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Value of Auditory Perception of Alphabet Letters Test (Arabic Standardized Version) in Evaluation of Arabic Speaking Bimodal Children

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ABSTRACT
Background: For unilateral cochlear implant (CI) candidates, benefit can be enriched by adding a hearing aid to the opposite ear, termed bimodal hearing. The best results are obtained when their hearing, speech, and language abilities are properly verified. The Arabic version of auditory perception of alphabet letters (APAL) is a reliable test of speech perception appropriate for use with kids who speak Arabic but have hearing impairment and a limited vocabulary.
Aim: Children who use linked hearing aids and cochlear implants were evaluated to test the correlation between the (APAL) test and auditory abilities, language acquirement and speech parameters.
Design: Eleven children were studied twice first 3 months after unilateral CI turn on and second 3 months after fitting linked hearing aid (HA) in non-implanted ear (6 months after CI turn on). Assessment of APAL test was performed in the audio-vestibular medicine department and the evaluation of speech characteristics, language, and auditory skills in the ENT department's Phoniatric Unit. Zagazig University. The findings were compiled and statistically evaluated.
Results: A statistically significant increase in correct scores of APAL test as well as language and auditory assessment after bimodal stimulation. There was a statistically significant +ve correlation (r=0.70 & p=0.02) between APAL and CAP among the studied cases.
Conclusion: APAL can be regarded as a reliable speech discrimination test that predicts the progress of a number of pre-lingual bimodal children's skills.
Keywords: auditory perception, bimodal system, APAL, Arabic speaking.

INTRODUCTION
Cochlear implants(CIs) which are designed to successfully regain hearing, can help those with severe to profound hearing loss. Indication criteria for CI eligibility have changed in recent years, enabling patients to pursue cochlear implantation if they have significant aidable hearing in the opposite ear. Bimodal hearing occurs when such patients continue to use a hearing aid (HA) in the non-implanted ear. Unilateral CI recipients benefit greatly from the ability to access low-frequency hearing through a hearing aid because it enhances their ability to understand speech in noisy environments, sharpens their ability to detect differences in pitch, music and voices, and provide enriched sound quality. Binaural summation, the binaural squelch effect, redundancy effects, with a head shadow effect all contribute to a higher subjective sense of well-being [(1)].

Bilateral CI is expensive and invasive, but there is a nonsurgical option which is the bimodal hearing. Amplification in the unimplanted ear is a potential option for people who still have some low-frequency hearing [(2)].

It was found recently that bimodal listeners judged the sound quality of matched linked devices in a study higher and had greater gains in speech comprehension. The Phonak Naida Link and Naida CI hearing aids (Q70 or Q90) sound processor from Advanced Bionics make up a dedicated bimodal solution designed to further increase performance in bimodal listeners. All of the functionality and signal processing on both devices are perfectly matched, making them ideal for use together [(3)].

A speech test called the (APAL) was translated and standardized to evaluate children who lacked the vocabularies necessary for assessments like the WIPI (Word Intelligibility by Picture Identification) or the phonetically balanced kindergarten tests (PBKG) [(4)].

This investigation was carried out to assess the correlation between the Arabic version of the APAL and the auditory language development in Arabic speaking bimodal children.

SUBJECTS AND METHODS
This study was given the go light by the Research Ethics Committee of the Zagazig University Hospitals' School of Medicine. After thoroughly explaining the testing procedures for all participants, signed informed consent was acquired. Human subjects' research was carried out in compliance with the World Medical Association's (WMA) Manifesto of Helsinki.

Study design: Children aged 3 to 6 (n = 11) who received cochlear implant (CI) surgery followed by the linked fitting of a hearing aid (HA) in the other ear were analyzed

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in a cross-sectional study of auditory and language development over a 6-month period.

Study groups: consisted of 11 unilateral CI users with unimplanted ear residual low frequency hearing (patients with Linked fitting bimodal stimulation). They were checked out at Zagazig University's ENT clinic's Phoniatric units and audio-vestibular medicine. They had their CIs during the period from of October 2021 to April 2022.

All individuals had prelingual bilateral severe to profound sensorineural hearing loss, as validated by Oto-acoustic emission and auditory brainstem response, meeting the requirements for CI candidacy in the CI program at Zagazig University. Even after a tough six-month program for auditory rehabilitation, the benefits of binaural digital hearing aids were not met with satisfaction. This was shown by the fact that young children often struggle to develop even the most fundamental auditory skills. Whereas in older ones less than 30% on open set speech discrimination test lists (phonetically balanced kindergarten words) indicates poor performance. Children between the ages of 1 and 6 with no medical or radiologic reasons to delay CI surgery were candidates (with no history of neurological problems or head trauma, good middle ear function, no vestibular complaints, and poor general health). None of them were particularly above or below average in terms of their non-verbal IQ (greater than or equal to 80 percent). Finally, with the help of family cure and realistic expectations.

