OTOACOUSTIC EMISSION: A REVIEW OF LITERATURE From 1978 to 1991

Reg NO M 9104

An independent project submitted as part fulfilment for the first year

M.Sc. (Speech and Hearing) to the University of Mysore

All India Institute of Speech and Hearing
MYSORE - 570 006

MAY 1992

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CERTIFICATE

This is to certify that the Independent Project entitled **"OTOACOUSTIC EMISSION: A REVIEW OF LITERATURE From 1976 to 1991"** *is a bonafide work, done in part fulfilment for the First year Degree of Master of Science (Speech and Hearing), of the student with* **Reg.No.M 9104.**

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MAY 1992

CERTIFICATE

This is to certify that the Independent Project entitled: **"OTOACOUSTIC EMISSION: A REVIEW OF LITERATURE From 1978 to 1991*** *has been prepared under my supervision and guidance.*

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Dr.(MISS).S.NIKAM
GUIDE

DECLARATION

I hereby declare that this Independent Project entitled. **"OTOACOUSTIC EMISSION: A REVIEW OF LITERATURE From 1978 to 1991"** *is the result of my own study under the guidance of* **Dr.(MISS).S.NIKAM,** *Professor and Head of the Department of Audiology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other Diploma or Degree.*

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INTRODUCTION

Otoacoustic emission means the emission of sound energy from ear which can be detected at the eardrum by a miniaturized sensitive microphone. It is an unbelievable fact because one can never think that eye can produce light or nose can produce smell. Then how is it possible for the ear to produce the sound energy?

This phenomenon is now almost established with a dramatic change in our understanding of the micromechanical properties of mammalian cochlea. The concept of the cochlea as a passive organ that converts the mechanical vibrations into neural discharges has been altered by the electromotile property of the outer hair cell. Brownell (1983) first demonstrated the motility of the outer hair cell stimulated by either d.c, or a.c. electricity. This electromitility, in turn, sets oscillations into outer hair cell at audible frequencies and hence, otoacoustic emission is produced. So now cochlea is considered to have bidirectional transduction property-both reception and production of acoustic stimuli.

Models considering cochlea as a passive transducer could not explain many of the auditory phenomena and hence, as early as 1948, Gold proposed that mechanics of basilar membrane are influenced by metabolic processes. He reasoned that the passive mechanics of the basilar membrane could not themselves account for psychological thresholds and frequency DL. Hence, .some type of active process which enhances the passive mechanical, response of the basilar membrane to sound had to be involved.

Bekesy in 1955 reported on the paradoxical wave travel along the cochlear partition, and he also could not explain all auditory phenomena.

On the other hand, tinnitus, perplexing pathological auditory symptom was also unexplained and needed proper explanation and the hearing scientists were trying to study this phenomenon objectively by measuring it with various techniques.

Due to these reasons, scientific experimentations were going on and Rhode (1971) was the person to report experimental evidence for nonlinearities in the vibration of the basilarmembrane. Later Kemp (1978) reported a most remarkable phenomenon of evoked acoustic emissions and this was an important milestone in the understanding of cochlear mechanics and also in the tinnitus related research.

Since then various experiments were done to explore the properties of various types of otoacoustic emissions (OAEs), to develop appropriate instruments to record, to find the appropriate stimulus parameters to evoke and to explore other facts and factors related to them along with the clinical applicability of OAEs to know the integrity of the cochlear-micromechanics and the effect of conductive and retrocochlear pathologies on OAEs.

TYPES OF OAEs: OAEs can be classified into two types:

(i) Spontaneous OAEs (SOAKs) occur in absence of any deliberate stimulation of ear. They can be detected in about 50% of all ears with normal hearing by sealing a sensitive miniature microphone into the EAM.

(ii) Evoked OAEs (EOAEs) occur in response to the presentation of acoustic stimuli to the ear. They can be detected in about 100% of all ears with normal hearing by sealing a sensitive miniature microphone and miniature ear speaker(s) into the EAM. On the basis of the stimuli used to elicit, EOAEs can be classified into three types:

(a) Transiently Evoked OAEs (TEOAEs) are elicited by a transient acoustic stimuli such as a click or tone burst.

(b) Stimulus frequency evoked OAEs (SFOAEs) are elicited by a single continuous sweep frequency puretones.

(c) Distortion product OAEs (DPOAEs) are generated in response to two continuous puretones, separated in frequency by a prescribed difference (in Hz).

OAE AND TINNITUS: When the OAE was discovered, many thought that they got the explanation, of tinnitus and they started experimenting in order to establish the link between OAEs and tinnitus. These people hypothesized that SOAEs are generated due to microlesions of the outer hair cells which does not manifest as a hearing loss and tinnitus and SOAEs have the same origin or may be they are one and same. But now this hypothesis is almost rejected and.

SOAEs are considered as a phenomenon observed from normal cochlea and the individuals most often are not even aware of them. Tinnitus, on the other hand, is a pathological annoying symptom due to which the individuals are disturbed. But some of the studies did find some evidence linking SOAEs and tinnitus.

OAK EXPERIMENTS ON OTHER ANIMALS: OAEs unlike many other auditory facts and properties were first discovered on human beings and then scientists turned towards experimenting other lower animals in order to understand the phylogenetic development of the cochlea in terms of cochlear nonlinearities, distortion products and OAEs.

CLINICAL IMPORTANCE OF OABs: TEOAEs and DPOAEs have the high potentialities to be developed as a strong clinical tool in the audiological test battery. Through these two recordings, we get frequency specific information from the cochlea especially basilar membrane and moreover all normal hearing ears can be evoked to produce TEOAEs and DPOAEs, so absence of the response indicates the pathology at the particular frequency related place of basilar membrane. Research is going on broadly on two lines (a) spectral analysis and latency of the response and (b) finding the OAE threshold. TEOAEs are mostly experimented and this test is almost ready to be included as a hearing screening tool for neonates and infants. DPOAEs are still in basic experimentation stage and this has the high potential to be developed as a diagnostic threshold testing.

As compared to these two types, SOAEs and SFOAEs are less experimented and have less clinical significance because (a) SOAEs are not found even in 50% of the normals, (b) SFOAEs are difficult to record and analyze for want of appropriate technological development and moreover SFOAEs give the same information as given by TEOAEs.

In addition, EOEs are an easy to use, noninvasive, rapid, cost effective and objective tests.

In India, little work in this area seems to be going on for want of instruments required to experiment with OAEs. Till now, Oto-dynamic ILO88 hardware and software systems are only commercially available instrument in the world. Programmable Otoacoustic Emission Measurement System (POEMS) is also developed for this purpose. There are other microcomputer based systems but none of them are commercially available. India being the exporter of computer and softwares, our computer engineers should be in a position to develop appropriate software programme so that we can also join hands with our foreign colleagues in research and development in the field.

With this as prime objective, a review of literature especially emphasizing the instruments needed, with the specifications was felt necessary. Even if we do not develop indigenous instrument we are still in a need to review the works already done till date in the area to update our knowledge and this may, in future, help us while experimenting this interesting area of research and clinical practice.

PURPOSE OF THE STUDY

The purpose of this study is to review the various articles on OAEs in the last 14 years (1978-1991) and see the trend in the following aspects.

1) Whether the articles are review, basic experiment or clinical application.
2) Whether more number of experiments on animals or human beings are reported.
3) The type of OAEs more frequently studied.
4) The instruments more frequently used in the experiments.
5) Major areas of focus of OAE research.
6) Authors who have contributed more to the field of OAE.
7) The journals in which more number of OAE articles are published.
8) Year-wise analysis of articles.

METHODOLOGY

The journal articles dealing with otoacoustic emissions in human beings and other lower animals were selected for the study. The articles were collected from various journals and the only book "Mechanics of Hearing" edited by de Boer and Viergever over a period of 14 years (1978-1991). The journals in which the articles were found are: (Further, these serial numbers are put for the respective journals in Tables).

1) Journal of the Acoustical Society of America.
2) Hearing Research.
3) Scandinavian Audiology.
4) Ear and Hearing.
5) Acta Otolaryngologica.
6) Annals of Otology, Rhinology and Laryngology.
7) Journal of Speech and Hearing Research.
8) British Journal of Audiology.
9) Audiology.
10) Archives of Otorhinolaryngology.
11) Laryngoscope.

All the journals related to ENT, acoustics and audiology including the above mentioned journals were scanned and a total of 129 articles were found to be related to the otoacoustic emissions. The articles were divided into 3 categories.

a) Basic experiments.

b) Clinical application.

c) Review and Related articles.

The articles under "Basic Experiments" were of basic kind of studies where the properties of different types of otoacoustic emissions were explored, the basic instrumentation needed for evoking and recording the otoacoustic emissions were developed and the various factors related to and affecting otoacoustic emissions were experimentally identified. They were further subdivided into five categories.

1) SOAE (Table 3.1.1) (2) TEOAE (Table 3.1.2)
3) SFOAE (Table 3.1.3) (4) DPOAE (Table 3.1.4).
5) Animal studies (Table 3.1.5)

The articles under "clinical application" were of applied kind of experiments where the various types of otoacoustic emissions were clinically tested in different groups of pathological cases in order to Justify the significance of this phenomenon as a strong tool of hearing diagnosis. They were further subdivided into three categories.

1) TEOAE (Table 3.2.1)
2) DPOAE (Table 3.2.2)
3) Tinnitus related (Table 3.2.3).

The information from these articles were classified under various columns and were tabulated chronologically.

After compiling the data in tabular forms, it was analyzed to determine the trend in various aspects. The findings are discussed.

RESULTS

The articles are summarized in the following thirteen tables in which they are arranged chronologically (year-wise) in alphabetical order. The columns of various tables indicate as follows:

TABLE-3.1.1: Summarises all the articles related to basic experiments in the area of SOAE in human subjects.

Column-1: Serial number of the article

Column-2: Year of publication

Column-3: The name(s) of the author(s).

Column-4: Serial number of the journal in which the article was published.

Column-5: Purpose of the article.

Column-6: Number of ears (e) and/or subjects (s) experimented.

Column-7: Age range of the subjects.

Column-8: Sex distribution of the subjects.

