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Language Development and Psycholinguistic Abilities in Sensorineural Hearing Loss Children using Cochlear Implants and Hearing Aids

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Abstract
Background: Young children with restricted oral language abilities may struggle with phonological awareness exercises, resulting in subsequent difficulties in reading proficiency throughout their school years. This work aimed to assess outcomes and factors affecting language development and psycholinguistic abilities in sensorineural hearing loss (SNHL) children who were rehabilitated by cochlear implant (CI) and SNHL children using hearing aids (HA). **Methods:** This observational-analytic-cross-sectional work with selected randomized sample had been conducted on 100 children aging from 5 to 10 years old, both sexes, with scores of intelligence quotient (IQ) assessment is 80 or above, participants had been allocated into two groups equally: Group A: SNHL children who were rehabilitated by CI for more than 3 years and group B: SNHL children using HA > 3 years duration. The two groups participated in regular individual therapeutic language sessions, consisting of two sessions per week, each lasting 30 minutes, for a duration of two years. **Results:** Active vocabulary was highly significant different between both groups(P<0.05). Age of child at word utterance, row receptive, comprehension of sentences, understanding of verbal instructions, verbal categorization receptive1 (VCR1), VCR2, row expressive (RE), morphosyntax, expressive vocabulary, phrase repetition, verbal categorization expressive2 (VCE2) and total score of language were highly significant different between both groups (P<0.05). Aided SRT dB, Receptive vocabulary (RV) and VCE1 were had been significantly varied among both groups (P<0.05). a highly significant positive association between aided sound reception threshold decibel and (right and left degree of hearing loss) in HA group, and between total language score and total psycholinguistic age in both groups (P<0.05). **Conclusions:** Children with HL using CI or HA as early as possible to prevent defects in language, reading and academic achievement.

Keywords: Language Development, Psycholinguistic Abilities, Sensorineural Hearing Loss, Cochlear Implants

Introduction:

Prior to birth, the formation of the auditory cortex is enhanced by auditory stimulation, which promotes spoken language and fosters emotional, cognitive, and social growth [1].

Consequently, hearing screening programs for newborns have been established. Since 2006, a program remains accessible to all Dutch newborns in the Netherlands, where hearing aids (HAs) are prescribed for children with mild-to-severe hearing loss (HL), and cochlear implants (CIs) are provided to children who are categorized as hard of hearing (HH) or deaf, with a threshold of hearing of 85 decibels (dB) HL or greater [2].

Parents of infants who are deaf or HH are presented with the opportunity for early intervention concerning interaction, and language, auditory support via HA or CI [3].

Earlier fitting of CI, prior to 12 months of age, enables children who are deaf or HH to attain adequate awareness and recognition of speech, facilitating almost advancement age-appropriate spoken language [4].

Children start to acquire language from birth and are almost complete by the time they are six years old. Early exposure to oral language improves a child's expressive and receptive vocabulary, language abilities and speech quality [5].

Children having hearing impairment are at risk of language delay owing to receiving insufficient auditory information during the critical period [6].

An infant with a hearing impairment is encountering specific challenges due to deficiencies in verbal communication skills. Inadequate language skills often result in reading difficulties and constrain academic achievement [7].

Infants with restricted oral language abilities often struggle with phonological awareness tests, leading to subsequent difficulties in reading proficiency throughout school years [8]. Children with hearing impairments do not learn language and communication in the same manner as normally hearing children due to their inability to perceive the spoken language in their environment. In typical acquisition of languages, auditory comprehension precedes linguistic development [9].

This research aimed to assess the outcomes and factors affecting language development and psycholinguistic abilities in sensorineural HL (SNHL) children who were rehabilitated by CI and SNHL children using HA.

Patients and Methods:

This observational-analytic-cross-sectional work with selected randomized sample had been conducted on 100 children aging from 5 to 10 years old., both sexes, with scores of intelligence quotient (IQ) assessment is 80 or above, bilateral severe to profound SNHL and received CI for more than 3 years, SNHL with different degree of hearing impairment and fitted with binaural HA > 3 years duration. Each group of children (CI and HA) participated in regular individual therapy sessions for language, undergoing two sessions per week, each lasting 30 minutes, for a duration of two years. Parents received parental counseling every three months to improve the children's language skills. All children were growing up in a monolingual environment (Arabic language).

