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Association Between Vision and Hearing: A Case-Controlled Study

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Abstract:

- ***Purpose***

This article aims to find out the association between vision and hearing.

- ***Methodology***

It is a prospective quantitative case controlled study in which 30 cases (15 low vision & 15 blinds) and 50 age matched controls were enrolled. This study is centric to the description and documentation of the ocular as well as audiological examination of the visually handicapped subjects of Janta Rehabilitation Training center for the visually handicapped in Bhimgarh kheri, Gurgaon, Haryana. Technique of sampling is cluster sampling technique in which many clusters were taken i.e. centers for visually handicapped in which 2 clusters were selected on the basis of simple random sampling. Oral as well as written consent form was also obtained from the in-charge of the center as well as from the subjects/guardian. The data were analyzed using SPSS version 20.

- ***Results***

Eighty subjects (30 cases & 50 age matched controls) were enrolled in the study. Among the subjects 30 were males and 50 were females. The median age was a 23 ± 2.75 years ranging between 17 and 33 years. The median height was 1.64 meter. BCVA, CS, GDT, DDPT, ITD & ILD were significantly different between controls, low vision and blind subjects (Kruskal wallis test, $p<0.05$). IDPT & DDPT was found significantly different between males and females (Mann whitney test, $p<0.05$). A statistically significant positive correlation was found between GDT & BCVA(r=0.581, n=75, p=0.00), DDPT & BCVA (r=0.305, n=75, p=0.008), ITD & BCVA (r=0.388, n=75,p=0.001), ILD & BCVA (r=0.281, n=75, p=0.014). A statistically significant positive correlation between GDT & CS (r=0.602, n=75, p=0.00) , DDPT & CS (r= 0.30, n=75, p=0.009) was found.

- ***Conclusion***

From the findings from our study, we conclude that in visually impaired subjects as one modality is compromised, they rely more on the other modality as their ability of other modality is found to be better.

Keywords: *"Vision", "Hearing", "Low Vision", "Blind", "Best Corrected Visual Acuity".*

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I. INTRODUCTION

Globally, an estimated 36 million people are blind and 217 million have severe or moderate visual impairment, totaling 253 million individuals with visual impairment.[1] Vision and hearing are linked across several domains, including communication, mood, functional ability, and social engagement.[2] Both visual and auditory tasks activate shared brain regions, such as the lateral parietal cortex, lateral frontal cortex, anterior midline, and anterior insular cortex.[3]

Visual and auditory perception undeniably share a crucial characteristic: the ability to ascertain the speed and direction of a moving object.[3] This integrated sensory information generates a cohesive understanding of the object's movement within the environment.[3] Furthermore, these two systems interact effectively to coordinate and direct attention, allowing for precise control over which modality to prioritize and influencing subsequent actions.[3]

Auditory skills are essential for an individual's ability to focus on and distinguish between environmental sounds and

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speech. For those with low vision, it is imperative to develop strong listening skills to effectively navigate school environments and acquire crucial literacy skills. Listening abilities are influenced by several key aspects, including the capacity to identify the direction of sounds, accurately recall auditory information, recognize variations in voice intonation, and maintain an awareness of rhythmic patterns. Developing these skills is not just beneficial but necessary for success. Auditory temporal processing is a vital skill for effective listening. It refers to the ability to perceive sound and variations in sound within a short time frame.[4]This skill allows us to detect subtle and rapid changes in sound stimuli. Having strong auditory temporal resolution is essential for understanding speech in noisy environments, particularly for individuals with normal hearing, hearing aid users, those with cochlear implants, and those with language disorders. Temporal processing is a fundamental ability necessary for perceiving both verbal and non-verbal stimuli.[5]

Individuals who are blind or have low vision must develop enhanced abilities, particularly in hearing, which is vital for their social development and adaptation from an early age.[6,7,8,9] During the critical sensorimotor period, spanning from birth to around 2 years, it is essential for blind children to engage with a rich array of auditory and tactile stimuli. This exposure is crucial, as it ensures that their hearing and tactile perception develop in tandem, enabling key movements such as rolling, crawling, balancing, and walking.[10] Sufficient auditory stimulation is not just beneficial but necessary for the social development of blind children and adults. There is a clear imperative for improved support in this area. It is essential that auditory sensory information is effectively integrated with other sensory pathways—this integration fosters practical intelligence, a solid understanding of objects, spatial organization, and the acquisition of speech.[11,12]

