

Auditory Development in Infants



Farzaneh Zamiri Abdollahi^{1*}, Mamak Joulaie², Akbar Darouie³ and Tayebeh Ahmadi⁴

¹Department of Audiology, AVA Rehabilitation Center, Iran

²Speech Language Pathology, AVA Rehabilitation Center, Iran

³Speech Language Pathology, University of Social Welfare and Rehabilitation Sciences, Iran

⁴Student of Audiology, AVA Rehabilitation Center, Iran

Submission: September 23, 2017; **Published:** September 26, 2017

***Corresponding author:** Farzaneh Zamiri Abdollahi, AVA Rehabilitation Center, Enghelab Street, Hadadi Blvd, Derakhti street, Karaj, Alborz, Iran, Tel: +982633555682; Email: audiology_zamiri@yahoo.com

Abstract

Auditory development started even before birth. It has interesting potential features that need auditory experience to show them. This article is a short review of auditory development in infants.

Keywords: Auditory Development; Auditory deprivation; Auditory localization

Hearing before birth

Fetus from 6 to 7 month gestational age has all necessary mechanisms for hearing process. It has been shown that a premature neonate who is in 25th week of gestational age, has good reaction to sound. In another study, presenting vibro-acoustic stimuli to fetus showed that 24-25 week-old fetus is able to show blinking response to sound [1]. Around fetus is full of liquid and layers of tissue so sound reaching there, is less intense than outside world. It seems that mean intensity of sound inside uterus is about 85 dB SPL [1]. This liquid and tissue layers work as low pass filters. Low frequency components (200-800 Hz) of sounds can reach inside of uterus [2]. Putting Hydrophone inside sheep uterus showed that there are different sounds inside womb including: mother's eating, drinking, breathing and muscular movements. Researchers spoke outside and gathered the sound from inside the womb and play it outside with loudspeakers. Interestingly, external conversations were audible but they were not always intelligible. In addition, the sound of mother's heart beat and blood flow were not as high as they were expected [3]. It seems that these auditory experiences help fine tuning of developing auditory system and hearing mother's speech before birth might have effects on speech understanding after birth [4].

Hearing after birth

Immediately after birth, sound environment of neonate changes dramatically. Now he is in air so he is exposed to wide variety of sound spectrum. Most basic function of auditory system

is detecting sound (detection) [1]. It is obvious that neonate from birth is able to detect sounds (e.g. startle to loud sounds, present OAE (otoacoustic emissions) and ABR (auditory brainstem response)) [5]. In neonates behavioral response to sound is not reliable and their reaction to sound is affected by their physiologic response (e.g. hunger and tiredness). Some of behavioral responses are widening the eyes, blinking, stop sucking for milk, changing sucking rate etc. Best reliable way to check neonates' response is physiologic and electrophysiologic responses. From 5 month old, it is possible to get reliable behavioral response from infants via visual reinforcement audiometry (VRA) [1].

Sound localization in infants

One of the amazing functions of auditory system is sound localization. Auditory system is able to detect sound and determine the location of sound source. All hearing functions are valuable for survival but localization is absolutely vital [6]. Infants show localization from birth but their spatial resolution is not as good as adults [1]. We have horizontal and vertical localization. Horizontal localization is dependent on detecting subtle timing (ITD; interaural time difference) and intensity differences (IID; interaural intensity difference) between two ears [6]. Vertical localization is reliant on auricle and changes it makes in sound based on sound source elevation in space [7]. Electrophysiologic responses like binaural interaction components (BICs) of ABR show that central auditory system of neonates from birth can detect subtle ITDs. Therefore all

the mechanisms and structures needed for horizontal localization is available at birth but child may not use them right away. Child's head grows from birth to adulthood and this change affects ITD and IID available for child (change of distance between two ears). Underlying central system for localization seems so plastic and it changes with child's head growth. Same thing happens for vertical localization. Child's auricle grows with age too [8-10].

Localization behavior shows that horizontal localization appears in younger age than vertical localization but in 4.5 month-old infants, localization is already two dimensional. With age, child shows faster reaction to sound source location. At birth there is a 7 second-delay but at 5 month-old infants this delay is only 2 seconds. At birth localization response is subcortical and reflexive but it becomes cortical and more controlled response with child development [1]. From 5 month, precedence effect (PE) appears in infants. 4 month appears to be transition age for PE. This function is one of the higher order functions of auditory system and helps localization in reverberant environments. Auditory system is able to locate sound source based on direct sound emitting from the source and can suppress echoes that come later (reflecting from walls and objects in the environment). This function develops with age [11]. Finally, sound localization is not purely auditory and it integrates with other senses especially visual information. This integration appears in 2 month-old infants and develops with age [1,12,13].

Infants' response to speech

Infants from birth prefer their mother's voice. In addition they prefer their mothers' voice when she is speaking in the native language and motherese speech [1]. Infants from 1 to 4 month of age are able to discriminate voiced and unvoiced consonants (e.g. /b/ /p/). In fact they can discriminate subtle differences in voice onset time (VOT) [14]. In first year of life, they can discriminate all the sounds they need to learn their native language [15]. This discrimination behavior has been tested by behavioural and electrophysiologic (e.g. Mismatch negativity or MMN) studies [1,5].

Another interesting characteristic of infants' auditory system is that it can ignore irrelevant differences among speech sounds. So it can put a phoneme in one category regardless of acoustic variations due to accent of the speaker, place of that phoneme in the word (first, middle or last part), stress and intonation, sex of the speaker etc. 6 month-old infants are pretty capable in speech categorization so auditory system has many capabilities for auditory skill development and speech understanding and production [1,15].

Auditory Experience

In spite of instinct capabilities of auditory system for development, experience is crucial for auditory skill development. It is shown that children with congenital profound hearing loss cannot develop auditory skills or speech without sensory aid and early intervention. Therefore, all underlying biologic auditory systems need appropriate stimulation to show their potentials [1]. Children are born with universal phonetic sensitivity. It means that his auditory system can discriminate all speech sounds from almost

all the languages around the world. However, in first year he lost his sensitivity to sounds from other languages because he is exposed to his native language during this time. Therefore, auditory map in cortex is complete by first year of life. One-year-old child is not able to discriminate phonemes that he has not heard because there is no defined neuron cluster for them. Now brain is devoted to the native language [1,16,17].

In infants' articulation, the same thing happens. Infants produce wide variety of sounds in their babbling and cooing. With appearance of first words of the native language, their productions got closer to their native language [18]. Infants' brain is so plastic. In fact most plasticity is seen till 3.5 years of age. Any auditory deprivation during this time has profound effect on child's auditory skill and speech development. At birth brain is like a computer with all hardware necessary for future functions available but it has not any software yet. Experience shapes software [1]. In lack of auditory stimulation, cross-modal re-organization happens and other senses especially visual sense take over auditory pathways. This can limit auditory neural capacity [1,19]. One of the auditory deprivations is recurrent otitis media. Today we know that this pathology can damage central auditory system and its' effects may not appear until school age [20].

Conclusion

Auditory development started even before birth. It has interesting potential features that needs auditory experience to show them.

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DOI: [10.19080/GJO.2017.10.555800](https://doi.org/10.19080/GJO.2017.10.555800)

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