METHODS

- **Audiological assessment:**

Arabic version of auditory perception test of alphabet letters (APAL)

The alphabet letters are produced orally and used as stimuli in the APAL test. The test was organized using the alphabet's 26 letters. The first four were used solely for practice, and each of the five forms consists of 30 letters.

Candidates: The most suitable candidates was those hearing impaired children who cannot be tested with open-set speech discrimination tests, either because of language or speech limitations, as well as, those for whom picture-pointing procedures are too easy.

Procedure:

1. In the 60dBHL test, a real person's voice was introduced at that intensity. The child sat in a soundproof booth with their back to the door and their heads turned toward the direction of the voice.
2. Instruct the child to listen to the alphabet letter names and to repeat the one they think they heard.
3. It is not necessary to keep score of the first four stimuli since they are only used for practise. Starting with item 5, mark the proper column (column 0) and the incorrect columns (columns I, II, or III) to indicate your answers. E.g. In the column labelled "[I]," circle the child's exact reaction if the stimulus was "س" and the child's answer was (ز,ش). Mark the answer in the [II] column if the child answered the options (غ ,ع ,م ,ج). If the child gives an answer that isn't one of the choices in columns [I] or [II], record the letter the child gave in column [III].

Scoring:

The degree of similarity between the given answer and the correct one affects the score. Column mistakes [I] are multiplied by 1.28%, in column [II] by 2.56% and in column [III] by 3.84%. The proportion of right answers is found by adding all the percentages of wrong answers and then subtracting that sum from 100.

- **Phoniatric assessment was done by:**

a) Language test [5]:

The standardized test for the Arabic language was used to evaluate the language skills of the candidates. This exam evaluated both receptive and expressive abilities, providing an overall "language age" in years. They reported their language barrier as a "language quotient." Subtracting the children's raw scores from the typical cutoff for their chronological age yielded this value. Given that the children being evaluated were of varying chronological ages, the use of language age would have yielded inaccurate findings, therefore instead, the language quotient of 60 was employed.

b) Auditory abilities [6]:

The method used was CAP scoring (Capacity of Auditory Performance)

Score: 0 = Not aware about sounds of surrounding environment

1 = Aware to sounds of surrounding environment

2 = Speech sound response

3 = can identify environmental sounds

4 = can discriminate speech sounds with no lip-reading

5 = Understand common phrases without lip-reading

6 = Understand conversation without lip-reading

7 = Utilization of phone with known listener books

c) IQ Test Stanford Binet Intelligence Scale V edition [7].

Ethical consideration:

The Ethics Committee evaluated and approved the protocol, informed consent form, and any other written information prior to starting this study of the Zagazig University Hospital.

Statistical analysis

Information was entered into a computer, and SPSS 27.0 (Statistical Package for the Social Sciences) was used to conduct statistical analysis (IBM, 2020). Multiple tests, including the Mc-Nemar, Paired Sample T, and Wilcoxon tests, as well as the Analysis of Variance (F) Test, were utilized.

RESULTS

Regarding patients' sex, 57.1% were male, study participants' ages varied between 3 and 6 years, with a mean of 4. 76.. The duration of CI usage was 3 months in the first assessment and 6 months following CI turn on in the 2nd assessment (three months after fitting and regular use of Naida link HA). All children had a single ear implanted, with the majority (71%) on the right and just (28.5%) on the left, and were given either an Advanced Bionics Naida Q70 or Naida Q90 sound processor and a Phonak Naida Link hearing aid.

APAL test demonstrates a statistically significant rise in the correct scores of APAL test after 6 months of CI turn on (CI+ linked HA) comparing to 3 months of CI turn on (CI alone) (Table 1).

Phoniatric assessment shows that language improved significantly with a statistical significance decrease in lip reading after 6 months of CI turn on (CI+ linked HA) comparing to 3 months after CI turn on. No change was reported in eye contact sign or inner language (Table 2). Moreover, language assessment improved significantly in both PV &AV as well as in the receptive age, expressive age and total age on performing the language test. In the auditory assessment there was a statistical significance improvement in CAP after 6 months of CI turn on (CI+ linked HA) comparing to 3 months after CI turn on (Table 3).