Numerous studies have clearly established that total blindness—defined as the absence of light perception or only the perception of light—leads to the enhancement of specific auditory spatial skills while deteriorating others.[13,14,15,16,17,18] Most existing research predominantly concentrates on echolocation and distance discrimination, primarily involving individuals who are completely blind. Moreover, the methodologies employed in these studies exhibit considerable variation. Our research addresses this gap by including both low vision and blind subjects, utilizing audiology tests designed to evaluate higher auditory skills. Importantly, there is a distinct lack of data on the hearing status of visually impaired individuals when assessed through tests such as the Gap Detection Test (GDT), Intensity Discrimination of Pure Tone (IDPT), Duration Discrimination of Pure Tone (DDPT), Inter-Aural Time Difference of Pure Tone (ITDPT), and Inter-Aural Level Difference of Pure Tone (ILDDPT). We are determined to investigate associations with critical factors like age, gender, vision, refractive error, color vision, visual field, and contrast sensitivity, given that previous studies have revealed inconsistent results in these areas.

II. METHODOLOGY

This study is centric to the description and documentation of the ocular as well as audiological examination of the visually handicapped subjects of Janta Rehabilitation Training center for the visually handicapped in Bhimgarh kheri, Gurgaon, Haryana. This study applies a quantitative case-controlled study design. As the study being a case controlled study, 30 Cases i.e. visually handicapped subjects (Low Vision as well as blind) were enrolled in the study and 50 age matched controls were also enrolled in the study. Each subject had given the verbal as well as written consent for their data to be included anonymously in the study through the database. Also written consent was taken from their guardian. Technique of sampling used in this study was cluster sampling in which many clusters were taken i.e. centers for visually handicapped in which 2 clusters were selected on the basis of simple random sampling. The study duration was one and a half year i.e. from January 2018 to May 2019.

➢ *Inclusion Criteria*

- Visually handicapped subjects (low vision as well as blind)
- Age range 12-35 years
- Visually impaired subjects with no history of hearing disorder

➢ *Exclusion Criteria*

- Subjects having any active ocular pathological conditions
- Subjects having any active systemic pathological conditions
- Candidates who were not willing to enroll in the study
- Subjects having multiple disabilities

➢ *Testing Protocol:*

A comprehensive eye examination was performed on all subjects. This included recording demographic data such as name, age, gender, education, height, and weight of the subjects. Height was measured using the "GK FML World's measure" inch tape, and weight was measured with a weighing machine. A thorough history was collected for each participant, covering their ocular history, family history, systemic diseases, use of glasses, and any history of trauma. Each subject was also asked about any previous ocular diagnosis and if they had any accompanying documentation. Additionally, they were questioned about their current chief ocular complaints.

Visual Acuity was assessed using distance Bailey-Lovie chart; designed with constant size progression ratio, each row having the same number of letters.[19] The chart designed on a logarithmic basis and visual acuity designated in terms of logarithm of the minimum angle of resolution or Log Mar.[19] Visual acuity was assessed taking the chart at sufficiently close distance at which subjects were able to read the letters on the chart and later correction factor was applied based on the testing distance at which subjects responded. Subjects who were not even able to read the chart at the most closest distance, were checked for finger count close to face, and if

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even lesser then checked for perception of light and perception of rays with the help of torch light. Distance visual acuity was also assessed with multiple pinhole to understand the visual prognosis of the subjects.[19,20] LVRC near visual acuity chart was used at 45 cm for near vision assessment. Chart was moved closer to subjects at sufficiently closer distance at which they were responding if they were not able to read at 45 cm.[19, 21]

