CATEGORIZATION OF EVERYDAY SOUNDS BY EGYPTIAN COCHLEAR IMPLANT CHILDREN

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ABSTRACT

Background: *Cochlear implantation is a common surgical procedure for children with profound hearing loss who receive minimal or no benefit from traditional hearing aids. Auditory categorization is an important process in the perception and understanding of everyday sounds. This process involves both high level cognitive processes and low-level perceptual encoding of the acoustic signal.*

Aim of the work*: To understand the ability of a cohort of Egyptian children with Cochlear Implant to perceive everyday sounds compared to normal hearing children.*

Patient and Methods: *Ninety subjects divided into 2 groups were included in the present study. Group I: Fifty normal hearing children (NH). Group II: Forty CI users. A set of 18 natural stimuli were studied. They were chosen to cover a broad range of everyday sounds that corresponded to four mains a priori categories: nonlinguistic human vocalizations, animal vocalizations, environmental sounds& musical instruments. Children were asked to name/identify the sounds in an open-set identification task.*

Results: *Results showed that cochlear implant users were different from normal hearing listeners regarding the perception of individual sounds. Normal hearing children could identify sounds better than the CI children. In normal hearing children, the best identification was for human vocalizations, while in cochlear implant children the best identification was for animal vocalizations. Both groups had lower identification scores for both environmental and musical sounds. Sound identification scores increased with increasing chronological age of both groups.*

Conclusion: *Cochlear implant children have reduced relative ability toward identification of superordinate category of non-linguistic human vocalizations compared to age and gender matched normal hearing children.*

Key words: *Categorization, Cochlear Implant.*

INTRODUCTION:

The cochlear implantation is now the preferred option for profound sensorineural hearing loss to promote speech &language development.

Everyday listening consists of perception of the properties of a sound source and the semantic information. Also, musical listening refers to the perception of qualitative aspects of the sound [(1)]. We have shown that categories are based on everyday listening and the semantic properties of the

sound source rather than musical listening and its acoustical properties[2].

Showed in their study that 24 children fitted with cochlear implant are able to categorize everyday sounds in a similar way to typically developing normal hearing children. In this study we will analyze how a cohort of Egyptian cochlear implant children perceive and categorize complex natural everyday sounds[3].

PATIENTS AND METHODS:

Study Population: Ninety subjects were included in this study. They were divided into 2 groups. **Group I** consisted of 50 NH children. They were 25 males (50%) and 25 females (50%). **Group II** consisted of 40 CI children. They were 19 males (47.5%) and 21 females (52.5%).

Methods: All subjects underwent full history taking**,** Psychometric evaluation (IQ testing)[4], aided sound field& Speech audiometry including**:** Speech Reception Threshold (S.R.T) using Arabic bisyllabic words for children & Speech Discrimination using Arabic PBKG[5].

Test of sounds categorization was developed and used in the following way: Authors selected 18 sounds from a larger set of 34 sounds that were retrieved from a web database (http://www.freesound.org/). Selected sounds were digitally manipulated using Audacity software program. Sounds represented different categories as elaborated by [3].Sounds were designed to include: Non-linguistic human vocalizations, which were 6 sounds (coughing & sneezing child, laughing& crying woman and coughing & sneezing man)**.** Animal vocalizations were 3 sounds only (sheep, roaster and dog). Environmental sounds were included in the form of (spoon chinning in a glass, telephone ring, door lock, ambulance) (4 sounds). Musical instruments were 5 sounds namely (drum, tuba, violin, Piano and Ood).

Authors chose additional five sounds as training before the test; these sounds were (Cow, birds, laughing man, sneezing woman and helicopter). Recording of the child response and scoring was conducted Using TCL-LabX software [6]. All participants were assessed with an open set identification task**[7].**

Each participant sat in a quiet room, in front of a computer positioned at eye level, sounds were presented at comfortable level 65 dB SPL using headphones for the NH children and sounds presented to one ear, and loudspeaker for the CI children, the speaker will be placed at 0 azimuth, and positioned 40 cm from the participant, both the child and the examiner sat in the same room.

Ethical considerations: All parents of children involved in this study gave their verbal consent before testing, after explanation of the aim and procedures of the test. Also, the study protocol was approved by Research Ethical Committee, Faculty of Medicine, Ain Shams University.