Regarding the relation between APAL results and Phoniatric assessment, it showed that there was a statistical significant decrease in the correct scores of APAL among cases with poor PV compared to cases with fair and good PV, also there was a statistical significance decrease in the correct scores of APAL among cases with bubbling in AV compared to cases that can say words and sentences. Finally, among cases who can recognize 6 and repeat 5 phrases, there was a statistically significant improvement in APAL accurate scores compared to other cases (Table 4). There was a statistically significant positive connection between APAL and CAP values among the patients analyzed (r=0.70 & p=0.02). (Figure 1). Finally, there was a statistical significant +ve correlation between APAL and all Language test age (repetitive, expressive and total ages) among the studied cases (Table 5).

Table (1): APAL among the studied cases at different times of follow up:

Variable		(3ms after CI turn on) (n=14)	(6ms after CI turn on) (n=14)	T	P
APAL:	Mean ± Sd	15.52±0	43.28±12.39	**8.38**	**<0.001 ****

t: Paired t test **: highly significant (P<0.001)

Table (2): Communicative abilities among the studied cases at different time of follow up:

Variable		(3ms after CI turn on) (n=14)		(6ms after CI turn on) (n=14)		P
		No	**%**	**No**	**%**	
Eye contact sign:	Good	14	100	14	100	---
Language:	-ve	9	64.3	3	21.3	
	+ve	5	35.7	11	78.6	**0.004***
Lip reading:	-ve	2	14.3	9	64.3	**0.01***
	+ve	12	85.7	5	35.7	
Inner language:	Intact	14	100	14	100	---

P: McNemar test NS: Non significant (P>0.05) *: Significant (P<0.05) **:Highly significant (P<0.001

Table (3): Language and auditory assessment among the studied cases at different times of follow up:

Variable			(3ms after CI turn on) (n=14)		(6ms after CI turn on) (n=14)		P
			No	%	No	%	
Eye contact sign:		Good	14	100	14	100	---
Language:		-ve +ve	9 5	64.3 35.7	3 11	21.3 78.6	**0.004***
Lip reading:		-ve +ve	2 12	14.3 85.7	9 5	64.3 35.7	**0.01***
Inner language:		Intact	14	100	14	100	---
PV:		Poor Fair Good	14 0 0	100 0 0	5 3 6	35.7 21.4 42.9	**0.002*$**
AV:		Bubbling 2 single words 3 single words 5-<10 single words 2 word sentence	8 0 4 0 2	57.1 0 28.6 0 14.3	1 1 4 4 4	7.1 7.1 28.6 28.6 28.6	**0.03*$**
Language test (PLS4)	**Receptive**	Mean ± Sd Median (Range)	3.43±3.08 1 (1-10)		12.21±2.69 13 (6-17)		**0.001*^**
	Expressive	Mean ± Sd Median (Range)	11.07±1.69 10 (10-15)		19.79±1.81 20 (15-23)		**0.001*^**
	Total	Mean ± Sd Median (Range)	5.36±3.73 7 (1-10)		16.14±1.61 16.5 (12-18)		**0.001*^**
Ling sound:		Detect 4 & repeat 0 Detect 5 & repeat 0 Detect 5 & repeat 5 Detect 6 & repeat 0 Detect 6 & repeat 2 Detect 6 & repeat 3 Detect 6 & repeat 4 Detect 6 & repeat 5	1 2 5 2 1 2 1 0	7.1 14.3 35.7 14.3 7.1 14.3 7.1 0	0 0 2 1 1 3 4 3	0 0 14.3 7.1 7.1 21.4 28.6 21.4	0.041*$
CAP:		Mean ± Sd Median (Range)	1.71±1.07 1 (1-4)		2.93±1 3 (2-5)		**<0.001**^**

$:McNemar test ^: Paired Wilcoxon test NS: Non significant (P>0.05)
*:Significant (P<0.05) **:Highly significant (P<0.001)
P: McNemar test

Table (4): Relation between APAL and the Language and auditory assessment among the studied cases 6 months after CI turn on:

Variable		N	APAL% Mean±Sd	F	P
PV:	Poor	2	**27.04±16.29**	**7.88**	**0.01***
	Fair	3	58.61±14.04		
	Good	6	41.55±0.66		
AV:	Bubbling	1	**15.52**	**4.78**	**0.04***
	2 single words	1	38.56		
	3 single words	2	41.12±0		
	5-<10 single words	3	42.4±0		
	2 word sentence	4	53.92±14.78		
Ling sound:	Detect 6 & repeat 0	2	34.08±12.43	**4.69**	**0.04***
	Detect 6 & repeat 2	1	42.4		
	Detect 6 & repeat 3	2	42.4±9.63		
	Detect 6 & repeat 4	2	41.12±7.41		
	Detect 6 & repeat 5	4	66.72±8.55		

Sd: Standard deviation F: ANOVA test *:Significant (P<0.05).