Column-9: Normalcy/abnormalcy of the ears experimented.

Column-10: Instruments used by the authors in the experiment. In this column the specifications and models of instruments are also given.

Column-11: Results/Conclusions - Wherever the authors did not conclusively infer out of the results obtained in the study the results (in place of conclusions) are stated. In the exploratory type of articles also, the findings (results) are stated.

Column-12: Remarks.

TABLB-3.1.2: Summarises all the articles related to basic experiments in the area of TEOAE in human subjects.

Column-1 to 9: Same as described in Table-3.1.1.

Column-10: Stimuli used to elicit the TEOAE. The specifications are also mentioned wherever it was reported in original article.

Column-11: Gives whether the article measures latency of the frequency specific responses or the threshold of TEOAE.

Column-12 to 14: Same as described in Table 3.1.1. under the columns 10 to 12 (in series) respectively.

TABLE-3.1.3: Summarizes all the articles related to basic experiments in the area of SFOAE in human subjects.

Column-1 to 10 and 12 to 14: Same as described in Table-3.1.2.

Column-11: Gives whether the study was done exclusively on SFOAE or along with other types of OAEs

TABLE-3.1.4: Summarizes all the articles related to basic experiments in the area of DPOAE in human subjects:

Column-1 to 10 and 12 to 14: Same as described in Table-3.1.2.

Column-11: Gives whether the article does the spectral analysis or threshold measurement of DPOAE.

TABLR-3.1.5: Summarizes all the articles on animal studies.

Column-1 to 5 - Same as described in Table 3.1.1.

Column-6: The animal who was subjected to experimentation.

Column-7 to 11: Same as described in Table 3.1.2 under the columns 6 to 10 (in series) respectively.

Column-12: Anaesthesia used during OAE measurements.

Colnmn-13: Type of OAE studied.

Column-14 to 16: Same as described in Table 3.1.2 under the columns 12 to 14 (in series) respectively.

TABLE- 3.2.1: Summarizes all the articles related to clinical applications in the area of TEOAE in human subjects. The columns are same as described in Table 3.1.2.

TABLE-3.2.2: Summarizes all the articles related to clinical applications in the area of DPOAE in human subjects. The columns are same as described in Table-3.1.4.

TABLE 3.2.3: Summarizes all the articles related to the tinnitus.

Column-1 to 10 and 12 to 14: Same as described in Table.3.1.2

Column-11: Gives the types of emission studied.

TABLE 3.3: Summarizes all the review and related articles in which models are also included.

Columns 1 to 4: Same as described in Table 3.1.1.

Column-5: Gives the heading of the articles.

TABLE-3.4: summarizes the instruments, their models and specifications used by the authors for experimentation. Only four important instruments are taken for the analysis and they are (a) Microphones, (b) Ear speakers, (c) Spectral analyzers and (d) Computer systems. The frquency distribution gives the number of times (articles) these instruments are used.

TABLE-3.5: Summarizes the major area of focus of research in different types of OAE.

TABLE-3.6: Summarizes the number of articles - (all the three, basic, clinical and review) against each author.

TABLE-3.7: Summarizes the year wise and journal wise breakup of experimental articles. Under each year:

Subcolunm a) means the number of articles reporting basic experiment.
Subcolumn b) means the number of articles reporting clinical application.

The first column gives the journal number as stated earlier.

3.1

BASIC EXPERIMENTS

3.1.1

SOAE

1	2	3	4	5	6	7	8	9
1	1981	Zurek P.N.	I	A survey search for otoacoustic emission and its properties.	36s	-	-	Both
2	1983	Ruggero N.A. etal	2	To cite an evidence tor the hypothesis that SOAKs and TEOSEs are due to disruption of active feedback emchanisms of the ORCs upon basilar membrane vibration.	le			Pathological
3	1984	Burns K.N. et al	2	To investigate the interactions among multiple spontaneous otoaconstic emissions.	5s		-	-
4	1984	Mcfadden D etal	1	To study the effect of moderate doses of aspirin on OAE.	5s		-	Normal

10	11	12
TWo different ear canal insert probe asseMbly (A) For Author: (1) S3 (2) Plastic tubing i.d. 1.375 mm (3) Miniature Microphone Knowles KA1842 (6) For others - GSI Standard Microphone B & K 4131 Have analyzer HP3581 X-Y plotter	SOAKs were most often found between 1.0 and 2.0KHz and the sound pressure in the earcanal was less than 200micro Pa. The contour of constant supression exhibits frequency selectirity like that commonly associated with cochlear frequency analysis.	Age and sex distribution not mentioned.
Plastic speculum Beyer DT-48 Earphone. Knowles EA-1842 microphone. amplifier (Princceton applied research CB 4 or Ithaco 1201) 10^2+10^4 Wave analyzer Hewlett Packard 3581A. *FFT* (MSP-3X).	An external continuous tone is able to supprss the SOAE. The 3dB-iso-suppression curve is broadly tuned and displaced, relative to the SOAE toward higher frequencies. An audiogram notch exists at frequencies just below that of of the SOAE.	Authors explain these findings in terms of disruption of active feedback mechanisms of the outer hair cells upon basilar membrane vibration.
Knowles transducers EA1842. Knowles transducers BR1888. Grason stadler otoadmittance meter earpiece. FFT (1.25Hz line spacing). Spectral averaging. Zwislocki coupler in a KEMAR.	The results of this study demonstrate the highly nonlinear and extremely complex nature of the active cochlear process.	The study should be repeated with more number of cases with sound experimental design.
Otoadmittance earpiece Grason Stadler modell720B. Knowles miniature Microphone XL-9073. Amplifier. High pass filter, 400Hz. High resolution signal analyser B&K 2033.	SOAEs gradually diminished and then disappeared during the drug regimen. Small SOAEs disappeared within 14-20 hours of beginning the drug regimen whereas large SOAEs to 40-70 hours to disappear completely. The initial size of SOAE appeared unrelated to the time required for it to recover to full strength once drug administration ceased. The recovery system has highly idiosyncratic.	Authors have not controlled the effect of any use of salicylate containing drugs on the results. These drugs are easily available in market. '

1	2	3	4 5		6	7	8	9
5	1984	Rabimowits W.M et al	1 To explore the basic properties of SOAEand their Interactions with tones	single external	19e 12s	18-36 yrs		Normal
6	1984	Wier C.C. et al	1 To determine the existence and characteristics of SOAEs In a nomally	hearing population	47s	19-50y	-	Normal
7	1984	Zwicker E. et al	1 To measure the amplitude and phase of evoked synchronous emissions, their frequency spacing and level dependence.		-	24-35y	-	Normal
8	1985	Strickland E.A. et al	1 To detenine the incidence of SOAEs in children and infants.		71s	5y7m-12y9m children 17-45d infants	21b-29g children 8b-13g infants	nonal

10	11	12
Two probes (a) Prob-1: Containing small microphone Knowles EA1842. (b) Probe-2; containing above microphone and a miniature receiver Knowles BK1888. Acoustic resistor Knowles BF1961. Preamplifier sigatics 5532; gain 40dB. Butterworth high pass filter; 400Hz;12dB/Oct. FFT spectrum analyser Hetlett-Packard 3582A. Audimetric earphone TDH39.	For suppressor tones below and slightly above the frequency of an SOAE, suppression is quite abrupt. As suppressor frequency increases above the SOAE, the rate of suppression decreases. A release from suppression was-demonstrated by the interaction, of an SOAE with two external tones. This finding is interpreted as the second tone having suppressed some aspect of the intracochlear influence of the first tone. The growth rate of secondary suppression appears to be near ldB/dB.	The physical measures of tone-on-tone suppression as derived from SOAE unmasking in subjects with an intense SOAE, can be compared with psychophysical measures of suppression from those same subjects; such comparisons might resolve whether intersubject differences in psychophysical results have an intracochlear physical counterpart.
Grason Stadler 1720B otoadimttance earpiece. Knowles miniature microphone IL9073. Low noise preamplifiers. High pass filter 400Hz, zero gain, 8-pole Butterworth design. Operational amplifiers NE5534As. Realtime spectral analyser Hewlett-Packard 3582A X-Y plotter.	SOAEs sere found 38% of the people 4 27% of the ears tested.	The results are quite similar to those reported by Zurek (1981).
Specially developed electret licrophone. Preaiplifier Tektronix AM502. Tracking frequency analyser B&K2020. Small transmitter AKG CE52. Knowles BT1754/Sennheiser 04-211 Microphone Spectral analyser HP3580A. Dynamic earphone Beyer DT48.	SOAE, SFOAE & TSOAE result from the same source, which is located within the cochlea and therefore mirrors their hydromechanical characteristics.	If these emissions are originated from the same source, the why there is difference in the incidence and save form of these eiissions.
Miniature microphone Knowles EA1842. Grason Stadler impedance probe. Wavetek-Rockland 5820A spectral analyser. Digital plotter.	There is no significant difference in the incidence of SOAEs with age. There is a significant difference in the incidence of SOAEs in males & females, females showing higher incidence.	So we can reject the hypothesis that the SOAEs are produced by the microlesions of outer hair cells.