The study was done from February 2021 to June 2023 in Phoniatric Unit, Minia University Hospitals following approval from the Ethics Committee, Minia University, Minia, Egypt (approval code: 7:2/2021). Informed written consents were obtained from their parents.

Criteria for exclusion included children with persistent medical or psychiatric conditions that impede regular therapy, as well as those with developmental delays, syndromes, autism spectrum disorder, children with auditory neuropathy and with score of IQ assessment less than 80.

Children had been allocated into two equal groups: Group A: SNHL children had been rehabilitated by CI and group B: SNHL children were rehabilitated by binaural HA

Each subject had been exposed to complete taking of history, ear nose and throat (ENT) and neurological examinations and subjective auditory perceptual assessment (APA) of speech and language.

Psychometric evaluation by IQ

The Stanford-Binet Intelligence Scale (5th edition) assesses intelligence in four domains: verbal-, quantitative-, abstract/visual-reasoning, and short-term memory. The domains include 15 subtests, which involve comprehension, vocabulary, verbal absurdities, pattern analysis, matrices, folding papers, copying, cutting, quantitative reasoning, number series, equation construction, sentence memory, digit memory, object memory, and bead memory. All test respondents had an initial vocabulary assessment, that, in conjunction with the subject's age, dictates the quantity and complexity of subtests to be delivered. Raw scores were determined by the number of questions answered and then transformed into a standard age score relevant to the respective age group [10].

Audiological assessment: Included middle ear evaluation by immitancemetry (tympanometry and acoustic reflex threshold recording), and auditory evaluation was conducted using one of the following techniques: Pure tone audiometry (conditioned play or conventional audiometry). Aided audiometry (250-4000 Hertz). Sound reception threshold (SRT). Aided discrimination at 30 dB sound level (SL).

Receptive Expressive Arabic Language scale (REAL scale)
It is a series of assessments designed to measure both expressive and receptive language abilities[11].The outcomes of the REAL scale provide a comprehensive assessment of the degree of linguistic impairments. REAL scale is a linguistic evaluation method done on an individual basis. It was intended to assess Arabic language proficiency in children aged 5 to 12 years and 11 months. It consists of twelve subtests: Row receptive (RR), sentence comprehension (SC), Receptive vocabulary (RV), understanding oral instruction (UOI), verbal categorization receptive 1 (VCR1) and VCR2. row expressive (RE), expressive vocabulary (EV), morpho syntax (MS), sentence repetition (SR), verbal categorization expressive 1 (VCE1) and VCE2.

Illinois test of psycholinguistic abilities (ITPA)
An independently given exam battery intended to assess the oral and written language ability of children aged 5 to 12. It could be used to identify particular strengths and weaknesses in language skills, facilitating the early detection of students at risk of academic failure. It has twelve subtests [12]. It gives a diagnostic profile of psycholinguistic capabilities.
The twelve subtests, auditory reception (AR): To assess the child's capacity to extract meaning from vocally delivered information which is increasing in difficulty as the test proceeds. The response is kept at "yes" or "no" level or shake of head. Visual reception (VR): It assess the child's capacity to gain meaning from visual symbols. Auditory sequential memory (ASM): It tests the child's capacity to reproduce sequences of digits from memory. Visual sequential memory (VSM): It tests the child's capacity to replicate patterns of non-meaningful figures from the memory.
Auditory association (AA): To assess the child's capacity to correlate concepts delivered vocally such as to relate words meaningfully using verbal analogies of increasing difficulty.

Visual association (VA): To assess the child's capacity to correlate concepts present visually.

Auditory closure (AC): To assess the child's ability to fill in missing parts of word.

Visual closure (VC): To assess the child's capacity to recognize a familiar item from a partial visual representation.

Manual expression (ME): It tests the child's capacity to express ideas manually in pantomime.

Verbal expression (VE): It tests the child's capacity to express his own concepts orally when presented with a concrete object and asked, "tell me about this".

Grammatical closure (GC): It tests the child's capacity to speak grammatically. Sounds blending (SB): The child hears the separation of a word and synthesizes from them into a word.