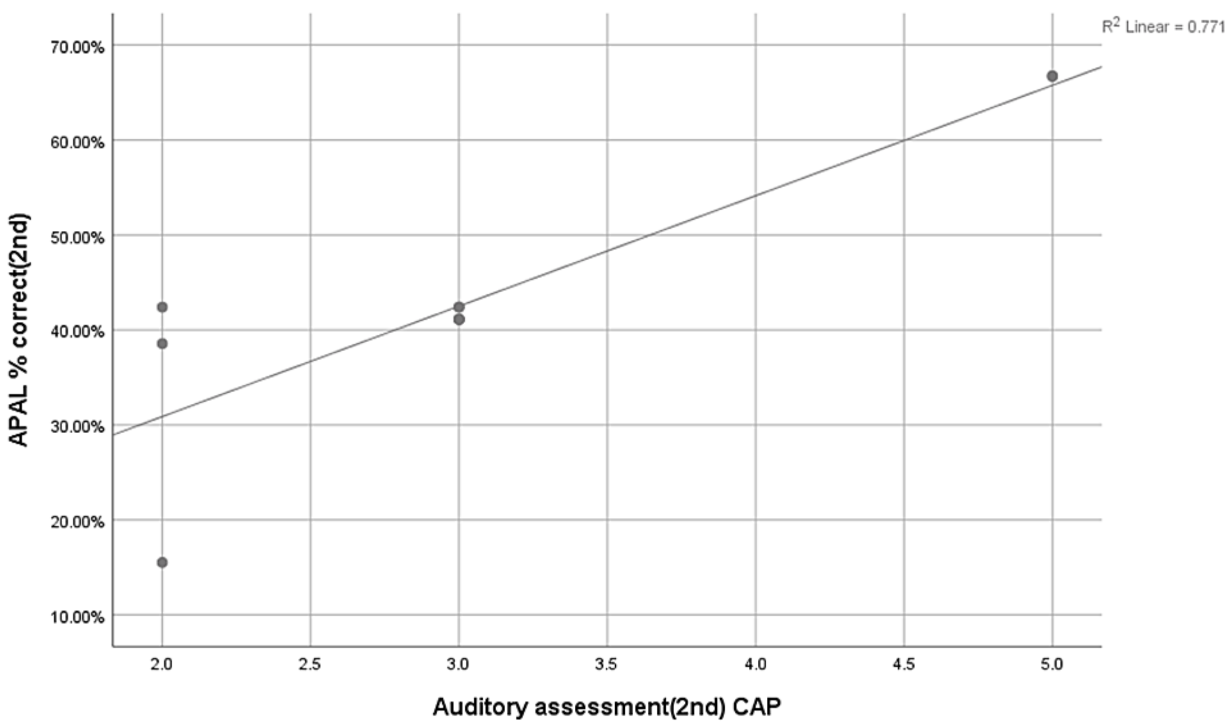

Figure (1) :(Correlation between APAL and auditory assessment)

Table (5): Correlation between APAL and auditory assessment & Language Test (PLS4) among the studied cases:

Variable	APAL (n=14)	
	R	P
Auditory assessment	**0.70**	**0.02***
PSL4 repetitive:	**0.60**	**0.04***
PSL4 Expressive:	**0.58**	**0.04***
PSL4 total:	**0.62**	**0.03***

r: Pearson's correlation coefficient *: Significant (P<0.05)

DISCUSSION

There is evidence that bimodal hearing improve hearing in comparison to cochlear implants, but the degree benefit varies from patient to patient. A period of adjusting to the new sound sensations will likely be needed in the early stages of bimodal stimulation. Patients who continue wearing their hearing aid for at least three months after receiving a cochlear implant are more likely to become successful bimodal users. Consistent fitting of a contralateral hearing aid within 3 months is beneficial for unilateral CI candidates [8].

APAL can serve as a trustworthy test of speech discrimination that forecasts the development of various skills of pre-lingual CI children [9]. In the current study, the score of APAL has improved significantly over the 6 months' period of follow up from (15.52) in first evaluation (CI alone) to (15.52-66.72) in second evaluation (CI + linked HA) (table 1). These outcomes support the conclusions of **Oxenham** who reported that all unilateral CI users with HA in the other ear have been found to show statistically significant improvement in their ability to recognize monosyllabic words in quiet settings over time [10].