1	2	3	4	5	6	7	8	9
9	1985	Wit H.P.	2	To investigate the short term stability of OAE frequency in detail.	2s	23-27	lm-lf	-
10	1986	Cianfrone G. etal	3	To explore the prevalence of SOU interms of rate of occurrence, frequency spectrum and intra and inter subject variability.	104e 52s	18-41	Both	Normal
11	1986	Probst, R etal	2	To know the efficacy of different stmiulus type in eliciting emissions and to know the effect of SOAE on E0AE.	28e 14s	19-35	7m-7f	Normal
12	1988	Bargones et al	1	To measure the tuning of OAEs in the developing auditory system by making longitudinal measurements of SOAESTCs in human infants.	34s	infant <3weeks adults 9-45yrs	-	Normal adults

10	11	12
Microphone. Princeton Applied Research 4512 real time spectrum analyser.	A statistically significant frequency decrease during the morning hours was observed.	More no. of cases should be taken for further studies. Sex difference observed should also be studied further.
1/2' microphone B&K 4166. Preamplifier B & K 2660. Sound level calibrator B & K 4230. Dual channel FFT analyser B&K 2032.	SOAEs has been detected in 26% of ears and 30.8% of subjects. Bilateral SOAEs have been observed in 68.8%. Frequencies of the strongest emissions ranged from 1-2KHz (96.3%). Amplitudes varied from 3 to 20 dB SPL above the background noise. Spectra were always very sharp and stable in frequency but less stable in amplitude.	These results generally agree with the data available in literature.
Acoustic probe: a) Miniature microphone Knowles BT1751. (b) Miniatue earspeaker Knowles BK1985. 2 c.c. coupler DB 0138. 1. condenser microphone B&K 4131. Spectral analyser Hewlett-Packard 3850a. Preamplifier (10^3) Band pass filter (0.25 to 6 KHz). Kroha Hite 3343 R. Amplifier (10^2) LSI-11 laboratory microcomputer. FFT. Flexible disk.	Two distinct pattens TEOAEs were identified (a) 18% ears showed short broadband clickevoked emissions lasting less than 20ms after stimulus onset (b) 82% ears showed click evoked emissions lasting longer than 20ns poststimlus onset.	Good explanation of the stimuli & Instruments used.
Knwles EA1842 microphone. Knowles 1888 driver. Grason Stadler impedanee probe. Function generator Hewlett Packard 3325A Wavetek Rockland FFT analyser 5820A.	Cochlear toning characteristic in 3weeks old infants are same range as those of adults.	This longitudinal study should be continued further to get even nore knowledge of development. Comparison of EOAE in children with that of the adults is questionable because the two groups were not matched. Evidence from two subjects suggested that developmental changes in the fine tuning of the system may be occur postnatally. So, the experiment should be repeated further by others with more objectivity

1	2	3	4	5	6	7	8	9
13	1988	Frick L.R. et al	4	To find out the effect of the external stimuli on spontaneous otoacoustic emissions.	31s	21-31y	Female	Normal
14	1988	furst M. et al	1	To study the discrepancy between the two interpretations of the source of DPOEAs in humans.	11e 8s	20-35y	-	Normal
15	1988	Long G.R. et al	1	To explore the relation between OAE (both SOAE and EOAE) and psychoacoustic thereshold microstructure.	4s	-	-	
16	1988	Wier C.C. et al	1	To explore the association between SOAE and DPOAE under aspirin use.	4s	-	Male	

10	11	12
Otoadmittance speculum assembly (Grason Stadler). An electret microphone Knowles 1842 PY517. Plastic tube (length 13mm, 1mm i.d.). Soft plastic impedance tip. Preamplifier signetics 5534 op-amp (40dB) Spectrum analyser (HP 35824) FFTs. ER-10 microphone & preamplifier assembly. ER-3A tubephone. Frequency synthesizer HP 3325A. Attenuator i-P 350D.	SOAEs were detected in 38.7% of subjects and 25.8% of ears screened. The frequency of SOASs ranged from 1304 to 4666Hz with 50% emissions detected between 1K and 2KHz and 50% above 2KHz. The amplitude of measured SOAEs ranged from 1.2 to 15.4dB SPL mean 6.94 dB SPL; SD 3.35). Multiple emissions were present in 66.7% of subjects and 62.5% of ears. Bilateral emissions were detected in 33.31 subjects. Completed suppression contours closely resembled the well documented psychophysical tuning curves of the ear.	Only females were subjected to the study. Future research should supplement existing data regarding the behavior of SOAEs and their interaction with external signals across a wide range of subjects.
Acoustic probe (a) Two Knowles BK-1888 receivers, (b) Knowles EA-1842 microphone. Preamplifier (40dB). Band pass filter (400Hzto 22KHz, 12dB/0ct). Spectral analyzer Hewlett and Packard 3582A.	Ears tended to exhibit all or none of the emission types that were sought. The magnitude of SFOAS and DPOAE showed a similar dependence on frequency. Simultaneous cancellation of perceptual and acoustic distortion was produced rarely.	The results can be interpreted qualitatively sith a model in which primary tones produce distortion at their interaction region within the cochlea, this distortion propagates to the distortion frequency place where it mediates perception. Detailed specifications of the stimuli used not given.
Probe (Grason Stadler otoadmittance earpiece a Knowles EA-1843 transducer, b) Knowles BT-1752 transducer. Amplifier. Wavetek - rockland 753A Brickwall filter (500 to 550082). Wayetek 5820A spectrum analyzer. B & K 2010 heterodyneslave filter. Nova 4x computer.	SOAE gradually diminished and then disappeared during drug regimen. EOAE and threshold microstructure were also reduced by aspirin consumption but persisted longer and recovered sooner. In most instances the initial change in threshold microstructure was a trend to increased sensitivity with a greater increase near threshold maxima than at threshold minima.. Further reduction in the levels of EOAE was accompanied by the eventual decrease in sensitivity.	The study should be repeated with a better experimental design on a larger sample. These findings are similar to the findings of McFadden and Plattsmier (1984).
Modified standard otoadmittance earpiece Garson-Stadler model 1720E. Knowles miniture microphone IL-9073. Two Knowles model 1869 receiver. Amplifier. High pass filter; 400Hz. Spectrum analyzer (Nicolet/Wavetek model 444a) TWO General Radio signal geneators (model l310A)	Aspirin consumption uniformly reduced the SOAEs to umeasurable or extremely low levels. Aspirin consuiption also reduced the amplitude of the DPOAEs but did not eliminate them entirely. The amplitude of DPOAE and its change with aspirin consuiption were related to both the proximity of the DPOAE to the frequency of the SOAE and to the level of primaries producing the DPOAEs.	The results indicate that peripheral auditory systems of humans and rhesus monkeys are alike in their responses to aspirin. The study lust be repeated with large sample.

1	2		4	5	6	7	8	9
17	1988	*Zizz* C.A. et al	7	To study the reliability of spontaneous otoacoustic emission suppression tunning curve measurements.	5s	23-38y	female	Normal
18	1990	Van Dijk P et al	1	To demonstrate the synchronization effect of DPOAE (2fl-f2) on SOAEs.	4e 4s	--	-	
19	1990	Van DiJk P et al	1	To present experimental data on amplitude and frequency fluctuations of SOAEs.	10e	-	-	
20	1991	Lonsbury Martin B.L. et al	1	To study the influence of aging on the generation of DPOAEs	60e 30s	31-60y	15a 15f	Normal

10	11	12
Modified grason stadler acoustic lmmittance probe assembly & 1720-9640. Miniature microphone Knowles EA-1842. Miniature earphone Knowles ED-1912. 4mm teflon tube (ID=1.35mm). Amplifier. High pass filter 400Hz, 30dB/0ct. Real time spectral analyser B&K type 2033. Oscilloscope (Hewlett Packard 1222A). Amplifier loudspeaker system. Interstate high Voltage AM-FM, model F46.	No significant difference between the SOAESTC trials (P>9.95) The mean slope of the SOAESTC low frequency segment was 53.7dB/oct whereas the mean slope of the SOAESTC high frequency segment was 124.8dB/Oct. The mean low to high frequency slope ratio was 2.4 The mean Q10 value was 5.3	The SOAKE STC low and high frequency slopes and Q10 were similar to psychophysical tuning curve data obtained in simultaneous masking and physiological tuning curve data.
Acoustic porbe (a) Condenser microphone. (b) Two earphones. Sony SL-C30E video recorder. Sony PCM-F1. Bandpass filter B&K 2020. HP 5326 a timer. Unigon 4512 FFT analyser.	When primaries were sufficiently loud (30dB SPL), phase fluctuated around a constant value: The emission was constantly synchromized to Fs. Lowering primary levels (20dB SPL) resulted in 360^0 phase jumps at random moments. The emission occasionally slipped out of synchronisation, trying to maintain its on natural frequency to.	This behavior can be described as synchronisation of an oscillator, fo to a sinusoidal force fs, in the presence of noise. The experiment can be replicated with more no.of cases and with the better design for further evidences and inferences.
Sensitive Microphone. Video tape (Sony SL-C30E video recorder) Pulse code modulatlon(Sony PCM-F1). Wavetek 178 signal synthesizer. Onigon 4512 FIT analyser. Band pass filter B&K 1623. Heterodyne Band pass filter B&K 2020. HP 5326 A timer.	Eiission amplitude and period both showed small fluctuations (a) A rms/Ao ranged from $0.7x10^{-2}$ to $6.3x10^{-2}$ for human emissions and was $24x10^{-2}$ for both frog emissions. Trms ranged from 1.4 to 6.9 x 10^{-7} for human emissions & was 50.0 and $55.0x10^{-7}$ for the two frog emissions. There was a positive correlation (R=0.9) between Arms/Ao and Trms.	Authors compare these results with that of second oscillator and observes that an oscillator with linear stiffness driven by white Gaussian noise cannot account for all experimental results.
Grason stadler E32 62A attenuator. Wavetek 116 sginal generator. Telex 1470 audiometric speakers. Artificial ear MI 4152. Acoustic probe. Two Etymotic research 11-2 Earspeakers. Etymotic research ER-10 microphone. Preamplifier Etymotic research 10-72. Computer	When compared to emissions in young ears, DPOAEs accurately tracked the systematic deterioration of high frequency hearing in aging individuals.	The instruments used are not described in detail. This finding can be clinically applied vhile interpreting the EOAE findings in aged cases. Further research is aanted with the pathological cases.

