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Does Shape of a Click Stimuli Play a Role in Transient Otoacoustic Emissions???

Authors
Kaushlendra Kumar[1], Anshul Arora[2], Jayashree. S. Bhat[3], Rashmi A. Pai[4]
[1]Assistant Professor, Selection Grade, Department of Audiology and Speech Language Pathology
Kasturba Medical College, Manipal University, Mangalore
Email: *kaushlendra.kumar@manipal.edu*
[2]Research Associate, Department of Audiology and Speech Language Pathology
Kasturba Medical College, Manipal University, Mangalore
Email: *ansh2100@gmail.com*
[3]Professor and Head, Department of Audiology and Speech Language Pathology
Kasturba Medical College, Manipal University, Mangalore
Email: *bhat.js@manipal.edu*
Corresponding Author
Rashmi A. Pai
Assistant Professor, Senior Scale,
Department of Audiology and Speech Language Pathology
Kasturba Medical College, Manipal University, Mangalore
Email: *rashmi.apai@manipal.edu, dessairashmi@gmail.com*

ABSTRACT

The discovery of Otoacoustic emissions (OAE) opened a new dimension in audiological assessment. Transient evoked otoacoustic emissions (TEOAE) have an advantage of being its ease of usage, faster administration, objectivity, non invasive nature and also high sensitivity[2] as compared to other audiological procedures. The present study aimed to compare transient evoked otoacoustic emission response using two different click (rectangular and trapezoid) stimulus shapes.

Materials and Methods*: A total of 30 ears were considered for the study. 15 normal hearing individuals (7 males and 8 females) with age ranging from 15-30 years served as Participants for the present study.*

Results: *The mean difference between the rectangular and trapezoid shape were 3, 3, 3, 1 and 2dB at the 1, 2, 3, 4 and 5 KHz respectively. The SNR for rectangular shape was better than trapezoid shape. The paired sample t- test results revealed significant differences in TEOAE amplitude for all the frequency.*

Conclusion: *It can be inferred that there is significant difference in TEOAE amplitude for all the frequencies between two different stimuli shape. This difference could be attributed to the broader spectrum that is seen in the rectangular shape as comparison with the trapezoid stimulus. Rectangular shape produced better SNR than trapezoid stimulus shape.*

Keywords: *TEOAEs, Stimulus shape, Signal to Noise ratio.*

Introduction

The discovery of Otoacoustic emissions (OAEs) opened a new dimension in audiological assessment[1]. OAEs are present in 98% of the normal hearing ears. Most promising application of evoked otoacoustic emissions has been its application as a screening device for the identification of hearing impairment, especially in neonates and infants. Transient evoked otoacoustic emissions (TEOAE) have an advantage of being its ease of usage, faster administration, objectivity, non-invasive nature and also high sensitivity[2].

TEOAEs can be evoked using Click and/or tone burst stimuli. In Click evoked otoacoustic emissions (CEOAE), the stimulus has a broader spectrum thus it can stimulate a broader frequency region of the cochlea in a single measurement. Whereas tone burst evoked OAEs (TBOAE) – uses narrow bandwidth tone stimuli. This allows stimulus energy to be concentrated on a particular area of the basilar membrane and elicits a frequency-specific cochlear response[3, 4]. Fourier analysis of TBOAEs indicates that emission spectra are similar to that of the tone burst stimulus[5, 6, 7].Traditionally the TEOAE responses can be evoked by two types of train stimuli: (a) by a set of four clicks of equal magnitude (referred to as the linear protocol) or (b) by a set of three clicks of positive polarity followed by a fourth click of an inverse polarity with a relative magnitude of 9.5 dB higher than the corresponding positive clicks (referred to as the non-linear or the derived non-linear protocol). Under the hypothesis that the TEOAE recordings originate from saturated cochlear generators, it is assumed that the nonlinear protocol removes stimulus artifacts of linear nature which can be misinterpreted as TEOAE responses [4]. It is generally accepted that this nonlinear protocol is a practical compromise to maximize the reliability of a TEOAE recording, and can be used to assess the integrity of the cochlear function of neonates as well as adults.