Retinoscopy was performed with the help of Heine retinoscope, trial frame & trial lenses. Radical retinoscopy was done in case of any opacities in media where retinoscope reflex was difficult to get. In this method, retinoscope was moved to whatever distance was necessary (i.e. 33, 25, or 20 c'm) to obtain a retinoscope reflex and later the appropriate working distance lens power (i.e. 3.00, 4.00, or 5.00 D) was deducted from the finding to get the exact values.[19,22] Subjective refraction was done based on objective findings as well as bracketing technique was also used for the same in some subjects where objective refraction was not possible. Chart was placed at 10 feet distance. In this bracketing technique, subjective testing was started with +6.00 D, plano, and -6.00 D lenses, with succeeding lens powers being used to "bracket" the subject's refractive end point. Abrupt lens changes was made as the subjects were not expected to respond to lens change as low as 0.25D or even 0.50D.[19]

Anterior segment of eye was assessed with the help of torch light whereas direct opthalmoscopy was done using Heine opthalmoscope for posterior segment evaluation. Color Vision was assessed using an Ishihara pseudo-isochromatic booklet and was performed under daylight illumination and with full optical correction .[19, 23] Contrast sensitivity was assessed using an application of Contrast sensitivity in Smart Optometry. It is an electronic testing which gives straight forward interpretation of contrast sensitivity. Test consists of 48 letters (8 rows & 6 columns). Contrast is usually expressed in percentage, and then the ratio is multiplied by 100. Hence the maximum contrast is 100%. The contrast of the upper letter on the left is 1 and the contrast is dropping to minimum (bottom right). Test was performed at 40 cm with full correction and the subject was asked to recognize the last letter that can be seen on the test. After finding it, subject named the letter and touched it on the screen which will be the final maximum contrast. For each subject, the luminance of the screen was maximum and kept constant. Visual field was assessed using the Confrontation technique. This was done in 8 half meridians (0, 45, 90, 135, 180, 225, 270, & 315 degrees) at one meter.[19] Low vision trial was done for both distance & near. Hand held magnifiers, Stand magnifiers with different magnification were used for near trial while monocular telescopes, spectacle magnifiers of different magnification were used for distance trial. Tints were used for trial for glare reduction in some subjects. Lastly, final prescription was done based on trial in case of improvement of vision.

Testing Protocols for Audiology Tests ;

- *Instrumentation*

A calibrated two channel diagnostic audiometer, HARP INVENTIS with TDH-50 headphones, was used for assessing the air conduction thresholds at octave frequencies between 250 Hz and 8000 Hz. The bone conduction thresholds were estimated at octave frequencies between 250 Hz to 4000 Hz using Radio ear B-71 bone vibrator coupled to the same audiometer. Gap detection test (GDT), Intensity Discrimination of Pure Tone (IDPT), Duration Discrimination of Pure Tone (DDPT), Interaural Time Difference (ITD) and Interaural Level Difference (ILD) were carried out using Maximum likelihood procedure toolbox of the MATLAB version R2013a platform loaded in the Sony vaio laptop. An adequate number of practice trials were given to each subjects for all the psychoacoustic tests included in the present study.

- *Test Environment*

Audiological evaluation and administration of psychophysical tests were carried out in sound treated room with the ambient noise levels within permissible limits (ANSI 1991). Audiometric testing was done in double room situation. However, psychophysical tests were done in single sound treated room situation.

- *Gap Detection Test (GDT)*

GDT was assessed using maximum likelihood procedure (MLP) toolbox implemented using MATLAB. Gap detection threshold was calculated using 750 millisecond of Gaussian noise with a gap in center. Here, gap duration was varied according to subject performance using MLP. The noise used here had 0.5 millisecond cosine ramps at the starting and end of the gap. Three alternative forced choice method was used where reference stimulus was always a 750 ms white noise (without gap), whereas the variable stimulus consisted of a gap. Participants's task was to identify the noise taken that had gap. A total of 30 trials/block were carried out and feedback was given to all subjects participated in the study.