3.1.2

TEOAE

1	2	3	4	5	6	7	8	9	10	11
1	1978	Keap D.T.	1	To report the experimental investigation of some what unconventional cochlear emissions by specially designed technique and instruments	15s			Both	200 microsec rectangular pulse; repe-tition rate 16 per sec.	Latency
2	1979	Wit H.P. et al	1	To investigate the influence of stimulus frequency upon the magnitude of the response.	9s	23-34y	-	Normal	1.7,2.8,4.2 KHz ft band-width 600-900Hz, repe-tition rate 16 per sec.	Latency
3	1981	Wit H.P. et al	1	To study the properties of the frequency spectra of EOAEs recroded from human earcanal.	4s	22-30y	-	Normal	1.7,2.8,4.2 Hz ft band-width 600-900Hz	Latency
4	1983	Ruggero M.A. et al	2	To cite an evidence for the hypothesis that SOAEs and TEOAEs are due to disruption of active feedback mechanisms of the OBCs upon basilar membrane vibration.	1e	-		Pathol-ogical	Clicks or tone pips (3.75ms steady; 1.25ms rise/fall time	Latency

12	13	14
Acoustic probe; 1.5cm long; 1 diameter, a) Miniature microphone, b) Miniature earphone. Signal averager. Computer.	A new auditory phonomenon OAE has been identified in the acoustic impulse response of the human ear. The slowly decaying response component was present in all normal ears tested, but was not present in ears with cochlear deafness.	The author supports cochlear reflection hypothesis with these results, further studies with better experimental designs and also exploratory in nature are required to explore the properties of TEOAEs.
Knowles K1671 miniature microphones. Spectral analyser ubiquitous 0A-6B. Modified princeton applied research type TDH 9 Signal average (100 memory points) or Datalab type DL400 digital averager (1024 memory points) High pass filter; 500Hz, 14dB/Oct	Stimuli of higher frequency generate much smaller emissions than stimuli of lower frequency at the same stimulus level. For low response levels the relation between stimulus level and response level is approximately linear. High response levels rise approximately as the cube root of stimulus level. A tuning curve could be derived by suppressing Missions with a second steady tone.	Sex distribution of subjects not reported. The same experiment sith large sample should be repeated.
Sensitive condnser microphone. Plastic tube 3.5mm i.d. Amplifier. Band pass filter (0.5-4KHz, 24dB/Qct). Spectral analyser ubiquitous UA-6B. Oscilloscope Datalab DL4000 signal average. LOW pass filter (Krohn-Hite 3343, 96dB/0ct)	The two procedures (viz.real time recording and calculation of the spectral of time averaged emission) give different input-output curves or TEOAE. The real time spectral recording procedure can be used to measure tuning curves or to study the distortion product 2fl-f2.	The results indicate that sharphy tuned emission generators are present in the human cochlea.
Plastic speculum Beyer DT-48 Earphone. Knowles EA-1842 Microphone. Amplifier (Princeton applied research CR 4 or Ithaco 1201) 10^{-2}-10^{4} Have analyzer Hewlett Packard 3581A. FFT (MSP-3X).	An external continuous tone is able to supprss the SOAE. The 3dB-iso-suppression curve is broadly tuned and displaced, relative to the SOAE toward higher frequencies. An audiogram notch exists at frequencies just below that of of the SOAE.	Authors explain these findings in terms of disruption of active feedback mechanisms of the outer hair cells upon basilar membrane vibration.

1	2	3	4	5	6	7	8	9	10	11
5	1983	Zricker.E	2	to investigate the differences reported iD the literature regarding the slope of the relation between stimulus level and emissioi level.		23-58y	-	Normal	Sinusoidal cycle/short tone brust/ G envelopes repetition rate 23-43 /sec.	Ltancy & threshold
» 6	198 4	Zsicker E. et al	1	To measure the amplitude and phase of evoked synchronous emissions, their frequency spacing and level dependence.		24-35y	-	Normal	No specific mention	Latancy 4 threshold
7	1986	Antonelli.A et al	3	To analyse the intrasubject stability of the TI0AE. To study the influences of the relative position between the head and body on the TEOAE.				Normal	Click-100 microsec. Brust-5ms 500micro sec rise/ fall time 21/sec.	Latency
8	1986	Probst, R. et al	2	To know the efficacy of different stimulus type in elicitiag emission and to know the effect of SOAE on EOAE.	28e 14s	19-35	7m-7f	Normal	Clicks-O.lis pulses Tone burst 0.5,1.1.543 KHs rise/fall 2 cycles	Latency

12	13	14
Microphone sennheiser HJH110/1 lith IOR frequency cat off at 0.31z. Earphone DT 48s Aiplifier. Octave band filter. Transforier.	SOAK level is directly proportional to the stimulus level till 20 dBSL above which EQAS saturates. SOAS lying in the saie frequency range as EOAE influences above relation. SPPs are lirror itages of HPPs.	Third conclusion gives the evidence that tasking is the cochlear (peripheral] phenomena.
Specially developed electret licrophone. Preaiplifier Tektronix AH502. Tracking frequency analyser B4I2020. Siall transittter AXG CE52. Snowies BT1754/Sennheiser IE4-211 Kicrophone Spectru analyser HP3580A. Dynaiic earphone Beyer DT48.	SOAE, SFOAE *k* TEOAE result froi the saie source, which is located within the cochlea and therefore lirrors their hydroiechanical characteristics.	If these eiissions are originated froi the saie source, than why there is difference in the incid-ence and wave fori of these eiissions.
Probes unofactured in cooperation with iiplald S.P.A. Band pass filter 200-5000Hz Bottenorth Floppy disks. Aiplaid HU software systei.	TEOAE waveforis are stable over tiie. A decrease in aiplltade and a tit: shift of evoked emissions whenever the subjects position was changed.	No.of cases, age&sex distribution was not lentioned
Acoustic probe: a) Miniature licrophone Inowles BT1751. (b) Miniature earspaker Inowles BI1985. 2 c.c. coupler B4K DB 0138. 1" condenser licrophone Bil 4131. Spectral analyzer Hewlett-Packard 38S0A. Preaiplifier (103) Band pass filter (0.25 to 6 Hz). Krohn lite 3343 B. Aiplifier (102) LSI-11 laboratory licrocoipoter. FFT. Flexible disk.	Two distinct patterns TEOASs were identified (a) 18X ears showed short broadband clickevoked eiissions lasting less than 20is after stiiulus onset, (b) 82X ears showed click evoked eiissions lasting longer tkas 20is poststiaulus onset.	Good explanation of the stiiuli 4 instruients used.

L	2	3	4	5	6	7	8	9	10	11
09	1987	Norton S.J. et al	1	To obtain systematic data on relationship between tone burst frequency and intensity aad E0AE characteristics in a group of norial ears.	75	22-28y	Females	Normal	Tone burst Latency 0.5,0.75,1.0 1.5&2.0KHz of 8.0,5.6, 4.0,4.2 & 4ms respect. repetiton rate 23/sec	Latency
10	1987	Van Dijk PP. et al	3	To determine whether Kemp echoes are useful techniques to define cochlear functioning.	210e 120s	18-25y	-	Normal	Clicks	Latency
11	1987	Zwicker E. et al	1	To elaborate on the correlation of the three values P(t), MPP & SPP	1s	62y	- -	-	Tone burst 1300Hz > 200 is; +3dBSPL	Latency
12	1988	Long GR et al	1	To explore the relation between 0AE (both SOAE and E0AE) and psychoacoustic thereshold microstructure.	4s - - -				For TEOAEs- 30microsec pulses at 20dBSL 2KHz half cycle at 20 dB SL for SFOAEs- puretone, range 1000 Is in 60sec 10 dBSL	Latency & threshold

12	13	14
Wavetek rockland 5826 A spectrum analyser. DAC. Programmable digital attemator. Acoustic probe. Etymotic research ER-2 earphone. Knowles EA1842 microphones. Amplifier 40dB gain. High pass filter 400Hz. Nicolet 1170 signal average	The spectra of TEOAEs resemble those of the evoking stimuli. The latencies of EOAEs are consistent with measures of forward basilar membrane travel time.	The above findings support the hypothesis that tone pip evoked emissions are a property of normal cochleas and are generated at places appropriate to their frequency along the cochlear partition.
Peters AP200 Small probe Microphone. Earphone.	Only a limited number (85 out of 210) displayed TEOAE.	They did not test the hearing before TEOAE recording. They assumed normal hearing because they were tested a few months ago while admission to speech & hearing graduate course. No specifications of the stimuli used provided. This finding limits the useful application of this techniques as a method to evaluate cochear functioning.
Microphone KE4 sesnnheiser DT-48 earphone MKH110/1 sennheiser microphone	The course of the SPP is a mirror image of that of MPP.	Similar resutls were found in animals.
Probe (Grason Stadler otoadmittance earpiece) a Knowles EA-1843 transducer. b) Knowles BT-1752 transducer. Amplifier. Wavetek - Rockland 753A Brickwall filter (500 to 5500Hz). Wavetek 5820A spectram analyzer. B&K 2010 heterodyneslave filter. Nova 4X computer.	S0AE gradually diminished and then disappeared during drug regimen. EOAE and threshold microstructure were also reduced by aspirin consumption but persisted longer and recovered sooner. In lost instances the initial change in threshold microstructure was a trend to increased sensitivity with a greater increase near threshold maxima than at threshold minima. Further reduction in the levels of E0AE was accompanied by the eventual decrease in sensitivity.	The study should be repeated with a better experimental design on a larger sample. These findings are similar to the findings of McFadden and Plattsmier (1984).