Compared with CEOAEs, TBOAEs at similar stimulus levels can achieve a stronger response level with a greater signal to noise ratio (SNR) in normal adult ears [8, 9, 10]. Also, the short- and long-term test-retest reliabilities for TBOAE were found to be acceptable when using high (76 dB peSPL) and mid (67 dB peSPL) stimulus levels [8]. Research on adult TBOAEs, with high level stimuli suggests that it saves recording time, elicits a stronger response and gives higher wave reproducibility and reliability[8] than lower level stimuli. There are not much of studies on the use of TBOAEs for assessment in neonates and young children [11]. Lower frequency TBOAEs may elicit better and more robust OAE response than CEOAEs in the lower frequency region [12]. Chirp can also be used to record the TEOAE. The chirp stimulus can produce TEOAEs with higher SNR than the click stimulus. There is dearth of information on the effect of different click stimulus shapes on the presence of TEOAE. Hence, this study was taken up to find out the effect of different click stimulus shapes on TEOAE. The aim of the present study was to compare transient evoked otoacoustic emission

response using two different click (rectangular and trapezoid) stimulus shapes.

Method

15 individuals (7 males and 8 females) with age ranging from 20-40 (mean age 25.5) years served as participants in the present study. A total of 30 ears were studied. All participants had hearing threshold within 15dBHL across the frequencies, with 'A' Type tympanogram and normal stapedial reflexes. None of the subjects had a history of otologic and neurologic problem.

Procedure

Initially pure tone audiometry was done to find out hearing threshold from 250Hz to 8 KHz for air conduction and from 250Hz to 4 KHz for the bone conduction thresholds using diagnostic audiometry. Following that immittance measures was done to rule out the middle ear pathologyusing GSI Tympstar (version-2). Subsequently, TEOAE was done using two different stimuli shapes, rectangle and trapezium with Neuro-audio (version 1). The total duration of the stimulus was set as 300µs. For the rectangle stimulus the rise and fall time was used as 0 µs and plateau time was used as 300 µs. For the rise and fall time for the trapezium the stimuli was set as 100 µs and plateau time also was 100 µs. In order to consider the response as present, reproducibility was taken as >80% and signal to noise ratio as 6dB. TEOAE was recorded at 85dBSPL across different frequencies such as 1KHz, 2KHz, 3KHz, 4KHz, 5KHz. A number total of 500 stimuli were presented. If the rejection was >5% then test was discarded and redone for the same subject.

Signal to noise ratio was compared between the two different click stimulus shape. The data was analyzed using SPSS software, version 15. Paired Sample't' test was used to compare the SNR of the two different stimulus shape.

Results and Discussion

The frequency responses were obtained for 1, 2, 3, 4 and 5KHz. Graph 1 shows the mean and standard deviation of two different stimulus shapes. The mean SNR for rectangular shape were 12.38, 20.73, 20.36, 16.91, and 14.90dB with different frequencies 1, 2, 3, 4 and 5KHz respectively. The mean SNR for trapezoid shapewere 9.62, 17.04, 17.98, 15.73 and 12.51dB for frequencies of 1, 2, 3, 4 and 5 KHz respectively, The mean difference between the rectangular and trapezoid shapes was 3, 3, 3, 1 and 2dB at the 1, 2, 3, 4 and 5 KHz respectively as can be seen in graph 1. The SNR for rectangular shape was better than trapezoid shape. As can be observed at low frequency and high frequency the SNR was less compared to mid frequency for the both stimulus shape. The standard deviation was same for almost all frequencies in both rectangular and trapezoid stimuli.