This study also in agreement with **Most *et al*.** who examined a group of CI recipients alone and another group with CI + HA (bimodal) [11]. Suprasegmental traits such as Word emphasis, syllable stress, and intonation were assessed. On all three tests, The CI alone condition was significantly underperformed by the bimodal condition. Based on the results of this research, it appears that the HA provides a large bimodal advantage for perceiving all suprasegmental characteristics and this most likely a result of the HA's improved low-frequency acoustic hearing.

Gifford *et al.* also proved that early bimodal stimulation is linked to considerably improved speech understanding, vocabulary, and language development in kids with aidable low-frequency acoustic hearing [12].

In this study there was a statistical significance improvement in language after 6 months of CI turn on (CI + linked HA) comparing to 3 months after CI turn on (CI alone). No change was reported in eye contact sign or inner language as shown in (table 2).

Firszt *et al*. documented in his study improvements for everyday communication function [13]. Also, a number of authors assumed that those who still had some hearing in the the contralateral ear may rely more on acoustic than electric hearing for daily conversation [14].

There was a statistical significant improvement in language assessment in both PV & AV as well as in the receptive age, expressive age and total age on performing the language test after 6 months of CI turn on (CI + linked HA) comparing to 3 months after CI turn on (CI alone) (table 3).

According to the results of a study that evaluated the advantages of a hearing aid in the opposite ear, children who used bimodal stimulation hearing aids had significantly better expressive and receptive language development as well as performance in auditory perception than children who used a cochlear implant alone [15].

These results are in agree with **Hassan *et al*.** who showed that in terms of Receptive and expressive semantics, word class, average utterance length, and speech intelligibility , the children who were bimodally-fit performed better than the children who had received unilateral CI[16]. After 9 months of therapy, there were statistically significant changes (P 0.047, 0.034, 0.03, 0.016, and 0.028).

The justification offered was that the low-frequency signal these kids' hearing aids picked up helped them learn to speak [17]. It was also found that the acoustic signal from the patient's contralateral HA improved their ability to interpret speech the most. [18].

In our clinical practice, there were statistical significance difference in ling sounds after 6 months of CI turn on (CI + linked HA) comparing to 3 months after CI turn on (CI alone) (table 3).

These results are in agree with **Marsella *et al*.** who showed that the first millstone is the detection of all six of Ling's sounds, proving that all speech frequencies can be accessed[19].

It is possible to provide the child the proper introduction to the world of sounds by continuing to utilize the implant and placing them in a stimulating sound environment (as measured by the MUSS questionnaire), This is essential for learning verbal language; likewise, the capacity to differentiate between various environmental sounds (investigated by the CAP) enables the development of the auditory skills required for language development.

In the auditory assessment there was a statistical significance improvement in CAP. This is in agreement with **Abdelmawgoud** who found that the CAP score showed hi/gher score in group III (using bimodal hearing strategy) as compared to the other groups and the number of participants with CAP score 5 and above was 0 in group I (using binaural regular powerful hearing aids), 6 (30 %) in group II (with unilateral cochlear implant) and 12 (60 %) in group III (using bimodal hearing strategy) [20].

These results are in agreement with **Chen *et al*.** who reported that bimodal recipients showed a persistent but stable difference in CAP at 3, 18, and 12 many months after the first mapping[21].

A relation between APAL and phoniatric assessment among the studied cases at 6 months after CI turn on (CI + linked HA) revealed that there was a statistical significant +ve correlation (r=0.70 & p=0.02) between APAL and CAP among the studied cases, Figure (1), a statistical significance decrease in APAL among cases with poor PV and those with bubbling in AV compared to cases with fair and good PV and those who can say words and sentences. There was also a statistical significance increase in APAL among cases can detect 6 and repeat 5 words compared to other cases (Table 4). Finally, there was a statistical significant +ve correlation between APAL and all Language test age (repetitive, expressive and total ages) among the studied cases (Table 5).

In line with the findings of **Mekki *et al*.**, we found a significant positive connection between APAL scores and those for total language age (TLA), auditory skills (CAP score), and speech intelligibility[9].

This may be associated with the jumbled assessment of letters in APAL speech materials. Because the APAL test takes into account how close the uttered letter was to the correct letter, rather than just whether or not it was the correct letter, the test's results were not black and white. These preverbal children also had very limited or no vocabularies. This scoring framework allows for a more inclusive evaluation of speech abilities progress. Thus, APAL is the most effective tool for gauging linguistic aptitude in pre-lingual CI children.

CONCLUSION

It is possible to use APAL as a trustworthy a speech discrimination test that forecasts progress in many capabilities in preligual linked bimodal children. As shown by the progress in the course of auditory stimulation and speech skills in all evaluated cases over time, concluding that APAL test is reliable for assessment of the linked bimodal stimulation.

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