1	2	3	4	5	6	7	8	9	10	11
13	1988	Rossi G et al	5	To study the EOAEs through bone conducted stimulation. To study the role of ossicular chain in the transfer of E0AE to the eardrum.	10s	18-43y	-	Both	l000Hz tone burst 5ms rise/fall time lms repetition rate 31/sec	Latency & thershold
14	1988	Rossi G et al	3	To explore the possibility of using the bone conducted stimuli evoke TEOAE.	24e 24s	19-24y	Both	Normal	lKHz tone burst; 3ms, rise/fall time 1ms; repeti- tion rate 31/s	Latency
15	1989	Rossi G et al	3	To cite an experimental evidence for active intracochlear mechanisms as the core of TEOAE.	11s	12-26y	-	Patho- logical	Tone burst 3ms and rise/ fall time lms frequency 0.5 1 & 2KHz, repetition rate 31/sec.	Latency
16	1990	Collet L. et al	6	To investigate the age factor in relation to EOAEs.	166e 93s	6w-83y	-	Normal	Unfiltered rarefaction click 100 microsec.rate 22.7/sec.	Latency
17	1991	Harris F.P. et al	9	To assess the amount of variability in the level and spectrum of TEQAEs from normal ears.	10s	31.5y mean	5m 5f	Normal	80microsec rectangular pulses.	Latency

12	13	14
Amplaid BEVI aystem. Amplaid Echo probe. Radio Ear B71 bone vibrator.	In normal hearing, subjects, TEOAEs by BCS showed the same characteristics as those evoked by ACS. In subjectswith unilateral otosclerosis before surgery no EQAE could be elicited by ACS from the otosclerotic ear, whereas they could be recorded by BCS. After stapedectomy, EOAE could be obtained by ACS too.	There results suggest that the osssicular chain is important but not essential in the transfer of the TEOAE to the eardrum. Further studies are required for more evidence.
Amplaid MK VI Amplaid Echo probe for AC Radioear B 71 vibrator for BC. Quest mod. 215-45-12 pbonometer. *FFT*	The Morphology of BCEOE behaves in the same way as that of ACKOE. By contrast with ACEOE, whose mean threshold is the same as that of the subjective tonal threshold for the same stimulus presented by the same stimulation modality BCEOE threshold On average, is about lOdB HTL higher. ACEOE can not be obtained in otosclerotic subjects whereas they appear after surgery. BCEOE are obtained before surgery and increase in amplitude postopertatively.	The last finding early demonstrates that the ossicular chain plays an important but not an essential role in the transfer of TEOAE from the inner to the external ear.
Aiplaid MK VI system. Amplaid Echoprobe Knowles BK 2606 earphone. Knowles BT 1751 microphone. Quset Mod 215-45-12 phonometer. FFT.	TEOAE could be superimposed by a passive intracochlear mechanism.	
Tandy WM 063T Microphone. Enowles K2912 earphone. Band pass filter 200-7000Hz. Nicolet Pathfinder II apparatus.	When age increases the presence of EOAEs by age group and the frequency peak in spectral analysis decreases and KOAE threshold increases.	Sex distribution not mentioned. This finding should be used while interpreting the clinical results.
IL0 88 Otodynamic analyser. Portable computer compaq III. Foam E.A.R. type eartip.	The amplitude for TEOAEs is stable over sucessive short term measurment. Variability within individual spectral bands was approximately idB from 0.9 to 4.1KHz and was slightly greater for 0.7KHz.	This is one of the properties why TEOAEs can be considered as a potential test for cochlear functions. The experiment should be repeated With a large sample.

1	2	3	4	5	6	7	8	9	10	11
18	1991	Ryan.S. et al	8	To cite an experimental evidence for Collet effect.	4s	25-40y	-	Both	Click; repetition 50/s	Latency

12	13	14
Otodynamic ILO 88 acoustic emission analyzer. A probe for the NTE containing loudspeaker. A probe for TE containing a) Microphone, b) Earspeakers.	Collet effect was demonstrated in all the normal subjects. The amplitude and phase changes, though small, were easily identified using the difference response techniques.	Further research is required to investigate the neural significance of the presence or absence of the Collet effect in retrocochlear pathologies. The same experiment may be repeated in clinical settings with more no. of cases with ILO 88, which is only commercially available OAE instrument. The hearing scientist community is waiting for a simplified procedure which could be included in the audiological and vestibular test battery to add information about the integrity of the cochlea and the status of the medial efferent system.

3.1.3

SFOAE

1	2	3	4	5	6	78	9	10	11	
1	1984	Zwicker E. et al	1	To measure the amplitude and phase of evoked synchronous emissions, their frequency spacing and level dependence.	-	24-35y	-	Normal	No. specific mention	With SOAE TEOAE
2	1988	Furst M. et al	1	To study the discrepancy between the two interpretations of the source of DPOES in humans.	lle 8s	20-35y	-	Normal	A Continuous sweep freq. tone, level 30dBSPL. 2 Primary tones	with DPOAS & SOAE
3	1988	Long G.R. et al	1	To explore the relation between OAE (both SOAE and EOAE) and psychOACoustic thereshold microstructure.	4s				TEOAEs 30micro sec pulses at 20dBSL/2KHz half cycle at 20dBSL. SFOAES-Paretone range 1000Hz in 60s lOdBSL.	With SOAE, & TEOAE
4	1990	Gaskill S.A. et al	1	To investigate (i) the dependence of DPOAE level on stimulus parameters and (ii) the relationship between DPOAS level and auditory sensitivity.	34s	15-50y	19f 15m	Normal	2 Primary tones fl & f2 100s continuous frequency sweep from 500-5500Hz	with DPOAE

12	13	14
Specially developed electret microphone. Preamplifier Tektronix AM502. Tracking frequency analyser B&K2020. Small transmitter AKG CE52. Knowles BT1754/Sennheiser KE4-211 Microphone Spectrum analyser HP3580A. Dynamic earphone Beyer DT48.	SOAE, SFOAE & TEOAE result from the same source, which is located within the cochlea and therefore mirrors their hydromechanical characteristics.	If these emissions are originated from the same source, then why there is difference in the incidence and wave form of these emissions.
Acoustic probe (a) Two knowles BK-1888 receivers. (b) Knowles EA-1842 microphone. Preamplifier (40dB). Band pass filter (400Hz to 22KHz, 12dB/Oct). Spectrum analyzer Hewlett and Packard 3582A.	Ears tended to exhibit all or none of the enission types that were sought. The magnitude of SFOAE and DPOAE showed a similar dependence on frequency. Simultaneous cancellation of perceptual and acoustic distortion was produced rarely.	The results can be interpreted qualitatively with a model in which primary tones produce distortion at their interaction region within the cochlea, this distortion propagates to the distortion frequency place where it mediates perception. Detailed specifications of the stimuli used not given.
Probe (Grason Stadler otoadmittance earpiece) a)Knowles KA-1843 transducer. b) Knowles BT-1752 transducer. Amplifier. Wavetek - Rockland 753A Brickwall filter (500 to 5500Hz). wavetek 5820A spectrum analyzer. B&K 2010 heterodyneslave filter. Nova 4x computer.	SOAE gradually diminished and then disappeared during drug regimen. EOAE and threshold microstructure were also reduced by aspirin consumption but persisted longer and recovered sooner. In most instances the initial change in threshold microstructure was a trend to increased sensitivity with a greater increase near threshold maxima than at threshold minima. Further reduction in the levels of EOAE was accompanied by the eventual decrease in sensitivity.	The study should be repeated with a better experimental design on a larger sample. These findings are similar to the findings of McFadden and Plattsmier (1984).
Perspex metal probe specially designed. a) two 1712 loudspeaker. b) 1843 microphone. Philips PM5193 function generator. Ampifier. Spectrum analyser Hewlett-Packard 3561A. FFT BBC microcomputer with IEEE interface.	The frequency ratio f2/fl at which DPOAE level is maximal varies only slightly across frequency and subjects. The average optimal ratio is 1.225. Beyond the laximum, the DPOAE level declines with increasing f2/fl ratio at rates of upto 250dB/oct. As the level of one stimulus is increased relative to the other, DPOAEs grow, saturate and in most cases show a bendover. Maximum distortion is generated when L1 exceeds L2.	

3.1.4

DPOAE

1	2	3	4	5	6	7	8	9	10	11
1	1984	Burns E.M. et al	2	To investigate the interactions among multiple spontaneous otoacoustic emissions.	5s	-	-	-	*No* specific mention	Spectral analysis
2	1988	Furst M. et al	1	To study the discrepancy between the two interpretations of the source of DPOAEs in hUMans.	l1e 8s	20-35y	-	Normal	A Continues sweep freq. tone, level 30dBSPL. 2 Primary tones	Spectral analysis
3	1988	wier C.C. et al	1	To explore the association between SOAE and DPOAE under aspirin use.	4s	-	male	-	at & around SOAE freq.; within 100H:; f2/fl 1.15	Spectral analysis and threshold
4	1990	Gaskill S.A. et al	1	To investigate (i) the dependence of DPOAE level on stimulus parameters and (ii) the relationship between DPOAE level and auditory sensitivity.	34s	15-50y	19f 15m	Normal	2 Primary tones fl & f2, 100s continuous frequency steep from 500-5500Hz	Spectral analysis & threshold

12	13	14
Knowles transducers EA1842. Knowles transducers BR1888. Grason Stadler otoadmittance leter earpieces. FFT (1.25Hz line spacing). Spectral averaging. Zwislocki coupler in a KEMAR	The results of this study demonstrate the highly nonlinear and extremely complex nature of the active cochlear process.	The study should be repeated with more number of cases with sound experimental design.
Acoustic probe (a) Two Knowles BK-1888 receivers. (b) Knowles KA-1842 microphone. Preamplifier (40dB). Band pass filter (400Hz to 22KHz, 12dB/Oct). Spectrum analyzer Hewlett and Packard 3582A	Ears tended to exhibit all or none of the emission types that were sought. The magnitude of SFOAE and DPOAE showed a similar dependence on frequency. Simultaneous cancellation of perceptual and acoustic distortion was produced rarely.	The results can be interpreted qualitatively with a model in which primary tones produce distortion at their interaction region within the cochlea, this distortion propagates to the distortion frequency place where it mediates perception. Detailed specifications of the stimuli used not given.
Modified standard otoadmittance earpiece Garson-Stadler model 1720B. Knowles miniture microphone XL-9073. TWO Knowles model 1869 receiver. Amplifier. High pass filter; 400Hz. Spectrum analyzer (Nicolet/Wavetek model 444a) Two General Radio signal feneators (modell3104)	Aspirin consumption uniformly reduced the SOAEs to unmeasurable or extremely low levels. Aspirin consumption also reduced the amplitude of the DPOAEs but did not eliminate them entirely. The amplitude of DPOAE and its change with aspirin consumption were related to both the proximity of the DPOAE to the frequency of the SOAE and to the level of primaries producing the DPOAEs.	The results indicate that peripheral auditory systems of humans and rhesus monkeys are alike in their responses to aspirin. The study must-be repeated with large sample.
Perspex metal probe specially designed. a) two 1712 loudspeaker. b) 1843 microphone. Philips PM5193 function generator. Amplifier. Spectrum analyser Hewlett-Packard 3561A. *FFT* BBC microcomputer with IEEE interface.	The frequency ratio f2/f1 at which DPOAE level is maximal varies only slightly across frequency and subjects. The average optimal ratio is 1.225. Beyond the maximum, the DPOAE level declines with increasing f2/fl ratio at rates of upto 250dB/oct. As the level of one stimulus is increased relative to the other, DPOAEs grow, saturate and in most cases show a bendover. Maximum distortion is generated when L1 exceeds L2.	