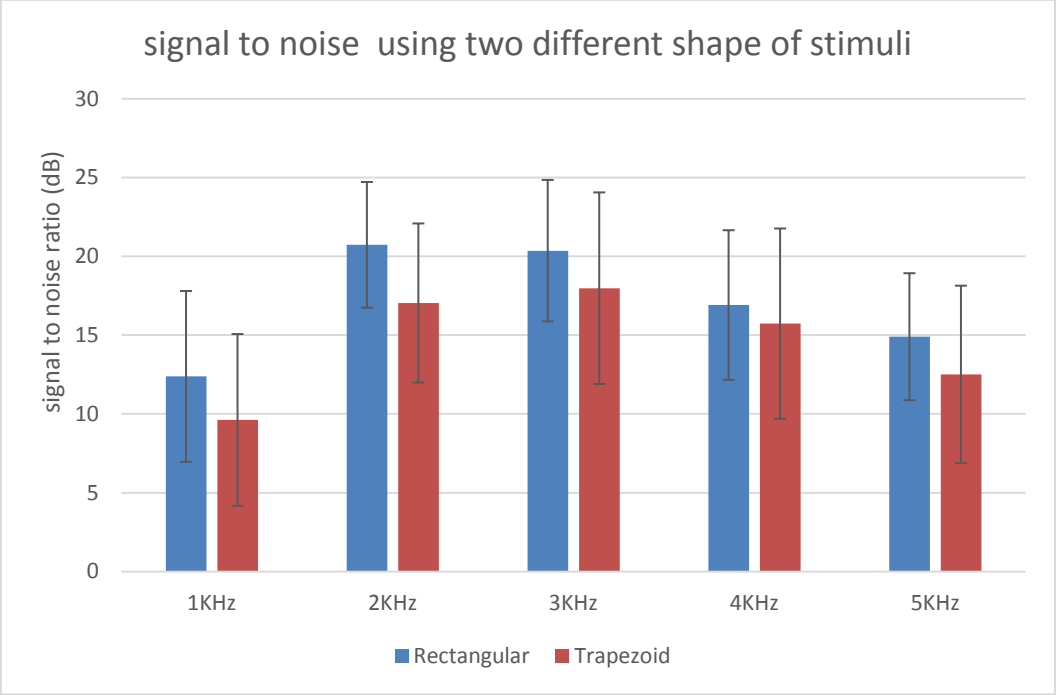

Figure 1: Shows the mean, standard deviation (SD) between rectangular and trapezoid shape.

To see the statically significant difference between rectangular and trapezoid, paired sample "t" was done for all the frequencies. From the "t" values of paired sample t- test of statistical analysis, it can be inferred that there was significant difference for rectangular and trapezoid click for 1 KHz (t= -4.023, df=29, P<0.05), 2KHz (t= -4.853, df=29, P< 0.05), 3KHz (t= -3.692, df=29, P< 0.05), 4KHz (t= -2.068, df=29, P< 0.05) and 5KHz (t= -3.050, df=29, P< 0.05). It can be inferred that there was significant difference in TEOAE amplitude for all the frequencies between two different stimuli shapes. This difference could be attributed to the broader spectrum that is seen in the rectangular shape in comparison with the trapezoid stimulus. The broad spectrum is known to stimulate the entire basilar membrane.

TEOAE findings using different stimuli like click and tone bust comparison has been studied in the past. The CEOAE uses click stimulus which has a broad spectrum, and consequently can stimulate a broad frequency region of the cochlea and TBOAE allows stimulus energy to be concentrated on a particular area of the basilar membrane and elicits a more frequency-specific cochlear response[3, 4]. Compared with CEOAEs, TBOAEs at similar stimulus levels can achieve a stronger response level with a greater signal to noise ratio (SNR) in normal adult ears. High reliability for TBOAEs was established for high and mid stimulus levels at all the frequencies tested [8, 9, 10].

Conclusion

From the present study it can be concluded that either of the click stimuli shapes i.e., rectangle or trapezoid can be used for recording of TEOAE. There was a significant difference observed between rectangular and trapezoid shape.

Rectangular shape produced better SNR than trapezoid stimulus shape. The results of this study can be strengthened by using different stimulus shapes and by trying on clinical population.

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