- *Intensity Discrimination of Pure Tone (IDT)*

Intensity discrimination of pure tone was carried out using maximum likelihood procedure (MLP) toolbox implemented using MATLAB with a pure tone of 1000Hz of 250ms in duration. The onset and offset of the tones are gated with two 10ms raised cosine ramps. We used two alternative forced choice procedures in which two tones (standard and variable) were presented one after the other. Participant's task was to identify loudest tone. A total of 30 trials/block were carried out and feedback was given to all subjects participated in the study.

- *Duration Discrimination of Pure Tone (DDPT)*

In duration discrimination using pure tone (1000Hz), we measured the minimum difference in duration required to perceive the two otherwise identical stimuli, using maximum likelihood procedure. The duration of the standard tone was 250 milliseconds. The duration of the variable tone was changed based on response of the participants. We used two

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alternative forced choice procedures in which the participants were asked to indicate which tone was longer in duration. A total of 30 trials/block were carried out and feedback was given to all subjects participated in the study.

- *Interaural Time Difference (ITD)*

Interaural Time Difference was assessed using a pair of 330 Hz pure tone of 250ms duration. The two tones were presented one after the other as leading in one ear and lagging in the other ear. We used two alternative forced choice procedure where the subjects were supposed to tell whether the leading tone of the tone pair comes from left or right ear. A feedback was provided after each trial. We measured the minimum interaural time difference required for correct response using maximum likelihood procedure. A total of 30 trials/block were carried out and feedback was given to all subjects participated in the study.

- *Interaural Level Difference (ILD)*

Interaural Level Difference was assessed using a pair of 250 ms pure tone of 5000Hz. The two tones were presented one after the other as louder in one ear compared to other ear. We used two alternative forced choice procedure where the subjects are suppose to tell whether the louder tone heard is in left or right ear. A feedback was provided after each trial. We measured the minimum intensity difference required to perceive one tone louder compared to the other tone using maximum likelihood procedure. A total of 30 trials/block were carried out and feedback was given to all subjects participated in the study.

III. STATISTICAL ANALYSIS

All the data was entered on Microsoft Excel and was checked thoroughly and thereafter was imported into and analyzed using Statistical package for Social sciences (SPSS for windows, version 22.0, IBM-SPSS, Chicago, IL, USA). Descriptive statistics were presented as median ± Inter quartile range. The Kolmogorov-Simonov was used to test for normality of data. As the data were not normally distributed, the Kruskal Wallis test and Post Hoc Mann Whitney test was used to compare means of three groups. Spearman correlation was used to find out correlation between ocular parameters and audiological parameters. A significant level (p) of less than 0.05 was considered statistically significant.

IV. RESULTS

A total of 80 subjects were included in the study, of which 30 cases (15 low vision and 15 blinds) and 50 age matched controls were enrolled. Among the subjects 30 were males and 50 were females. The median age was 23.00±2.75 years, ranging between 17 and 33 years. The median height was 1.64 meter. Five of the blind subjects were not co-operative for the audiological tests although repeatedly tests were performed 5 to 6 times. Details of ocular and audiological parameters are shown in Table 1.

Table 1: Association Between Vision and Hearing: A Case Controlled Study: Details of Ocular and Audiological Parameters in Different Groups

Groups	BCVA	CS	GDT	IDPT	DDPT	ITD	ILD
Control (n=50)	Constant	0.787±0.30*	2.16±0.50 *	-28.63±1.20 *	279.83±32.57*	0.30±0.20*	5.48±1.43*
LV (n=15)	1.32±0.60*	4.13±9.85*	4.12±8.56*	-28.83±1.40*	291.49±24.86*	0.30±0.02*	Constant
Blind (n=10)	Constant	Constant	2.95±1.84*	-28.23±1.90*	307.23±51.15*	Constant	5.48±0.18*
P-Value	0.00#	0.00#	0.00#	0.410#	0.013#	0.005#	0.018#
Total (n=75)	0.00±1.32*	0.984±0.49*	2.39±1.52*	-28.73±1.10*	283.11±33.65*	0.30±0.09*	5.48±0.29*

BCVA=Best Corrected Visual Acuity; CS=Contrast sensitivity; GDT= Gap Detection Test; IDPT=Intensity Discrimination Puretone; DDPT= Duration Discrimination Puretone; ITD=Interaural Time Difference; ILD=Interaural Level Difference
*Median±IQR
#Kruskal Wallis test

Best Corrected Visual Acuity, Contrast Sensitivity, Gap Detection Test, Duration Discrimination Puretone , Interaural Time Difference and Interaural Level Difference was significantly different between controls ,low vision and blinds subjects (Kruskal Wallis test, p<0.05).