1	2	3	4	5	6	7	8	9	10	11
5	1991	Hanser.R et al	1	To determine the effect of primary tone level variations L2-L1 on the amplitude of distortion product otoacoustic emissions (DPOAEs)	20e 10s	22-32y	5m 5f	Normal	2 Primary puretones fl&f2(f2>fl) GM=1kHz, 2KHz&4KHz f2/fl 1.25, 1.23, 1.21 respectively	Spectral analysis & threshold
6	1991	lonsbury Martin B.L. et al	1	To study the influence of aging on the generation of DPOAEs	60e 30s	31-60y	15m 15f	Normal	Equilevel (L1=L2) Primary tones. f2/fl=1.21	Spectral analysis & threshold

12	13	14
Two channel frequency synthesizer (Hewlett-Packard 3326A). Two insert earphones Etymotic Research, ER-2A. Microphone Etymotic Research, ER-2A. Precamplifier Etymotic Research ER-10-72. Amplifier custom built. High pass filter 400Hz. Signal analyzer Hewlett-Packard 3561A. FFT Personal computer Macintosh II	The level differences L2-L1 generating maximal DPOAE amplitude;s depended on L1 and on the geometric mean frequency of fl & f2. L2-L1 evoking maximal nean DPOAE amplitudes was -l0dB for gemetric means frequencies of 1 and 2 KHz with Ll=65 dBSPL for 4KHz, L2-L1 was -5dB with Ll=65 dBSPL and OdB with Ll=75dBSPL The mean slopes of the DPOAE growth functions in the initial linearly increasing portions were steeper at higher stimulus frequencies, increasing from 0.52 at 1KHz to 0.72 at 4Khz for Ll=65 dB SPL and from 0.48 at 1KHz to 0.72at 4KHZ for Ll=75dBSPL	The complexity of the interrelationships among parameters and additional factors originating from the characteristics of individual ears, such as middle ear mechanics. Possible influen-ces of the central nervous system and other types of otoacoustic emissions needs to be addressed to understand the variability in the amplitude of DPOAEs.
Grason Stadler E3262A attenuator. Wavetek 116 signal generator. Telex 1470 audiometric speakers. Artificial ear B&K 4152. Acoustic probe. Two Etymotic Research ER-10 Earspeakers. Etymotic Research ER-10 microphone, Preamplifier Etymotic Research 10-72. Computer	When compared to emissions in young ears, DPOAKs accurately tracked the systematic deterioration of high frequency hearing in aging individuals.	The instruments used is not described in detail. This finding can be clinically applied while interpreting the EOAE findings in aged cases. Further research is wanted with the pathological cases.

3.1.5

ANIMAL STUDIES

1	2	3	4	5	6	7	8	9	10	11	12	13
1	1981	Schmiedt R.A et al	2	To investigate the Cochlear origins of the TEOAE and the DPOAEs with the aid of cochlear micro-phonic recordings.	Mongolian Gerbil (Meriones Ungui-culatus)	20s	4-12 Months -		Normal	TEOAE: 50micro sec-200micro sec clicks or 2ms tone pips with 75ms rise fall time; stimuli rate 10/sec	Iatraperi-toneal injec-tions of ure-thane (1.5g/kg) or sodium pentobarbital (40mg/kg)	TEOAE DPOAE
2	1981	Zurek P.M. et al	1	Search for acoustic emission in the ears of chinchillas.	Chinchillas	23s	-		11 normal 6 patho-logical	Suppression tone near the SOAE frequency	Diabutal (Sodium pen-tobrbital) Ketaset (Ketamine hydrochloride)	SOAEs
3	1981	Zwicker E et al	2	To establish the presence or absence of acoustical responses in guinea pigs and to compare their pro-perties to those found in the case of man.	Guinea Pigs	7s 10e	-			Single period 45/sec for EOAK	Neurolepta-salgesia	TEOAE

14	15	16
Beyer DT-48 or TDH-49 earphone. 1/2" condenser licrophonem (B&K4134) or Knowles microphone (EA-1842) Single micropipette in scala media and a wire electrode at the RW (for cochlear microphonics)	Stimulated acoustic emissionss in the fom of echoes to transient stimuli are not present in the earcanal of the anesthetized gerbil. Acoustic emissions in the form of distortion products produced by two tones are present in the earcanal of the anesthetized gerbil at levels 20-40dB greater than those found in a small cavity. The levels of acoustic and CD distortion products are resistant to death by anoxia for at least 1-2 hours. Elimination of the acoustic distortion products is also concurrent with the total disappearance of the negative EP and the CM response to fundamental tones.	No mention of the stimuli parameters for DPOAE. It is an invasive technique so can not be replicated with human beings.
Earpiece from Stadler 1720. Miniature microphone Knowles electronics EA1842). Wave analyser (Hewlett-Packard 3581A). X-Y recorder (Hewlett Packard 7035B)	The absence of SOAE in 26 ears of 17 healthy Chinchillas. Two chinchillas demonstrated continuous narrow band otoacoustic emissions after exposure to noise.	Human ears are exposed to noise, and hence this findings leads us the reconsider whether the SOAE is a normal phonemenon. this may be because of microlesions in the organ of Corti due to noise exposure.
Earphone DT 48S. Microphone - 2. Amplifier Octave band filter. Transformer.	Acoustical responses are readily measurable in the guinea pig and can be established as such by simple criteria such as nonlinearity, hypoxia sensitivity and low frequency suppression.	The specifications of instruments and their models are tot mentioned.

1	2	3	4	5	6	7	8	9	10	11	12	13
4	1982	Wit H.P. et al	2	To show that EOAEs occur in monkey ears also.	Monkey	5s -		•ale	-	0.2-5KHz driven with electrical pulse of 0.lm sec; repetition rate 40/sec	Ketalar 20mg/ kg	TEOAE
5	1982	Zurek P.M. et al	1	To assess the usefulness of measures of acoustic distortion products for disclosing the presence of cochlear disorders.	Chinchillas - -				Both	3 pair of primary tones 1. fl=il5Hz, f2=1250Hz, 2. fl=3680Hz, f2=4010Hz 3. fl=3680Hz. f2= 4815Hz	Diabutal 66mg/kg intra-peritoneally.	DPOAE
6	1984	Brown A. M. et ai	2	To investigate the origin and mode of emission of the acoustic distortion product. Whether the DPOAE is similarly produced in gerbil and man.	Mongoliam gerbils (Meriones ungu-iculatus) & normal human	-	Gerbil 6-8 months	-	Normal	2fl-f2	Neubutal Droperidol & Phenoper-idine	DPOAE

14	15	16
Miniature microphone Knowles BL 1671 Amplifier. High pass filter 500Hz. FET switch Second high passfilter 400Hz 24dB/oct. Data lab DL 4000 averager. Digital tape recorder. Computer-FFT algorithm.	Like human ears and ears of other animal species these monkey ears also emitt at one or only a few frequencies.	Instead of age they mentioned weight range 3.5 to 10.5kg. They have not taken female monkeys. Good description of instruments.
TRO knowles miniature ear phones. One knowles miniature mic. Grason stadler Otoadmittance meter 1720. Two oscillators. TWO attenuators. Programmable attenuator two. Amplifier two. Wave analyzer Hewlett-Packard 3581A. Computer PDP-8/1.	when fl&f2 were in between 30 and 90dBSPL 2fl-f2 and 2f2-f1 distortion products were 30to50dB below primary tone levels. Noise exposure that caused temporary or permanent hearing loss produced corresponding temporary or permanent reduction in DPOAE levels. In the absence of conductive impairment DPOAE levels can be used as a sensitive indicator of hearing sensitivity and the condition of the Cochlea.	This can be introduced as a test of differential diagnosis in our clinical practice.
Knowles transducers (2 loudspeakers and one microphone) Second microphone in meatus via a 4mm long 1mm i.d tube Insulated silver wire with an exposed and chlorided tip in the round window region as electrode to monitor CM.	The cubic difference tone 2fl-f2 responses from the gerbil can be used as a model for the human 2fl-f2 response. This response can be used to obtain information about cochlear frequency selectivity. DPOAE is a valuable tool for non-invasive monitoring of cochlear activity over a wide frequency range in both species.	No.of subjects and sex for both animal & human groups not mentioned. Age range (mean age) of huamn subjects not mentioned. The auditory pathology of the gerbil subjects not investigated. The specification of stimuli used not mentioned.

1	2	3	4		5 6	7	8	9	10	11	12	13
7	1984	Clark W.W et al	2	To bring together salient features of otoacoustic cochlear histopathological and behavioural threshold shift observations to aid in understanding the mechanisms underlying SOAE.	Chinchilla	56e	-	-	28 noise exposed ears 4 28 unexposed ear	Frequency of the SOAK 1) With a band width 3012 suppression experiments. 2) With a band width 300KZ for recovery function Frequency of the distortion product: With band Width 30Hz for inter modulation distortion product.	Diabutal (60Kg/kg i.p) Sodium Pentobarbital	SOAE
8	1984	Ruggero M.A et al	2	To report very intense SOAE produced by both ears of a young dog, Samson.	An American Eskino Dog	1	5 months	Male	Pathological	No Stimuli	Atropine Sulphate (0.04mg/kg) Sodium Thiamyial (18mg/kg) Halothane	SOAK
9	1985	Dolan T.G. et al	1	To explore the possibility of mechanical changes being associated sith long term adaptation by examining changes in the aplitude of DPOAE following sound exposure	Cat		Adult	-	Normal	Two equilevel continuous tones for DPOAE Tone bursts for AP	Sodium Pentobarbital (50mg/kg body weight) Intaperitoneally	DPOAE

14	15	16
Earpiece Grason Stadler 1720 with a 7 tip with a Knowles electronics microphone EA1842 Sweep frequency sate analyzer (Hewlett-Packard 3580A) X-Y recorder(Hewlett-Packard 7035B) Oscillators (Hewlett-Packard 239A) Attenators (Hewlett-Packard 350) Earphones (Knowles 1716)	Two cases of SOAEs have been found among 28 . chinchilla ears after noise exposure. No cases of SOAEs have been found among 28 unexposed ears.	Small sample size-5o the results can not be generalised Good description of instruments.
Plastic Speculum Beyer DT-48 earphone Knowies **EA-1482 m**icrophone Amplifier Oscilloscope Wave analyzer Hewlett Packard 3581A ABR.	Intense (59dBSPL) SOAE are produced by both ears of a young dog.	With the Help of ABR Results, the Authors tries to strengthen his hypothesis the SOAE is generated near the transition between normal and abnormal regions of the chochlea.
Oscillators TDH-39 Earphone General Radio 1900 save analyzer	Sound exposure can alter the mechanical response of the cochlea to two tone input. Both DPOAE and Action potential are reflections of the same underlying cochlear process. Adapter effectiveness is strongly influencd by the state of the middle ear.	By removing the antiresonance of the middle ear cavities and the build up of negatve pressure by opening the bulla and removing the septum, the study should be repeated.

