Paediatrics Open Access Open Journal

SOAOJ PUBLISHING

Brief Report

Cognitive Functions and Communication Development of the Hearing-Impaired Children

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Received: Nov 19th, 2020; **Accepted:** Nov 24th, 2020; **Published:** Nov 26th, 2020

Citation: Panagiotopoulos GK. Cognitive functions and communication development of the hearing-impaired children. *Paedia Open A Open J.* 2020; I(1): 6-9

ABSTRACT

Hearing Loss (HL) can be easily described as an invisible acoustic filter that attenuates, eliminates, messes up and distorts incoming sound signals reaching the central auditory system. Children suffering from HL affecting both ears typically exhibit degraded speech and language capabilities. Moreover, current evidence highlights that besides hearing impairment, cognitive skills can also serve as a significant predictor of outcome regarding communication development of young children. The present study highlights the importance of early diagnosing and managing even borderline or minimal HL, as it can undoubtedly affect speech perception in noise and the need for further longitudinal studies and analyses that look into children with various types of additional cognitive impairments and different types and degrees of HL.

Keywords: *Children; Hearing loss; Cognitive Functions; Communication Development.*

INTRODUCTION

We don't hear with our ears but with our brain. Ears merely provide the mean, in order to deliver the appropriate sound signals to the Central Auditory Nervous System (CANS). It is up to the cortex to make a coherent message with those sound signals, a task specifically defined as auditory processing. A reduction in auditory processing can be seen due to deficits in the auditory system causing auditory deprivation. Such deprivation may lead to developmental drawbacks in children, structural abnormalities inside the auditory system itself, along with numerous other functional impairments.[1]

Full maturation of the auditory brain is a prerequisite for the normal development of speech and language communication skills in toddlers, regardless of their underlying hearing status. Nevertheless, only early acoustic stimulation of the auditory pathways can lead to their proper maturation through brain's neuroplasticity.[1] The developing brain has a maximum potential for neuroplasticity during the first three and a half years of life and it is particularly sensitive to a great amount of experiences.[1,2] It exhibits a withstanding ability to plastic alterations that effect behavior patterns throughout the life span. Only when cognitive skills are mastered, when a child is biologically preintented to do so, they can result in developmental synchrony otherwise several impairments may emerge.[1]

HEARING LOSS DURING EARLY DEVELOPMENT

Hearing loss (HL) can be easily described as an invisible acoustic filter that attenuates, eliminates, messes up and / or distorts incoming sound signals reaching the auditory brain.[1] Precise establishment of an unchangeable, steady auditory deficit as soon as possible is crucial to optimize the development of speech and language. Universal newborn hearing screening can reliably detect most of approximately 1-2 /1000 infants suffering from permanent HL.[3] Nevertheless delayed onset HL may appear at any period summing up to five out of one thousand children in total.

Children suffering from HL affecting both ears typically exhibit degraded speech and language capabilities. Moreover, current evidence highlights the various consequences that different types of additional cognitive impairments may induce on language development in toddlers suffering from HL.[4] That being said one can easily conclude

that besides hearing impairment, cognitive skills can also serve as a significant predictor of outcome regarding communication development of young children.

COGNITIVE SKILLS AND DEVELOPMENT

Cognition invokes conscious cortical functions that involve among others thought, rational, comprehension, learning, memory and finally action.[5] Among the most important cognitive functions,[5] working memory enables hanging on to information while it is simultaneously in use. Sensory memory reflects the capability to retract data deriving from any of the five senses such as olfactory, gustatory, somatosensory, visual, and auditory ques. Short term memory defines the capability to recall information for up to several minutes On the other hand long term memory enables hanging on to, and accessing accumulated data which were acquired previously, from several minutes to hours, days etc. before.[5] This function may affect competences such as word recollection along with retrieving other people's names, skills that are particularly essential during social activities.

Sustained attention enables the ability to remain focused and on a predetermined task over a sufficient amount of time.[5] Selective attention incorporates the ability to disregard distractions and hold over a particular task.[5] Divided attention allows a subject to recall data while performing two different tasks at the same time. Failure in establishing appropriate focus can cause someone to disregard crucial input.[5] Auditory processing enables the analysis, blending, and segmentation of various sounds, thus representing a crucial skill for successful listening comprehension. Visual processing allows a person to conceive in terms of visual stimuli.[5] Logic and reasoning activates the potential to reason, form ideas, solve problems and completing tasks in general.[5] Deficient reasoning and problem-solving abilities can cause young children to encounter asperities with regards to the way they communicate. They may be unable to comprehend the rational behind someone's opinion, and be sturdy in their own points of view.[5] Processing speed refers to the ability to perform the various tasks both quickly and accurately.[5] Finally cognitive fatigue is a typical drawn-out outcome of borderline cognitive decline / status. Once fatigued, young children may frequently perform suboptimal with their cognitive communication abilities. Attention along with concentration may worsen. Eventually these children may turn pettish and cranky, being incapable of thinking distinctly enough.