Statistical analysis
Statistical analysis had been conducted employing SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative parameters had been displayed as mean and standard deviation (SD) and contrasted among both groups employing unpaired Student's t-test. Qualitative parameters had been displayed as frequencies and percentages (%) and analyzed employing the Chi-square or Fisher's exact test when appropriate. Correlation between various parameters had been conducted employing Pearson moment correlation equation. A two-tailed P value < 0.05 was considered statistically significant.

Results:
Demographic data and age of first word and sentence utterance and IQ test were enumerated in this table. **Table 1**

Audiological profile was enumerated in this table. **Table 2**

Demographic data, prenatal, perinatal, postnatal complication, and IQ assessment were insignificantly different while history of jaundice and passive vocabulary were significantly varied among both groups (P<0.05). Active vocabulary was highly significant variation among both groups(P<0.05). **Table 3**

Age of child at word utterance, age of child at first sentence, RR, SC, UOI, VCR1, VCR2, RE, EV, MS, SR, VCE2 and raw total score of language were highly significant variation among both groups (P<0.05). Aided SRT dB, RV and VCE1 were significantly varied among both groups (P<0.05). Age of child when fitted with CI or HA, aided SD and at 250, 500, 1000, 2000, 4000 dB were insignificantly different between both groups. **Table 4**

PLA of VR, VSM, AC and VC were significantly varied among both groups P<0.05). PLA of AR, VR, AA, ASM, VA, ME, VE, GC, SB and total PLA were insignificantly different between both groups. **Table 5**

A significant positive association existed between aided SRT dB and (right and left degree of HL) and between total score of language and (total PLA in both groups and age of child in HA group). A significant negative association existed between binaural aided SD and (total of language and right and left degree of HL) (P<0.05). A significant positive association existed between total score of language and IQ in HA group. A significant positive association existed between PLA and IQ (P<0.05). **Table 6**

Table 1: Demographic data, age of (first word and sentence utterance) and IQ test of studied groups

		Group A (n=50)		Group B (n=50)	
Age (months)		91.26±18.25		85.6±18.3	
Sex	**Male**	28(56.0%)		29(58.0%)	
	Female	22(44.0%)		21(42.0%)	
Family history		21(42.0%)		22(44.0%)	
Consanguinity		19(38.0%)		26(52.0%)	
Prenatal complication	**Irrelevant**	43(86.0%)		46(92.0%)	
	Any complications	7(14.0%)		4(8.0%)	
Perinatal history					
Weight at birth	**Average**	43(86.0%)		46(92.0%)	
	LBW	7(14.0%)		4(8.0%)	
Jaundice		40(80.0%)		30(60.0%)	
Incubation		4(8.0%)		9(18.0%)	
Neonatal cyanosis		0(0.0%)		0(0.0%)	
Postnatal complication	**Fever**	0(0.0%)		2(4.0%)	
	Fits and trauma	0(0.0%)		0(0.0%)	
	Ear discharge	2(4.0%)		6(12.0%)	
		Group A	**N**	**Group B**	**N**
Age of first word utterance (months)		38.98±19.141	50	24.70±10.197	50
Age of first sentence utterance (months)		61.71±21.195	34	47.96±15.191	45
IQ		85.470±4.2503	50	86.200±4.9115	50
Mental age		78.98±18.283	50	74.14±17.266	50

Data are presented as mean ± SD or frequency (%). LBW: Low birth weight, IQ: Intelligence quotient.

Table 2: Audiological profile of studied groups

		Group A (n=50)	Group B (n=50)
Audiological history			
Onset of HL	**Congenital**	42(84.0%)	27(54.0%)
	Acquired late HL	8(16.0%)	23(46.0%)
Course	**Progressive**	15(30.0%)	20(40.0%)
	Stationary	35(70.0%)	30(60.0%)
Degree of HL			
Degree of HL in Right ear	**Moderate**	--	2(4.0%)
	Moderate to severe	--	19(38.0%)
	Severe	9(18.0%)	9(18.0%)
	Severe to profound	35(70.0%)	35(70.0%)

	Profound	6(12.0%)	6(12.0%)
Degree of HL in Left ear	**Moderate**	--	3(6.0%)
	Moderate to severe	--	9(18.0%)
	Severe	4(8.0%)	11(22.0%)
	Severe to profound	38(76.0%)	6(12.0%)
	Profound	8(16.0%)	12(24.0%)
Type of implant	**Medal**	41(82.0%)	--
	Cochlear	9(18.0%)	--
Duration of using HA (months)		16.28±12.66 (before implantation)	42.76±19.87
Age of child when fitted with CI or HA		45.64±12.478	42.80±22.84

Data are presented as mean ± SD or frequency (%).CI: cochlear implant, HA: hearing aids, HL: hearing loss.