1	2	3	4	5	6	7	8	9	10	11	12	
10	1985	Horner K.C. et al	1	To evaluate the relation betseen cochlear dysfunction and particular features of DPOAE.	mice	20 normal 35 hearing impaired mutant mice	15-328 days	-	Both	2fl-f2 at equal level	Urethane (2mg/g body weight	DPOAE
11	1985	Kossi M et al	2	To investigate the properties of KOAE in the Mustache bat Comparison of this EOAE with Human EOAE. To investigate the relation betseen echolocation frequencies and properties of the hearing system	Mustache Bat (Pteronotus Parnelli)	15	-	-	-	I Series: continuous tones sweeping from 10 to 120 KHz with a 100 or 1000Hz/s sweep speed II series: Phase locked tone bursts and clicks	Nembutal or Halothame	SFOAE TEOAE & SOAE

14	15	16
Knowles Electronics microphone (EA1751) B & K 2608 Amplifier. Spectrum Analyser Hewlett-Packard 3580A) B & K 4134 microphone Oscillator Mixer Attenuator	In the normal hearing animals, primary tones at levels of 60 to 100 dB SPL evoked DPOAEs at 20-50 dB below the primary levels. In the hearing impaired mutants the level was dependent on the particular type of auditory dysfunctions associated with the mutation.	DPOAE can be used as a noninvasive monitor of cochlear function. But we should have normative data so that this can be put in clinical use. Can we really consider this data applicable to the human beings
B & K 4135 {1/4")microphone. Condenser loudspeaker HP 3594A oscillator HP 3590A wave analyser Wavetek 112 frequency generator Bell & Howell tape recorder Vuko-22-16 PDP 11/23 micro computer Glass insulated tungsten electrodes.	EOAE can reach an amplitude as large as 70dB SPL and occur in the frequency range most important for echolocation. A sharp maximum of the amplitude of cochlear microphonic potentials at about 62Khz could be correlated with the emission frequency. In one bat EOAE response changed to a SOAE Frequency and amplitude of the EOAE responses reversibly decreased often exposure for 1 minute to continuous sounds of more than 85dBSPL with frequencies of about 2.5 to 7.5KHz above the EOAE frequency.	There is no Mention of auditory normalcy/abnormalcy and its measurement before or at the time of eimssion recording. EOAE converting into SOAS is something of important consequences and it should be further experimented.

1	2	3	4	5	6	7	8	9	10	11	12	13
12	1985	Martin G.K. et al	2	Incidence of SOAEs in non-human primates(monkey)	monkeys	61	1.5-13.9 months	49males 12 female	Normal	No stimuli	Ketamine Hydrochlor-ide Vetalar 20mg/kg	SOAE
13	1987	Lenior M. et al	2	To investigate how acoustic emissions develop during the cochlear maturation	Wistar Rats	82s	ll-40days	-		Two continuous primary frequen-cies at equal level; f2/fl=1.17 2fl-f2-3,5, 7KHz	Nembutal Intraperiton-eal 50mg/kg	DPOAE
14	1987	Manley G. A. et al	2	To report the presence and characteristics of OAEs in an european starling, strunus vulgaris.	Songbird (Starling sturnus vulgaris.	5e		Both		Frequency sweeps 1KHz wide; total range 1.0to5.5KHz level-15 to 50 dBSPL. Single period pulse.	Halothane Nembutal 50mg/kg l00mg/Kg	SFOAE & TEOAE

14	15	16
Knowles, 1834 mic Probe tube 2.8mm I.D. 15mm length. Pediatric immittance probe tip. Differential amplifier data Inc.2124. HRSA B&K 3033 X-Y recorder B & K 2308.	2.5% of the ears and 5.02 of the monkeys were found to have SOAES.	Only light anesthesia used-possiblity of anesthesia reducing SOAE amplitude is not ruled out. Sample comprised of 80% of male.
Probe Microphone knowles 1842 Two knowles 1850 earphones Catheter; 8mm long; 0.5mm i.d. Two frequency generator. Attemator. Tektronix preamplifier AM502. Spectral analyser B&K 2033 1/2" B&K licrophone 4134. Artificial ear.	Adult like patterns of the acoustic responses were achieved by day 18 for 2fl-f2=3 KHz, by day 20 for2fl-f2=5KHz and by day 28 for 2fl-f2=7KHz. The fact that the 2fl-f2 OAEs reached adult charateristics from the low to high frequencies is not consistent sith the development of the tuning properties of the basilar membrane. The long development of the 2fl-f2 OAEs at 7KHz, suggests that the organ of Corti undergoes subtle changes sell after the end of its apparent maturation.	The similar experiments with the human newborn and children should be done.
Spectrum analyzer Transformer Earpiece 1/4" electret microphone X-Y or X-T plotter.	SFOAEs were found in 61% of the birds. They appeared with rather broad synchronisation widths (about 200Hz) and predominantly as frequencies in the upper half of the hearing range of the bird. SFOAEs varied in level from below 30dB to 2dBSPL and showed typically non-linear intensity functions. Emissions were present even following extirpation of middle ear muscle and could be suppressed by anaesthetics.	As compared to human being the incidence of EOASs in bird is low. this may be of significance in phylogenetic development.

1	2	3	4.	5	6	7	8	9	10	11	12	13
15	1990	Brown A.M. et al	1	To explore the similar- ities b/w rodent and human responses using moderate to low levels of sound stimulation	Guinea Pig (Pigmented)	20 -	--			Tone pulses 10ms rise/fall 5ms	Hypnom (0.25ml/kg) & Diazepam (25mg/kg)	DPOAE
16	1990	Van Dijk. P et al	1	To present experimental data on amplitude and frequency fluctuations of SOAEs.	Human and Frog (Rana esculanta)	8e Human 2e Frog -	--			No Stumli	Not mentioned	SOAE

14	15	16
Probes accompaying two Knowles, 1712 loud speakers and Knowles, 1842 microphone. Hewlett Packard spectrum analyzer (3561A)	The guinea pigs can be used as a model for acoustic 2f1-f2 distortion generation in the human ear provided that the response to moderate to low level sound is compared. Although underlying process is the same, human response is more structured and less predictable.	Number of human beings in the comparison group not mentioned. Age range and sex of the guinea pig not mentioned.
Sensitive microphone. videotape (Sony SL-C30E video recorder) Plse code modulation/ SonyPCM-Fl) Hawetek 178Signal synthesezer. Unigon 4512 FFT analyser. Band Pass filter B&K1623 Heterodyne band pass filter B&K 2020 HP 5326A timer.	Emission amplitude and period both showed small fluctuations. (a) Arms/Ao ranged from 0.7x10-2 to 6.3Xl0^{-1} for human emissions and was 24x10^{-2} for both frog emission. (b) Tras ranged from 1.4-6.9x10-1 for human emisslon and was 50.0 and 55.0x10"' for the two frog emissions. There was a positive correlation (R=0.9) between Arms/Ao and Trms.	Authors compare these results sith that of second order oscillator and observe that an oscillator with linear stiffness driven by white Gaussian noise cannot account for all experimental results.

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3.2

CLINICAL APPLICATION

3.2.1

TEOAE

1	2	3	4	5	6	7	8	9	10	11
1	1982	Johnsen l.J. et al	3	To describe instrumental set up and lethod adopted by the authors for the signal analysis.	2J	29-42y	1B If	Both	Click, rarefa-ction pulse of 2KHi repetition rate 10/s	Lateny and threshold
2	1982	Johnsen B.J. et al	3	To obtain norMative data for the click evoked acoustic eMissions in young adults and to investigate the infuence of posture on the eMissions.	10s	21-42y	6f 4M	Normal	Clicks of 2khZ repetition rate 10/s	Latency
3	1983	Johnsen N.J. et al	3	To point out the possibility to develop the recording of evoked eaissions into a neonatal screening test.	20s	48-96hrs	11F 9M	Nor«al	Click, rarefac-tion pulse of 2Khz repetition rate 10/s	lateNcy

12	13	14
Probe Danplex ZA30, weight l0g KnoWles BT1751 Microphone. KnoWles BK 2615 earphone. AMplifier. Band pass filter (250Hz, 24dB/Oct to 5KHz, 18dB/Oct). CED/ALPHA LSI-2 computer.	Recording from a normal hearing subject served as an example and a clear response could be traced down and below the psychoacoustic threshold. The threshold was elevated and the response pattern altered when a SH hearing loss was induced by ingestion of acetylsalicylate. No response could be recorded from a deaf ear with an intact ear drum and mobile ossicular chain.	He can not generalise these findings of the study as because single case is not enough to generalize. Hence study with more number of cases should be repeated.
Modified probe Danplex ZA30, weight i6g. a) Knowles BT1751 microphone. b) Knowles BK2615 earphone. Amplifier. Band pass filter (25QH.2, 24dB/Oct to 5Ib, lBdB/Oct). CED/ALPHA LSI-2 coiputer. Floppy disc.	A clear response could be traced down to or below the psychoacoustic threshold in all ears. Response pattern differed from one ear to another (intra- and inter subject variability). Both the methods applied to get group latency were almost identicial. The individual input output functions exhibited nonlinearity. The latency vs. frequency relationship was ambiguous. TEOAE demonstrated high stability of response pattern from the individual ear. Response pattern were unaffected by posture.	Sample size is small - hence generalization not possible.
Modified probe Danplez ZA30, weight l0g. a) Knowles BT1751 microphone. b) Knowles BK2615 earphone. Amplifier. Band pass filter (250Hz, 24dB/Oct to 5Hz 18B/Oct). ED/ALPHA LSI-2 computer. floppy disc.	A clear and reproducible response was identified from all ears at 50dB att. The echo group latencies and amplitudes were within the same range as in normal adults and the amplitude input output curves exhibited a clear non linearity. Final conclusion is that the recording of TEOAE could be applicable as a screening procedure in newborns.	A follow up of these children will give confirmatory results. So a prospective study with more nuiber of neonates are required. It is difficult to clearly diagnose a child as normal just based on otoscopy and tympanometry. ABB could have been done for a better estimate of hearing status.