RESULTS:

I-Demographic data:

The age at cochlear implantation was mainly around age of 4 years with mean=46.67±14.89 months & the mean of CI use was 54.50±19.83 months.

II-Aided performance:

The aided PTA were shown in diagram (1), while SRT & word recognition scores were shown in the table.

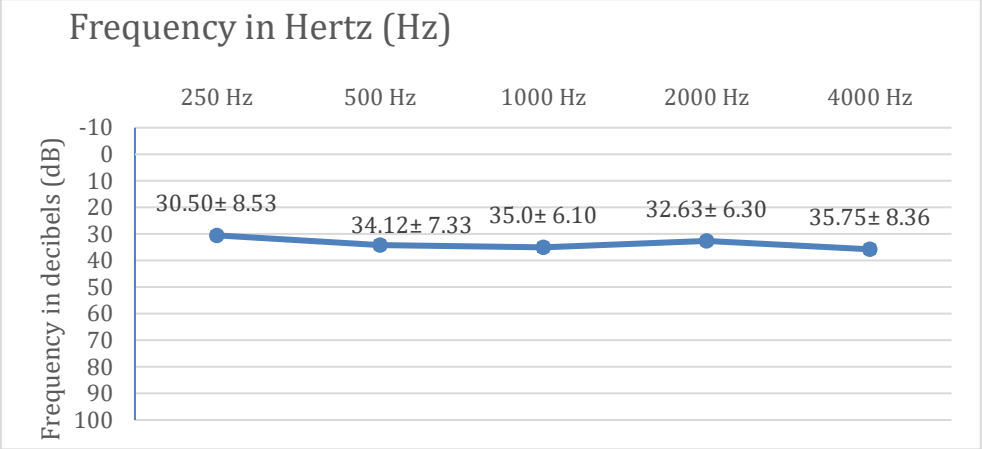

Diagram (1): Mean of Aided PTA by dB HL in the study group

Table : Aided SRT in dB HL& word recognition scores by PBKG

	CI group (n=40)	
Aided SRT dB HL	Mean± SD	34.75± 5.99
	Median (IQR)	35.0 (30.0- 40.0)
	Range	20.0- 45.0
Word Recognition by PBKG (%) at 60dBHL	Mean± SD	63.70± 12.76
	Median (IQR)	64.0 (60.0- 70.0)
	Range	36.0- 88.0

III-Results of everyday sounds categorization test:

Sound identification scores:

Regarding NH children the best identification was for non-linguistic human vocalizations followed by animal vocalizations, environmental sounds& musical sounds respectively. The CI children followed different pattern in grouping as they identify and group best the animal sounds (90%) identification followed by non-linguistic human vocalizations, environmental sounds& lastly musical sounds.

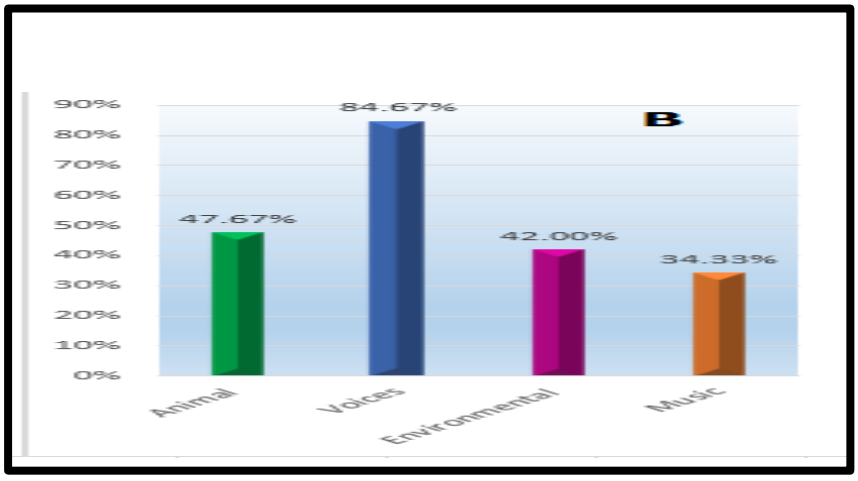

Diagram (2): Bar chart showing percentages of correct sound identification of superordinate categories by normal hearing children