Cognitive function progression in young toddlers incorporates the gradual advancement of learning capabilities, such as attention, memory and thinking. These fundamental functions allow toddlers to procedure not only auditory but sensory information in general and finally learn to remember, make evaluations, perform analysis, compare and comprehend the principle of causation leading to decisions and actions. Even though cognitive progression is up to a point linked to an individual's genetic background, the majority of cognitive functions are somehow learnt. This proposes that thinking and learning potentials may further develop with adequate recitation.

Cognitive functions grow up variably for each child and that is why children may exhibit wide diversities with regards to acquisition and cognition, especially when HL co-exists.[5] Nevertheless cognitive ability is not locked, therefore poor cognitive functions may be further developed based on the individualized brain's plasticity and through the use of intense mental exercise.

COMMUNICATION CATEGORIES AND COMMUNICATION MODES

Typically adult communication incorporates initiations, prompts, or responses from an adult to the target child.[6] Prompts are delineated as particular and straight motivations to allow the child to engage words, signs, symbols, or some sort of answer in general.[6] Child communication on the other hand, involves initiations, responses, or repairs from the target child to an adult.[6] Repairs are delineated as, any time a child reacts to the adult's particular demand for interpretation when the adult can not comprehend the child's initial reaction.[6]

With regards to communication modes, speech is defined as an utterance including one vowel along with one or more consonants (or immature consonant replacements of the initial phrase) in the right position per syllable in the word.[6] The word should be utilized though in a semantically and subjectively proper manner.[6]

Sign is referred to as a mixture of hand constellations that can indicate expressions, words, numbers or corresponding combinations, which are indicative of a sign communication module.[6]

Gesture on the other hand represents a nonverbal mean of communication which may be recognized by fellows of the same cultural group.[6] Typical everyday examples of established gestures incorporate a face nod or shake for yes or no, shoulder movements, finger in front of lips as a "*sss*" nod, or a upright hand as a "*high five*" example. On the other hand, nonconventional gestures may incorporate a toddler pulling a grown-up by the hand, tapping someone, or handling or pointing something to someone else.[6]

Symbols include pictures, drawings or other signs that may correspond to a tangible and visible entity, behavior, or happening which can be shown, transmitted among communication sides, or upheld by someone to boost the toddler to pay attention to the symbol or to a particular task in general.[6] Appropriate illumination cards should be a substance of the toddler's oriented means of communication. Taking this fact into consideration, typical flash cards utilized during admissive verbal skills, cannot be regarded as symbols if they do not include letters, words, or numbers.[6]

Vocalization finally refers to one or more repeated phonemes, that do not represent a typical word but contain some sort of message, and can be targeted to someone.[6]

COMMUNICATION DEVELOPMENT IN CHILDREN WITH NORMAL HEARING VERSUS CHILDREN SUFFERING FROM HL

Prelinguistic language acquisition develops in a predictable manner in toddlers with normal hearing. Vowels like productions begin to happen during the first half year after birth, postdated by canonical babbling. [7] Canonical babbling is considered as a crucial milestone in infant vocal development and incorporates at least one vowel and one consonant such as /da/, /ga/.[7] Proto words, jargon, and first words appear immediately afterwards during the language acquisition series.[7] Youngsters tend to include variable intonation and rhythm in the making of jargon that resembles formal speech. Finally, words emerge around the first year of life.[7]

HL on the other hand can inhibit a child's potential to develop during language acquisition chronology. It can disrupt a toddler's potential to conceive alterations in intonation. Toddlers suffering from HL cannot distinctly comprehend verbal sounds surrounding them and their language acquisition progress will denote this inaccuracy.[7]

A draw back in any of the phases, particularly during the beginning of babbling, can potentially suppress future language development. Nevertheless, hard of hearing children may potentially succeed in making verbal sounds which are optically prominent on the speakers face.[7] Templates of such optically prominent verbal sounds are /m/ and /b/. Rest verbal sounds cannot be visualized on the lips and may be hard for toddlers suffering from HL to acquire, in case of total lack of audible input. One typical example is the /k/ speech sound which is shaped at the back of the mouth. Should a toddler can not evolve during the usual phases of vocalization development, because of the inability to create canonical babbling, first word implementation shall be markedly disrupted.[7] The observation of delayed canonical babbling acquisition in children suffering from HL and its connection to language progression, highlights the necessity for early diagnosis and appropriate management.