Best Corrected Visual acuity and Contrast sensitivity was higher (better) in control group followed by low vision and blind subjects (post hoc mann whitney test, p=0.00).GDT was significantly higher in low vision subjects followed by blinds and control group (post hoc mann whitney test, conservative p<0.02). DDPT and ITD was higher in blind subjects followed by low vision and control group (post hoc mann whitney test, conservative p<0.02). ILD was higher in low vision subjects followed by blind and control group (post hoc mann whitney test, conservative p<0.02).

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Table 2: Association Between Vision and Hearing: A Case Controlled Study: Details of Post Hoc Mann Whitney Significance Values in Different Groups for Different Parameters

BCVA		Control & LV	LV & Blind	Control & Blind
	P value	0.00	0.00	0.00
	U value	0	0	0
CS	P value	0.00	0.00	0.00
	U value	16	10	80
GDT	P value	0.00	0.009	0.008
	U value	20	28	118
DDPT	P value	0.409*	0.034*	0.004
	U value	322	37	106
ITD	P value	0.038*	0.082*	0.007
	U value	255	55	130
ILD	P value	0.008	0.077*	0.237*
	U Value	240	60	200

BCVA=Best Corrected Visual Acuity; CS=Contrast sensitivity; GDT= Gap Detection Test; IDPT=Intensity Discrimination Puretone; DDPT= Duration Discrimination Puretone; ITD=Interaural Time Difference; ILD=Interaural Level Difference, LV=Low Vision
*Not statistically significant

All the audiological tests (GDT, IDPT, DDPT, ITD, ILD) and ocular tests (BCVA & Contrast sensitivity) was compared between males and females. IDPT & DDPT was found significantly different between males and females (Mann whitney test, $p<0.05$). No statistically significant difference in GDT, ITD & ILD was found between males and females, although males were found to have higher GDT and ILD than females and females were found to have higher ITD as compared to males.

Relationship of different audiological tests (GDT, IDPT, DDPT, ITD, ILD) with BCVA, Contrast sensitivity and age was assessed using Spearman Correlation. Details of correlation values between audiological tests & BCVA, Contrast sensitivity & age are shown in table 3 .A strong positive correlation was found between GDT and BCVA which was statistically significant ($r=0.581$, $n=75$, $p=0.00$). There was statistically significant moderate positive correlation between DDPT and BCVA ($r=0.305$, $n=75$, $p=0.008$), ITD and BCVA ($r=0.388$, $n=75$, $p=0.001$), ILD and BCVA ($r=0.281$, $n=75$, $p=0.014$).Though not statistically significant, a week positive correlation was found between IDPT and BCVA ($r=0.147$, $n=75$, $p=0.208$).

Similarly, a statistically significant strong positive correlation was found between GDT and Contrast sensitivity ($r=0.602$, $n=75$, $p=0.00$); moderate positive correlation between DDPT and contrast sensitivity ($r=0.30$, $n=75$, $p=0.009$). And although not being statistically significant, IDPT, ITD and ILD was found to have week positive correlation with contrast sensitivity.

Similarly, Age was found to have no statistically significant correlation with any of the audiological tests (GDT, IDPT, DDPT, ITD & ILD) Although GDT & ITD was found to have weak positive correlation with age and IDPT, DDPT & ILD was found to have negative weak correlation with age.