Table 3: Comparison between group A and B regarding demographic data, prenatal, perinatal, postnatal complication, IQ assessment and subjective APA of language

		Group A (n=50)	Group B (n=50)	P
Age(months)		91.26±18.25	85.6±18.3	0.125
Sex	**Male**	28(56.0%)	29(58.0%)	0.840
	Female	22(44.0%)	21(42.0%)	
Family history		21(42.0%)	22(44.0%)	0.840
Consanguinity		19(38.0%)	26(52.0%)	0.159
Prenatal complication		43(86.0%)	46(92.0%)	0.338
Perinatal history				
Weight at birth	**Normal**	43(86.0%)	46(92.0%)	0.338
	Below	7(14.0%)	4(8.0%)	
	Above	0(0.0%)	0(0.0%)	
Jaundice		40(80.0%)	30(60.0%)	**0.029***
Incubation		9(18.0%)	4 (8.0%)	0.137
Postnatal complication	**Fever**	0(0.0%)	2(4.0%)	0.153
	Ear discharge	2(4.0%)	6(12.0%)	0.140
IQ assessment		85.47±4.25	86.20±4.91	0.429
Subjective APA of language				
Passive vocabulary	**Poor**	9(18.0%)	1(2.0%)	**0.008***
	Rich	41(82.0%)	49(98.0%)	
Active vocabulary	**Single words**	22(44.0%)	5(10.0%)	**<0.001***
	2 words sentence	12(24.0%)	14(28.0%)	
	3-4 words sentence	8(16.0%)	10(20.0%)	
	Long sentence	8(16.0%)	12(24.0%)	
	Can tell story	0(0.0%)	9(18.0%)	

Data are presented as mean ± SD or frequency (%). *Significant p value <0.05. IQ: Intelligence quotient, APA: Auditory perceptual assessment.

Table 4: Comparison between group A and B regarding age of (first word and sentence utterance), audiological profile and REAL scale test

	Group A	N	Group B	N	P
Age of child at first word utterance (months)	38.98±19.141	50	24.70±10.197	50	**<0.001***
age of child at first sentence utterance (months)	61.71±21.195	34	47.96±15.191	45	**<0.001***

Audiological profile	**Age of child when fitted with CI or HA**	45.64±12.478	50	42.80±22.847	50	0.442
	Aided SRT Db	43.33±6.455	33	39.76±11.205	42	**0.018***
	Aided SD%	48.12±29.509	34	59.70±29.991	47	0.088
	250	38.30±9.980	50	37.50±8.283	46	0.672
	500	44.90±8.660	50	42.10±10.695	50	0.152
	1000	44.30±9.742	50	45.80±15.628	50	0.566
	2000	40.60±9.457	50	43.40±16.826	50	0.308
	4000	47.80±8.931	50	50.70±17.143	50	0.291
REAL scale test	**RR**	44.20±19.727	50	78.46±30.097	50	**<0.001***
	RV	14.02±6.479	44	17.66±6.513	44	**0.010***
	SC	14.74±10.919	46	32.17±15.520	46	**<0.001***
	UOI	9.02±8.477	50	22.84±10.803	50	**<0.001***
	VCR1	1.94±2.0	30	9.82±6.3	32	**<0.001***
	VCR2	2.12±2.61	41	5.41±5.15	37	**0.001***
	RE	26.54±23.871	50	78.68±54.409	50	**<0.001***
	EV	13.98±11.074	50	32.08±17.666	50	**<0.001***
	MS	2.78±3.929	50	20.22±16.671	50	**<0.001***
	SR	7.27±10.312	48	23.06±20.454	50	**<0.001***
	VCE1	1.42±1.5	30	3.15±3.8	32	**0.020***
	VCE2	0 .68±1.350	41	2.81±3.558	37	**<0.001***
	total language score	70.06±42.519	50	157.18±80.116	50	**<0.001***

Data are presented as mean ± SD.*Significant p value <0.05. CI: Cochlear implant, HA: Hearing aid, SRT: Sound reception threshold, dB: Decibel, RR: Row receptive, RV: Receptive vocabulary, SC: Sentence comprehension, UOI: Understanding oral instruction, VCR1: Verbal categorization receptive 1, VCR2: Verbal categorization receptive 2, RE: Row expressive, EV: Expressive vocabulary, MS: Morpho syntax, SR: Sentence repetition, VCE1: Verbal categorization expressive 1, VCE2: Verbal categorization expressive 2.