THE RELATION BETWEEN HL AND COGNITIVE FUNCTIONS

Recent evidence emphasizes the belief that there may be a causative connection between HL and poor cognition.[8] It is well established that the CANS exhibits an intrinsic plasticity. This plasticity is up to a point immune to mild HL. It is the plasticity itself that permits the CANS to learn (through acquired knowledge) to perform advanced sound processing, to be fine-tuned, to reliably cypher a tonal or a non-tonal language, and to isolate speech from noise.[8] This plasticity allows Cochlear Implants (CI) to properly function with regards to children and elders. Finally, this plasticity will take control when speech perception will increasingly depend on optical cues as the auditory input gradually starts to deteriorate. On the other hand, adequate word recognition that is disrupted by HL may withhold cognitive resorts which may otherwise be utilized for sound encoding or for the understanding of fast, cognitive loaded speech that frequently takes place in ordinary terms.[8]

Evidence suggests that the innate plasticity of the CANS fine-tunes it in terms of sensitivity to the acoustic environment in a manner that can either upwards or downwards promote how signals are decoded in a subcortical level (as the periphery up to the brainstem reliably encodes the waveform of sounds).[8,9] Moreover, listening activities provide an excellent way for the central mechanisms to adapt and develop inducing cognitive progression and functionality during lifetime. In hearing impaired populations, if sound perception can somehow be restored (properly deploying HAs, CIs, assistive listening devices etc.) such kind of auditory training might improve preexisting concomitant cognitive impairments as well.

COMMUNICATION DEVELOPMENT OF THE HEARING IMPAIRED AND COGNITIVE IMPAIRED CHILDREN

Published data argue that moderate cognitive disabilities do not constantly forestall a young sufferer from HL from accomplishing adequate speech, language, and communication goals that are close to those achieved by their peers without any extra disabilities.[4] Nevertheless the existence of a serious intellectual impairment will be almost always ample to inhibit typical communicative progression, regardless of the degree of preexisting HL.[4]

Interestingly enough, besides age of diagnosis of HL, individual variations in the communication goals obtained by children with HL along with extra cognitive disabilities, may reflect not only audiological related differences but also family related demographic variables. In more detail, four demographic variables are found in the literature to be statistically correlated with youngsters' speech, language and functional hearing results.[4] First of all, exclusive utilization of verbal communication instead of a combination of oral and sign language was correlated with superior receptive and expressive language outcomes, along with superior auditory functional results. Secondly, high maternal education was also correlated with superior receptive, expressive and listening outcomes. Thirdly, more severe cases of HL were correlated with lower receptive vocabulary results. Finally, children suffering from more severe cognitive disabilities obtained poorer receptive and expressive language scores than those with milder cognitive impairments.[4] Further statistical analysis in the same study also revealed that milder levels of HL were correlated with superior scores only in receptive vocabulary and not in receptive or expressive language. Nevertheless, no statistical correlation was found between age of fitting (either HAs or CIs) and children's demonstration on any of the outcome scores.[4]

The main conclusions derived from the study were that although certain degree of hearing impairment may not always account for the significant specific variations in language scores for children with more severe cognitive disabilities it does remain a crucial predictor of language development scores for the subgroup of young sufferers from other types of additional, less severe cognitive impairments.[4] Moreover, higher levels of maternal education (especially mothers who have completed postsecondary education in comparison to those who have twelve years or less of formal schooling) and the usage of oral communication at home, is a major predictor of positive children's language development scores in total. The extent and type of hearing impairment on the other hand plays an important role, mainly for the combined group of children with additional visual or speech output deficits, and syndromes.[4]

CONCLUSION

Communication is a far from simple process, which incorporates many every day aspects of mental thinking and socially performing. If the underlying cognitive status inhibits any of the functions involved, then it can endanger the capability to communicate adequately. 'Cognitive communication difficulties' is typically the term most often utilized for the resulting troubles. Hearing status also plays a fundamental role not only in communication but also in cognitive development. Trying to highlight the importance of considering all the contributing cognitive factors in order to explain the communicative deficits in patients that are also affected by HL, and in order to stay in agreement with suggestions from older studies, outcome scores should include typical evaluations of speech and language progression along with more subjective assessments of functional auditory behaviors (post audiologic intervention) based on parents' and / or clinicians' reports.[4]

Hearing impairment is not always directly detected and therefore typically in the past has not been given the proper attention needed.

Children with HL can be properly diagnosed at significantly variant age groups due to a plethora of various social, financial, cultural, and psychological factors, besides the fact that many countries have laws that mandate universal newborn hearing screening.[10] If HL is not properly detected during infancy (before the 3rd month after birth) and appropriate intervention options are not implemented as soon as possible then a child's language, emotional, and cognitive evolution can be disrupted in a vice versa manner.[10] This condition will inhibit the ability to read and write and induce additional academic difficulties later on regardless of the underlying cognitive status.[10]

Furthermore, pure tone thresholds between 15 and 20 dB HL, are not routinely recognized in clinical practice or even used in the literature, as borderline or minimal HL, although evidence suggests that they can undoubtedly affect speech perception in noise.[11] There are very few publications looking into the communication and language outcomes achieved by children with HL and additional cognitive disabilities.[4] Further studies and analyses are mandated separately for children with various types of additional cognitive impairments and different types and degrees of HL.

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