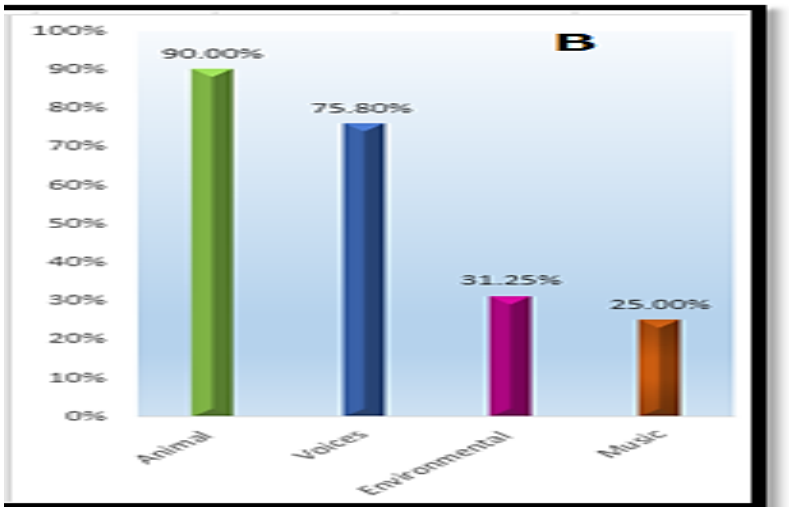

Diagram (3): Bar chart showing percentages of correct sound identification of superordinate categories by Cochlear Implant children.

In order to calculate the sum of sound identification scores, the children who recognized the sounds correctly scored 2 and the others who partially recognized the sounds scored 1, for example, (police instead of ambulance) (music instead of the name of the musical instrument). Finally those who couldn't identify the sound or identified it wrongly scored zero. Accordingly the maximum score was expected to be 36 and the minimum score was zero. The sum of sound scores was used to perform correlation with the chronological age of cochlear implant and normal hearing children.

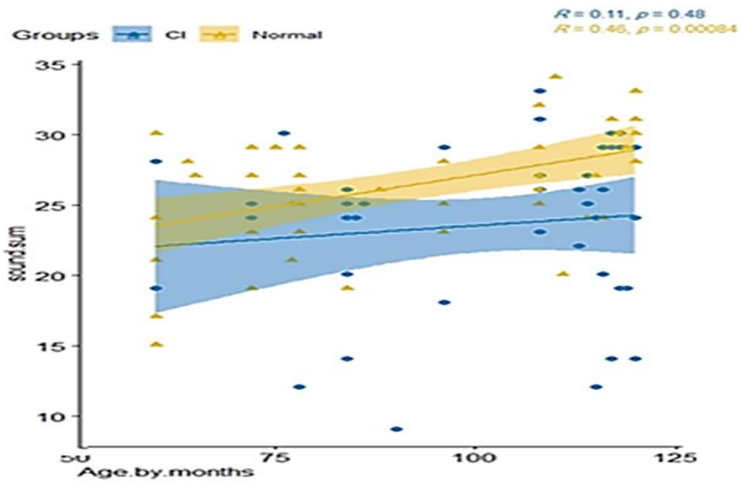

Diagram (4) A Scatter plot for CI & normal children age and their sum of sound scores.

*From diagram (4), we notice that normal hearing children have higher sum of sound scores than the CI children.

There is a positive correlation between chronological age of the child and the sum of sound scores for both groups.

DISCUSSION:

In the current study two groups of participants (NH and CI children) were included in sound categorization test. Examined sounds were nonlinguistic human vocalizations, animal vocalizations, musical sounds and environmental sounds.

I-Aided performance:

The average of aided threshold was 34.4dBHl **(Diagram 1)**, and the word recognition scores (%) by PBKG was fair (mean=63.70±12.76) **(Table)**.

Reyes-Quintos & Chiong (2012)[8] reported that young children implanted early and older children implanted with previous hearing aid use would usually reach the ≤45 dB aided hearing threshold within the first 3 months post implant.

II-Results of everyday sounds categorization test:

In the current study, the cochlear implant children showed lower sound identification scores than normal hearing children. The Cochlear Implant children showed relative reduced ability to identify human vocalizations compared to normal hearing children, in contrast they better identified animal sounds and this may be due to training in rehabilitation programs **(Diagram 2&3)**.