Table 3: Association Between Vision and Hearing: A Case Controlled Study: Details of Spearman Correlation Significance Values for Different Parameters

		GDT	IDPT	DDPT	ITD	ILD
BCVA	Corr. Coeff	0.581	0.147	0.305	0.388	0.281
	P value	0.00	0.208*	0.008	0.001	0.014
CS	Corr. Coeff	0.602	0.170	0.30	0.046	0.088
	P value	0.00	0.146*	0.009	0.694*	0.452*
Age	Corr. Coeff	0.091	-0.059	-0.163	0.020	-0.174
	P value	0.438*	0.615*	0.163*	0.867*	0.136*

BCVA= Best Corrected Visual Acuity; CS= Contrast sensitivity; GDT= Gap Detection Test; IDPT=Intensity Discrimination Puretone; DDPT= Duration Discrimination Puretone; ITD=Inter-aural Time Difference; ILD=Inter-aural Level Difference, Corr. Coeff= correlation coefficient (r)
*Not statistically significant

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V. DISCUSSION

To the best of our knowledge, there is no previously published study for hearing status in normal, visually impaired and blind subjects using GDT, IDPT, DDPT, ITD & ILD including its association with the parameters such as age, gender, vision, refractive error, colour vision, visual field and contrast sensitivity in this age group in the Indian ethnicity.

The accession of spatial hearing is a basic importance for visually impaired children as it comprise a good measure of the ability to independently travel or navigate in the environment and the predisposition to involve in the social interactions with others.

The gap detection tests (temporal resolution) reported in our study are comparable to those reported by Mohammad khani etal, 2011. They have evaluated gap in noise test between the congenitally blind and sighted control group and the inclusion age range of subjects they took in their study is somehow similar from our study. They have found significant difference in the approximate threshold and the percent of corrected answers between congenitally blind and sighted controls ($p<0.05$).However they did not find any significant difference between males and females in this regard ($p>0.05$). But in our study we performed not only gap detection test, but also intensity discrimation, duration discrimination, interaural time difference and interaural level difference in 3 categories of subjects i.e. normal, low vision and blind subjects to understand the correlation as well as the difference in these categories of subjects.

The current study not only took congenitally blind and low vision but also the subjects who acquired the visual deficits in their lifetime. International Tinnitus journal (2017) Volume 21 indicates that there is no significant difference in GDT & DDPT between congenitally visually impaired and normal sighted individuals. Literature also evidences that individuals with visual impairment do not have better discrimination abilities for puretone audiometric thresholds than to sighted individuals. However, the current study results indicated that there is a statistically significant difference in GDT, DDPT, ITD, ILD in all the 3 groups of subjects (conservative $p<0.02$). Also, there is significant moderate to strong correlation between BCVA and GDT, IDPT, ITD, & ILD ($p<0.05$). Contrast sensitivity was found to be significantly correlated with only two of the audiological tests i.e. GDT & DDPT ($p<0.05$). There was no significant correlation between any of the audiological tests and age. However, we also found statistically significant difference between males and females in two of the audiological tests i.e. IDPT & DDPT ($p>0.05$).

The visual feedback represents the most important stimulant for actions and activities for sighted individuals and thus for development of mobility and social skills which is compromised in blind or low vision individuals. Thus, visually impaired and blind individuals strongly rely and depend on auditory markers to code spatial & social information.

REFERENCES

[1]. Balantrapu, T. Lancet Publishes Latest Global Blindness & VI prevalence figures. Retrieved from https://worldcouncilofoptometry.info/lancet-publishes-latest-global-blindness-vi-prevalence-figures. 2017

[2]. Guthrie D, Davidson M , Williams JG, Campos N, Hunter JK, Mick P, Wittich W. Combined impairments in vision, hearing and cognition are associated with greater levels of functional and communication difficulties than cognitive impairment alone: Analysis of inter RAI data for home care and long-term care recipients in Ontario. Plos One 2018; 13(2). doi:10.1371/journal.pone.0192971

[3]. Lewis JW, Mijovic T, Zeitouni A. A Comparison of Visual and Auditory Motion Processing in Human Cerebral Cortex. Cerebral Cortex 2000; 10(9), 873-888. doi:10.1093/cercor/10.9.873

[4]. Musiek FE, Shinn JB, Jirsa R, Bamiou D, Baran, JA, Zaida E. GIN (Gaps-In-Noise) Test Performance in Subjects with Confirmed Central Auditory Nervous System Involvement. Ear and Hearing 2005; 26(6), 608-618. doi:10.1097/01.aud.0000188069.80699.4

