by a study which showed a significant difference in which the pattern components were presented alternately and randomly between ears. The sequences that were presented in the right ear were more readily put into order (as cited in Pinheiro & Musiek, 1985).

Many studies have demonstrated age-related differences in temporal processing (Fitzgibbons & Gordon-Salant,1996) and simultaneous changes in the auditory brainstem (Walton, Frisina, Ison & O'Neill,1997) that do not appear to be induced by a peripheral hearing loss. The present study revealed that the scores improve with the increase in age and shows a decline after 45 years, indicating the effects of ageing on temporal processing.

Conclusion

A person must be able to process auditory information at a rapid pace in order to develop various appropriate listening and language skills. For understanding the auditory information, we make use of auditory processing. Temporal Processing is one of the aspects of auditory processing–the rate at which we can process auditory information. There is a phenomenon in temporal processing called temporal ordering. As ageing occurs deficits in temporal processing takes place and thereby temporal ordering. One of the tests to assess temporal ordering is Pitch Pattern Sequence. Where high and low pitch will be presented, and the individual has to judge its order through verbal and humming modes.

As different reviews claim that ageing can affect the temporal processing, therefore, the current study was carried out to find the effect of ageing on Pitch Pattern Sequence Test. A total of 90 individuals were included in the study, 30 individuals in each group of 9-18years, 19-45years, and 46-65 years. Prior to the audiological evaluation, screening was done for all the individuals using Screening checklist for auditory processing (SCAP) Yathiraj & Mascarenhas (2003) for children & Screening checklist for auditory processing for adults (SCAP-A) Vaidyanath & Yathiraj (2014) was carried out. Individuals who passed for the screening checklist were subjected to pure-tone audiometry and immitance audiometry. The results obtained were recorded and statistically analyzed using SPSS (13.0).

From the results obtained from the current study, it was concluded that there was a significant effect of age on Pitch Pattern Sequence Test on different age groups. These findings were supported by Fitzgibbon et al., (1994, 2006 & 2015); Trainor et al., (1989); Russo et al., (2012); Frederigue-Lopes., (2010); Mukari et al., (2010); Craig et al., (2010); Bellis et al., (2001) and Delecrode et al., (2014). Also, better scores were obtained for humming response than the verbal response which was supported by Frederigue-Lopes, Bevilacqua, Sameshima & Costa (2010). Results of the current study also indicated a significant difference between the right ear scores and the left ear scores across the three age groups (as cited in Pinheiro & Musiek, 1985).

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