Berland et al. (2019) [3] documented that in both CI & NH groups, human vocal sounds - which are crucial for social communication - were clearly distinguished from other categories, despite the absence of speech content.

On the contrary, there was a poorer performance for music sounds (25% for CI&34.33 for NH were correctly identified). This was similar to results of **Berland et al. (2019)** [3] that showed a poorer performance for music sounds (35% correctly identified). This may be explained by lack of training on different types of differentiation among various musical instruments.

Despite hearing some musical cues, however, children using CIs continued to perform more poorly than typical hearing peers [9] and more poorly than adult CI users [10] on musical perception tasks. This indicated that these children do not have access to all the acoustic information carried in music.

There was also poor performance for environmental sounds (31.25% for CI& 42% for NH correctly identified). This was similar to previous studies on children with CIs that had already shown that they perform poorly on environmental sound recognition, compared with their normal hearing peers [11]. Using a closed-set format, they found that mean identification accuracy across all participants ranged between 59 and 68% for common environmental sounds.

Also, several studies had shown that normal hearing (NH) listeners demonstrated accurate identification of a large number of environmental sounds with little difficulty [12]. On the other hand, environmental sound identification might present considerable difficulty for CI patients who received distorted sensory input, and after a period of deafness, may often need to relearn many common environmental sounds [13].

Sum of sound scores was higher for normal hearing children than Cochlear Implant children & it increased as the chronological age of both groups increased (**Diagram 4**).

The CI device delivered much more crude information, especially spectrally, and this degraded component of acoustic information prevent listener to appropriately identify individual stimuli [14].

The process of categorization is thought to be an essential part of understanding how the world is perceived. Identification and categorization were one in the same process which sought to extract

meaning from a stimulus via the identification of certain properties [15].

The performance of Cochlear Implant children regarding the categories was based on the perception of semantic information associated to the sound producing event. This would suggest that "top-down" processes involved in categorization were well developed and possibly driving the strategies used by CI children. A strong factor in these processes was the idea of how the listener may interact with the object [16]. These top-down processes seem to be used by CI children even after periods of deafness[17].

Conflicts of Interest: The authors state that the publishing of this paper is free of any conflicts of interest.

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تصنيف الأصوات اليومية من قبل الأطفال المصريين زارعى القوقعة

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هدف البحث:فهم قدرة مجموعة من الأطفال المصريين زارعى القوقعة على ادراك الأصوات اليومية مقارنة بالأطفال ذوى مستوى السمع الطبيعى.

المرضى والطرق:90 طفلا تم تقسيمهم إلى مجموعتين: المجموعة الأولى 50 طفلا ذوى مستوى سمع طبيعى مع تطابق العمر والجنس مع المجموعة الثانية والتى تضم 40 طفلا زارعى القوقعة،وقد تم تقييم إدراك الأصوات اليومية بناءً على مهمة الفرز الحر.تتكون الأصوات من 18 صوتا مختلفا تنتمي إلى أربع مجموعات تم تحديدهم مسبقا وتشمل: الأصوات البشرية غير اللغوية ، وأصوات الحيوانات ، والأصوات البيئية ، والآلات الموسيقية.

النتائج: أظهرت النتائج أنه كان هناك اختلاف بين الأطفال زارعى القوقعة والأطفال ذوى مستوى السمع الطبيعى فيما يتعلق بإدراك الأصوات الفردية. يمكن للأطفال ذوي السمع الطبيعي التعرف على الأصوات بشكل أفضل من الأطفال زارعى القوقعة. تمكن الأطفال ذوى مستوى السمع الطبيعى من التعرف بطريقة افضل على الأصوات البشرية غير اللغوية, بينما تم التعرف بطريقة افضل على أصوات الحيوانات فى الأطفال زارعى القوقعة،كما تبين ان كلا المجموعتين قد تعرفوا بنسب أقل على كل من الأصوات البيئية والموسيقية, وقد زادت نسبة التعرف على الأصوات مع زيادة العمر لكلا المجموعتين.

الخاتمة: قدرة الأطفال زارعى القوقعة على التعرف على الأصوات البشرية غير اللغوية كانت أقل من الأطفال ذوى مستوى السمع الطبيعى من نفس العمر والجنس.