[5]. Shive, T, Bellis TJ. Central Auditory Processing Disorders. The Handbook of Psycholinguistic and Cognitive Processes 2003; doi:10.4324/9780203848005.ch17

[6]. Lessard N, Paré M, Lepore F, Lassonde M. Early-blind human subjects localize sound sources better than sighted subjects. *Nature 1998;* 395 278–280. 10.1038/26228

[7]. Röder B, Teder-Sälejärvi W, Sterr A, Rösler F, Hillyard SA. Improved auditory spatial tuning in blind humans. *Nature* 1999; 1999 162–166. 10.1038/22106

[8]. Leclerc C, Saint-Amour D, Lavoie ME, Lassonde M, Lepore F. Brain functional reorganization in early blind humans revealed by auditory event-related potentials. *Neuroreport* 2000; 11 545–550. 10.1097/00001756-200002280-00024

[9]. Moehlecke R. Cegos de nascença têm audição mais apurada. Faculdade Evangélica do Paraná; Mundo da Psicologia: 2004. .5 ano 1.

[10]. Caumo DTM, Ferreira MIDC. Relação entre desvios fonológicos e processamento auditivo. Rev Soc Bras Fonoaudiol. 2009; 14(2):234–240.

[11]. Farias GC. Intervenção precoce: reflexões sobre o desenvolvimento da criança cega até dois anos de idade. Pensar a Prática. 2004; 7:85–102.

[12]. Guida HL, Feniman MR, Zanchetta S, Ferrari C, Giacheti CM, Zorzetto NL. Revisão anatômica e Fisiológica do processamento auditivo. ACTA ORL. 2007; 25(3):177–181.

[13]. Voss P, Collignon O, Lassonde M, Lepore F. Adaptation to sensory loss. Wiley Interdiscip. Rev. Cogn. Sci. 2010; 1, 308–328

[14]. Kolarik AJ, Cirstea S, Pardhan S , Moore BCJA. Summary of research investigating echolocation abilities of blind and sighted humans. Hear. Res. 2014; 310, 60–68

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25dec1559

[15]. Thaler L, Goodale MA. Echolocation in humans: An overview. Wiley Interdiscip. Rev. Cogn. Sci. 2016; 7, 382–393
[16]. Voss P. Auditory spatial perception without vision. Front. Psychol.2016; 7, 1960
[17]. Collignon O, Voss P, Lassonde M, Lepore F. Cross-modal plasticity for the spatial processing of sounds in visually deprived subjects. Exp. Brain. Res. 2009; 192, 343–358
[18]. Kolarik AJ, Moore BCJ, Zahorik P, Cirstea S, Pardhan S. Auditory distance perception in humans: A review of cues, development, neuronal bases and effects of sensory loss. Atten. Percept. Psychophys. 2016; 78, 373–395
[19]. Grosvenor T. Primary care Optometry, 5th edition St. Louis (MI): Elsevier Butterworth Heinemann. 2007
[20]. Abdul N, Meyer N, Van Bosch M, Van Zyl A, Viljoen M, Carlson AS. The effect of pinholes of different sizes on visual acuity under different refracting states and ambient lighting conditions*. *African Vision and Eye Health* 2009; *68*(1). https://doi.org/10.4102/aveh.v68i1.150
[21]. Eze CC, Okoye OI, Okoye O, Nwachukwu N, Okoloagu NN, Onwasigwe EN. Profile of Low Vision Patients in a Resource-Poor Underserved Setting of a Developing Country. *Open Journal of Ophthalmology* 2018; *08*(02), 120–131. https://doi.org/10.4236/ojoph.2018.82016
[22]. Lens AI, Nemeth CS, Ledford JK. Ocular anatomy and physiology 2nd Edition
[23]. Parmar T, Vanathi M, Ghose S, Dada T, Venkatesh P. Colour Vision Revisited. *The Official Scientific Journal of Delhi Ophthalmological Society 2014; 24*, 223-228.