Table 5: Comparison between group A and B regarding ITPA test

	Group A	**N**	**Group B**	**N**	**P**
AR	57.96±12.519	50	60.94±11.663	50	0.221
VR	70.90±11.939	50	64.30±15.275	50	**0.018***
ASM	57.60±12.397	50	62.58±12.790	50	0.051
VSM	62.28±4.882	50	59.38±4.861	50	**0.004**
AA	59.90±8.340	50	60.76±9.482	50	0.631
VA	67.70±8.596	50	67.64±10.785	50	0.976
AC	52.18±10.333	50	57.14±8.079	50	**0.009***
VC	60.04±9.026	50	56.42±7.757	50	**0.034***
ME	53.14±8.048	50	50.46±8.924	50	0.118
VE	49.98±8.775	50	50.02±10.619	50	0.984
GC	49.48±3.716	50	48.98±2.979	50	0.460
SB	59.90±8.340	50	60.76±9.482	50	0.631
Total PLA	65.70±9.834	50	61.98±9.684	50	0.060

Data are presented as mean ± SD.*Significant p value <0.05. AR: Auditory reception, VR: Visual reception, ASM: Auditory sequential memory, VSM: Visual sequential memory, AA: Auditory association, VA: Visual association, AC: Auditory closure, VC: Visual closure, ME: Manual expression, VE: Verbal expression, GC: Grammatical closure, SB: Sound blending, PLA: Psycholinguistic age.

Table 6: Correlation between degree of HL and (aided SRT, binaural aided SD and total score of language) in group B. Correlation between total score of language and (age at time of implantation or using hearing aids, age of child by months and total PLA and correlation between IQ and(total score of language and total PLA) in both groups

		RT degree of HL	LT degree HL
Aided SRT dB	**r**	0.786	0.642
	P	**<0.001***	**<0.001***
Aided SD	**r**	-0.692	-0.514
	P	**<0.001***	**<0.001***
Total score of language	**r**	-0.669	-0.510
	P	**<0.001***	**<0.001***
		Total score of language	
		Group A (n=50)	**Group B (n=50)**
Age of child when fitted with CI or HA	**r**	-0.185	0.235
	P	0.199	0.101
Age of child (months)	**r**	0.264	0.489
	P	0.063	**<0.001***
Total psycholinguistic age	**r**	0.464	0.557
	P	**0.001***	**<0.001***
		IQ	
Total score of language	**r**	0.210	0.342
	P	0.144	**0.015***
Total psycholinguistic age	**r**	0.320	0.381
	P	**0.023***	**0.006***

R: Correlation coefficient. *Significant p value <0.05. RT: Right, LT: Left, SRT: Sound reception threshold, dB: Decibel, SD: Sound discrimination, CI: Cochlear implant, HA: Hearing aid, PLA: Psycholinguistic age, IQ: Intelligence quotient, HL: hearing loss, SD: Sound discrimination.

Discussion

Our result revealed that HA group could utter first word and sentence before CI group. This result could be explained by less severe degree of HL in hearing aid group compared to CI group. children with less severe degree of HL promote language development more than profound degree, Also, the prompt detection of HL and the provision of early intervention services positively influence cognitive and language developments. This outcome aligns with the findings of Tomblin et al. [13] , who indicated that one of the primary objectives of HAs in early children is to promote the development of language and speech. this result agreed with Geers et al. who showed that children who had a time of normal hearing before developing a substantial HL have better results for spoken language, speech production, and speech perception.

Our results about aided SRT revealed significant differences between CI (GA) and HA (GB). HA group demonstrated lower aided SRT than CI group. This might be explained by aided SRT depend on discrimination rather than detection of sound and HA group had different degree of hearing loss and better residual hearing, which allowed and improved speech discrimination in HA group.

