Effect of Different Click Durations on Transient Evoked Otoacoustic Emission

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Abstract: Otoacoustic Emissions (OAEs) are sounds which emerge from ear canal when (paradoxically) tympanic membrane receives vibrations from cochlea transmitted by middle ear. The present study was taken up as the literature review shows that the effect of different click durations on the presence of Transient Evoked Otoacoustic Emission (TEOAE) has not been studied. The present study involved 15 subjects (30 ears) with normal hearing sensitivity and having no history of any otologic or neurological problems. The results revealed that there was a reduction in Signal to Noise Ratio (SNR) of the TEOAE in all the frequencies from 1 kHz to 5 kHz when the duration was increased to more than 300 µs. Hence from the present study we can conclude that duration of 300 µs or below gives a maximum SNR in TEOAE.

Keywords: Click, TEOAE, Cochlea, Frequency, Signal to Noise Ratio.

1. INTRODUCTION

Otoacoustic Emissions (OAEs) are sounds which emerge from ear canal when (paradoxically) tympanic membrane receives vibrations from cochlea transmitted by middle ear (Kemp, 2002). These vibrations occur as a by-product of a specific and vulnerable cochlear mechanism known as “cochlear amplifier” and highly contribute to hearing sensitiveness and discrimination of frequencies (Kemp, 1978; Kemp, 2002).

Traditionally the transient Evoked Otoacoustic Emission (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 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 (Kemp et al, 1986; Kemp et al., 1986; Harris et al., 1991, Harris & Probst, 1997). When cochlea is involved by noise exposure, acoustic trauma, drug administration, surgery, age and contralateral stimulation, TEOAE can suffer alterations, in both composition of frequencies and in amplitude (Harris et al., 1991), for this reason it is a sensitive technique to identify changes on cochlear function (Kemp, 2002).

Need for the Study

The most promising application has been the use of evoked otoacoustic emissions as a screening device for the identification of hearing impairment, especially in neonates and infants. TEOAE have been widely used to assess the functioning of cochlear outer hair cells. Since the Click evoked otoacoustic emissions (CEOAE), click stimulus has a broad spectrum and consequently can stimulate a broad frequency region of the cochlea in a single measurement, CEOAE measurement has been especially applied as a general tool in universal neonatal hearing screening (UNHS) programs (Hall, 2000; and Kemp, 1990). In most of healthy ears, OAE are present, and they can be registered when thresholds are better than 25dBHL in frequencies of 250Hz to 8 KHz in TEOAE and in DPOAE, better than 45dBHL in the same frequencies (Kemp and col., 1986; Harris et al., 1991, Harris & Probst, 1997). When cochlea is involved by noise exposure, acoustic trauma, drug administration, surgery, age and contralateral stimulation, TEOAE can suffer alterations, in both composition of frequencies and in amplitude (Harris et al., 1991), for this reason it is a sensitive technique to identify changes on cochlear function (Kemp, 2002).
was taken up to find out the effect of different click durations on the presence of TEOAE.

**Objectives of the Study**

The aim of the present study is to compare TEOAE response using different click durations stimuli.

**2. METHODOLOGY**

Total of 15 subjects (30 ears) were taken for the study. 15 normal hearing individuals (7 males and 8 females) with age ranging from 15-35 years served as subjects for the present study. All the subjects were having hearing threshold within 15dBLHL across 250Hz to 8 KHz with ‘A’ Type tympanogram and stapedial reflexes being present within normal range. None of the subjects had a history of otological and neurological problem. All the tests were carried out in sound treated room.

**Instrumentation**

1. To evaluate the hearing sensitivity GSI- 61 was used.
2. To analyze the middle ear function GSI Tympstar (version-2) was used.
3. Neuro-audio (version 1) was used to obtain TEOAE.

**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 was evaluated for the bone conduction threshold. Following that immittance measures was done to rule out the middle ear pathology. Subsequently, TEOAE was done using eight different click durations i-e, 50µs, 100µs, 150µs, 200µs, 250µs, 300µs, 350µs and 400µs using Neuro-audio (version 1). The click stimulus shape used was rectangular, which had only plateau time and 0 µs on time and off-time. To consider the response present reproducibility was taken as >60%. Finally TEOAE in normal hearing subjects was recorded with the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity</td>
<td>80dBSPL</td>
</tr>
<tr>
<td>Analysis frequency</td>
<td>1KHz, 2KHz, 3KHz, 4KHz, 5KHz</td>
</tr>
<tr>
<td>Stimulus</td>
<td>Click</td>
</tr>
<tr>
<td>Stimulus shape</td>
<td>Rectangle</td>
</tr>
<tr>
<td>Total number of stimulus</td>
<td>500</td>
</tr>
</tbody>
</table>

If the rejection was >5% then test was discarded and redone for the same subject. Signal to noise ratio was compared between the different click duration stimulus.

**Analysis**

The data was analyzed using SPSS software, version 10. One way ANOVA test was carried out to see the significant differences of signal to noise ratio using different duration of click stimuli. Post Hoc analysis (Bonferroni) was also done to see the effect on different click duration.

**3. RESULTS**

In the present study, a total of 30 ears from 15 subjects were taken. The frequencies at which responses obtained were 1, 2, 3, 4 and 5KHz. Graph 1 shows the mean SNR of the eight durations used.

![Graph 1: Shows the Mean SNR for Different Duration Click Stimuli](image)

From the above bar chart it can be seen that as the duration was increased more than 300µs there were reductions in SNR for all the frequencies from 1 to 5 KHz. The minimum mean SNR was obtained at 1 KHz using the different duration. The maximum mean SNR compared to other frequency was obtained at 2 and 3 KHz. It was observed that the mean SNR increases as the duration of the click stimuli is increased from 50 μs to 300 μs. For all the frequencies from 1 to 5 KHz the maximum mean SNR were obtained using the click duration 300 µs.

![Graph 2: Shows Standard Deviation for Different Duration Stimulus](image)

As shown in graph II, have approximately same standard deviation for 1, 2, 3, 4, and 5KHz for all the duration from 50 to 400 µs. One way ANOVA revealed no significant main effect of click duration on TEOAE on SNR amplitude.
4. DISCUSSION

Result of the current study at the 1 KHz there was reduction in SNR as compared to other frequency. This might be because of physiological or biological noises which mask the low frequency TEOAE response. There was reduced SNR at 5 KHz as compared to 2, 3 and 4 KHz. This might be because of the time difference between stimulus offset and onset of the recording of TEOAE response.

It was also revealed from the present study that there was no statically significance difference in response elicited by clicks of different duration. But as the duration increased from 50µs to 300µs, there was increase in signal to noise ratio. This might suggest the possibility of temporal integration that occurs at cochlear level. As the duration increased beyond 300µs there was reduction in SNR. Reduction in TEOAE SNR, as the function of stimuli duration, could probably be due to the following reasons. 1) The spectral dips for 350µs stimulus occurs every 2857 Hz and for 400µs it occurs at every 2500 Hz which is leading to reduced stimulus energy and thus resulting in reduced SNR. 2) As the duration of stimulus increases, the pre-stimulus period for the noise estimation reduces which might result in higher estimation of noise floor which might be reducing the SNR for the longer duration of click stimuli.

5. CONCLUSION

The present study reveals that at the 300µs there was maximum SNR when compared to other duration. Beyond the 300µs there was reduction in the SNR for all the frequencies from 1 to 5 KHz. From the present study we can conclude that click duration can be used as 300µs which gives maximum SNR or below. There is a need to explore this study on hearing impairment subject to see the artifact.

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References