We observed non-significant differences between CI and HA regarding binaural SD, the difference is approaching the statistical significance. The HA group done better in SD than the CI group. there are several issues with CI group, including irregularity in the use for instance, recurrent disconnections between the external transmission coil and the internal apparatus, socioeconomic status and a subpar rehabilitation program, because the children were not from the same area and received rehabilitation training at local rehabilitation centres rather than at the rehabilitation centre itself.

In agreement with our result about auditory perceptual assessment (APA) of language. Fitzpatrick et al. [14] indicated that children with HAs had superior results compared to their counterparts with CIs in the areas of receptive vocabulary, phonological memory, language, and reading comprehension. Additionally, in accordance with Tomblin et al. [13], who demonstrated that the severity of HL and the effectiveness of HAs in enhancing speech audibility, as quantified by the speech intelligibility index (SII), significantly affect spoken language development; greater severity of HL and diminished assisted speech audibility correlate with more adverse outcomes. This was also consistent with Fagan and Pisoni [15] posited that the spoken language acquisition, which remains continuously subpar in children with CIs, is primarily hindered by vocabulary comprehension, with observed delays in both the quantity of words understood (i.e., vocabulary size) and the pace of receptive vocabulary development. Eisenberg et al. [16] also identified impairments in language development in children with CIs when contrasted with both their hearing peers and children using HAs.

In agreement with our result about REAL scale test. Fitzpatrick et al. [14] revealed that children with moderate-or-severe HL fitted with HA done significantly better compared to their peers with profound HL received CIs on receptive vocabulary and overall language ability. Eisenberg et al. [16] found that Ongoing delays in spoken vocabulary understanding among deaf children with CIs seem to indicate both reduced availability to spoken and auditory language information prior to implantation and sluggish vocabulary development post-implantation. Yoshinaga-Itano et al. [17] reported that the number of words generated was considerably greater for children with mild-to-moderate HL between 8 and 39 months of age. In addition, delayed age of implantation in the CI group may be a factor attributed to less expressive vocabulary. This was against Hassan et al. [18] who revealed that a significant variation existed between CI children in all language parameters in comparison to HI children. In addition, highlighted the advantages of CI over HA.

In agreement with our result about ITBS, Surowiecki et al [19] asserted that several youngsters employing CI may discern subtle distinctions between speech sounds but aren't advancing as anticipated in receptive language proficiency. Teachers provide compelling evidence that some children with CI have deficient short-term auditory memory, potentially hindering their language development, temporal sequencing, and short-term memory retention, requiring advanced cognitive processing. Significant hearing deprivation before implantation may have resulted in cortical auditory processing abnormalities. Timothy et al. [20] shown that CIs correlate with enhancements in visual selective attention throughout infancy development, with increases in visual tracking and attention being among the first seen following CI.

Non-significant difference was found between CI and HA regarding the PLA of AR (Auditory reception), this reflects the non-statistically difference regarding the binaural SD between both groups. The children with impaired hearing had low capability to understood sounds and spoken words with difficulty in deriving meaning from a verbally delivered material, this could be attributed to the presence of limited vocabulary, an underdeveloped semantic structure (i.e., the associative or similarity-based relations between words) than their peers with normal hearing.

A significant variation was obtained between CI and HA as regard the PLA of VR (visual reception), the CI group performed better compared to the HA group in VR. This is due to early auditory deprivation period prior to implantation lead to visuospatial advantages over hearing. Children with hearing impairments outperformed their hearing counterparts in recalling complicated visual figures; however, this advantage diminished when the figures were given in segments and required sequential visual and/or verbal memory.

Non- significant variations were existed between CI and HA regarding the PLA of ASM (Auditory sequential memory). This reflects that weakness in the auditory reception in both group leads to inability to understand, recall the order of sounds and impaired recall of consecutive information in individuals with HI. These results suggest that early language development may improve various auditory recall abilities in hearing-impaired persons owing to brain plasticity. This was against Hassan et al. [21] who revealed that significant disparities exist between the CI group and the HI group for all aspects of auditory short-term memory, including auditory sequential memory, auditory association, blending of sounds, auditory closure, and verbal expressiveness.

We identified a substantial difference among CI and HA for the PLA of VSM (visual sequential memory) and the PLA of VC (visual closure). The CI group outperformed the HA group. This is attributable to the disparity in visual perception between the two groups. This finding aligns with Engel-Yeger et al. [22] who posited that, although hearing persons exhibit peak attention in the central visual field, those with hearing impairment have heightened attention in peripheral regions. Individuals with hearing impairment exhibited improved peripheral processing, whereas those with normal hearing demonstrated greater central processing.

Findings of the work demonstrated highly significant positive association among total score of language and total PLA of child by months. Hassan et al. [18] reported that HA and CI children revealed considerable advancement as regard development of language and academic achievement. In HA (GB), findings of the work showed highly significant negative association between binaural aided SD and degree of HL, between total score of language and degree of HL. Agreed with Abdi [23] who reported that the patients used HA had greater SDS scores comparing with the patients declined to utilize HA, and speech perception had been greater in the aided group contrasted to the unaided group. Also, Tomblin et al. [13] reported that the greater the severity of the loss of hearing and the decreased assisted speech audibility, the more adverse the impact is. In CI (GA), results of the study revealed negative association between total score of language and age of child when fitted with CI. This agreed with Heman-Ackah et al. [24] who showed that children implanted prior to the age of two do substantially greater compared to children implanted when they are older. In CI (G1), findings of the work showed positive association between total language score and IQ, such difference did not reach statically significant difference in CI. While in HA (G2), results of the work showed statistically significant positive association between total language score and IQ. This was supported by Chomsky. [25] who stated that language development is strongly associated with IQ in all stages.

In both groups**,** findings of the work showed significant positive association between total PLA and IQ. This was due to higher IQ scores indicate higher psycholinguistic scores.
Limitations of the work included that the sample size was relatively small. So, we recommended continuous follow-up, support language development in children with CI, and HA. Early detection and intervention of HL prior to the age of six months. Multisensory training is essential in both therapeutic sessions and educational settings, with an increased emphasis on visual stimulation. An auditory training program ought to involve challenges designed to develop and improve auditory short-term memory capacity.

Conclusions:

Children with HL using HA or CI as early as possible to prevent defects in language, reading and academic achievement. Despite early intervention, there is large variation in language skills, and persistent language impairment co-occurring with the HL. Some of these children may catch up, others will not. Children with HI, regardless of severity, encounter several simultaneous physical, developmental, communication, psychological, and emotional issues when they fail to comprehend their surroundings. In the absence of suitable therapies, these children are susceptible to the development of mental health issues.

Early detection and intervention of HL prior to 6 months of age significantly enhances the development of a child's language, encompassing picture, relational, and oral vocabulary, sentence integrating, grammatical comprehension, grammatical completion, phonological analysis, differentiation-, production- of words, semantics, and syntax. The linguistic advancements of a hearing-impaired youngster in visual vocabulary, grammatical completion, word differentiation, phonological analysis, and word generation are significantly augmented by early detection and treatments for HL.

List of abbreviations:

SNHL: sensorineural hearing loss
HA: hearing aids
CI: cochlear implant
IQ: intelligence quotient
VCR: verbal categorization receptive
HL: hearing loss
HI: hearing impairment
HH: hard of hearing
dB: decibel
SRT: Sound reception threshold
SL: sound level
REAL: Receptive Expressive Arabic Language
RR: Row receptive
RV: Receptive vocabulary
SC: sentence comprehension
UOI: understanding oral instruction
VCE: verbal categorization expressive
RE: Row Expressive
EV: Expressive vocabulary
MS: Morpho syntax
SR: Sentence repetition
VCE: Verbal categorization expressive
ITPA: Illinois test of psycholinguistic abilities
PLA: Psycholinguistic age
AR: auditory reception
VR: Visual reception
VSM: Visual sequential memory
ASM: Auditory sequential memory
VA: Visual association
AA: Auditory association
AC: Auditory closure
VC: Visual closure
ME: Manual expression
VE: Verbal expression
GC: Grammatical closure
SB: Sounds blending
SD: standard deviation

Declarations:

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The work had been conducted from February 2021 and June 2023 following approval from the Ethics Committee, Minia University Hospitals, Minia, Egypt (approval code: 7:2/2021).

Consent:

Each patient’s relatives signed an informed consent.

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