1	2	3	4	5	6	7	8	9	10	11
4	1985	Elberling C. etal	5	To evaluate the TEOAEs in response to various tonal stimuli in normal hearing adults. To evaluate the type I errors.	100s	48-96hrs	-	Normal	*2KHz* click or a tone burst repatition rate 20/s	Latency
5	1987	Bray P. et al	8	To detemine if the advanced cochlear echo techniques developed could acquire a valid otoacoustic recording from the typical child patient with typical noise present.	105e 55s	6m-13y	-	Both	-	Latency
6	1987	Tanaka.T. et al	5	To ascertain whether OAF is clinically applicable for evaluating the degree of impairment in hearing loss.	52s		*30m* 22f	Patho-logical	Tone burst, 3ms; rise-fall 1ms.	Latency and threshold

12	13	14
Probe (a) Miniature microphone. (b) Receiver (earphone). Amplifier. Band pass filter (250Hz, 24dB/oct, & 5KHz, 18dB/Oct). Computer.	Evoked activity from each ear contains energy in preferential frequency bands and change of stimulus frequency has only a minor effect on the power spectra. Significant information is obtained by the click rather than by tonal stimuli. Emission amplitudes were of the same order of lagnitude as those previously found in normal hearing adults. Cochlear echo can be recorded in normal hearing newborns with an extremely low rate of type I errors.	Precise description of the instrument used is not given. Testing time can be reduced markedly by increasing the repetition rate and reducing she number of test runs.
Knowles 1712 miniature earphone. Knowles 1843 miniature microphone. Brasstube 2n external diameter; 1mm internal diameter; 11MM length. 2.5 mm Heine speculum. C.A. ALPHA 2/40 minicomputer. CED 502 analogue interface. 80M byte Winchester disc with lOOKHz writing speed. DMA CRT display. 502 DAC.	The subject noise problem in acoustic cochleography can be solved and that a properly engineered test device could be useful addition to the audiometric test battery for children not just neonates.	The field trial is necessary. Less expensive microcomputer should be utilized to make it cost effective.
RION AA - 61BN audiometer. BIOS, RS-30 impedance audiometer. Acoustic probe, a) Danavox, SMW-68 earphone, b) Knowles EA 1843 microphone. Amplifier. Signal processor SA NEI 7S11 X-Y recorder SANEI, 8016.	TEOAE are excellent in reproducibility. The interaural difference is a useful indicator in unilateral SH hearing loss. The interaural difference of the TEOAE threshold was large in inner ear impairments, and it was nil in cases of functional deafness. There was a positive correlation between the interaural differences of the psychoacoustic threshold and those of the TEOAE threshold The TEOAI is clinically applicable in the differential diagnosis of SH hearing losses & in evaluating the degree of inner ear impairments.	They have not taken any control group for comparison but the comparison is made with the normal ear and pathological ear of the same subject.

1	2	3	4	5	6	7	8	9	10	11
7	1988	Bonfils P. et al	5	To summarise the results of TEOAE obtained it adults and infants both with normal hearing and other pathological condition.	330e	-	-	Both	Clicks-100 microsec. repetition rate 21/s	latency and threshold
8	1988	Johnsen N.J. et al	3	To obtain normative data from newborns and to discuss the practical & methodological problems related to the recording of the EOAE.	100s	48-96hrs	43f 57M	Normal	Click, rarefaction pulse of 2KHz repetition rate 20/s	Latency
9	1988	Steveas J.C.	8	To study the potentiality of TEOAE in detecting hearing impairment.	67e 37s	16-85y	20a 17f	Both	100 microsec. unipolar sq. wave rarefaction interstimulus interval 80msec.	Latency and threshold
10	1989	Bonfils P. et al	8	To determine the clinical applicability of EOAES as objective indicators of cochlear disease.	137e	14-76y		Both	Rarefaction clicks 0.1MS repetition rate 19/s.	Latency and threshold

12	13	14
Miniature microphone Knowles BT-1751. Earspeakers Knowles, BE-2615. Length of probe 3cm. Height of probe - 20g. Spetrum analyzer Hewlett Packard.	TEOAEs can be clinically used for a) Objtctiye assessment of sensorineural hearing loss, (b) staging Meniere's disease by recording glycerol induced changes. (c) Diagnosis of retrocochlear pathology, (d) Screening of auditory function in infants.	TEOAE is an easy to use, nonisvasive, rapid and objective audiologicai procedure.
Modified probe Danplex ZA30, weight lOg. a) Knowles BT1751 microphone, b) Knowles BK2615 earphone. Amplifier. Band pass filter (250Hz, 24dB/Oct to 5KHz, 18dB/0ct). CED/ALPHA LSI-2 computer. Floppy disc. Madsen ZO 70 Impedance meter.	No sipificant differences could be demonstrated between males and females or between left and right ears with regard to the latency of the emissions,the peak to peak amplitude, the main frequency component or the waveform correlation between the two 70dB aud recording in each ear. A significant correlation between left and right ears was found for the amplitude and frequency of the emissions. Envelope techniques was the most simple and reliable technique of determining latencies.	TEOAE recording can be used as a screening test in newborns. A prospective study evaluating the false positive and false negative cases sill further confirm the worth of TEOAE as a neonatal screening.
Puretone audiometer Kamplex AC4 or Peters AP6. Knowles Electronics ED2950 miniature earphone. Knowles electronics BT 1751 miniature microphone. Analog filters.	The level of stimulus required to obtain a recordable emission was found to be correlated with the psychoacou-stical threshold of the click stimuli but not to a high enough level to make this a useful measure of hearing loss.	The results obtained for normal hearing group and impaired group can not be compared because they are not matched as per age.
Acoustic probe; length 3.5cm, wieght 20g. a) Knowles BI1751 microphone. b) Knowles BK2615 earphone. Impedance probe protector. Medelec AA6 MK3 amplifier; gains 1000 to 10000 Band pass filter; 250Hz to 8KHz, 16dB/Oct to-wards Iow freq. and 6dB/0ct towards high freq. Flexible disks. High resolution signal analyzer Hewlett-Packard 3661A.	TEOAE can be used as a reliable technique for objective study of normal micromechanical activity within the cochlea and for detection of subtle changes in cochlear disease.	It is not possible to differentiate various cochlear disease with the TEOAE recordings. Instruments and stimuli used are described very such in detail.

1	2	3	4	5	6	7	8	9	10	11
11	1989	Bonfils.P.	11	To determine some basic features of SOAEs relative to (1) age and sex of normal subjects, (ii) Audioaetric threshold and SQAE threshold with SN loss subjects.	284e	2d-40y	-	Both	for TEOAEs:rare faction clicks 0.1ms repetition rate 19/s	Latency and threshold
12	1989	Collet.L. et al	30	To specify otoacoustic emission characteristics in relation to SN hearing loss.	148e 76s	42.3y mean	51m 25f	Patho- logical	Rarefaction clicks;100 microsec. repetition rate 22.7/s	Latency and threshold
13	1989	Collet.L. et al	3	To ascertain whether the evoked potential recorded under bone conduction stimulation are purely auditory or contain an additional mechanical somatosensory composer. To study the existence of bone conduction stimulated OAE.	30s	18-35y	-	Normal	Clicks 100 microsec. repetition rate 22.7/s	Latency
14	1989	Johses N.J. et'al	3	To study the developmental changes in the EOAEs recording, if any.	20s	-	-	Normal	Clicks of 2KHz repetiton rate 20/s.	Latency

12	13	14
Acoustic probe; length 3.5cm; weight 20g. (a) Knowles BT 1751 microphone. (b) Knowles BK 2615 earspeaker. Impedance probe protector. Medelec AA 6ME 3 amplifier; gain 10^4 for SOAE. High pass filter; 250Hz, 16dB/oct for SOAES. Band Pass filter; 250HZ to 8KHz, 16dB/0ct towards low freq and 6dB/0ct towards high freq. High resolution signal analyser Hewlett Packard 3661A. * and **10^3-10*** for TEOAE.	The incidence of SOAEs, decreased from 68% in the group of infants less than 18 months old to 0% after the age of 70 years old. No Star.Diff.is SOAE incidence found b/w participants with or without tinnitus. In the group of subjects with SN loss, the incidence of SQAEs decreased linearly with increasing click threshold or the detection threshold of TEOAE. Insignificant difference is SOAE incidence found b/w participants with or without tinnitus.	Instruients & stimuli used are described very much in detail. Age range of immoral group not mentioned. Sex distribution of uses not mnetioned.
Acoustic probe, a) Tandy WM 063T microphone. b) Knowles K 2912 earphone. Band pass filter 200 to 7000 Hz. Amplifier , 4 x 10^4 Micolet pathfinder II apparatus.	There is a highly statistical significant correlation between EOAE threshold and hearing loss at 1KHz. The presence of EOAE indicates middle frequency functional integrity of outer hair cells of Corti's organ.	Absence of TEOAE is barder to interpret.
Micolet pathfinder II aparatus. Bone vibrator. Specific to ABE+MLR Siver, Silver chloride cup electrode. Specific to TEOAE Probe (a) Tandy WM 063T microphone. b) Knowles K2912 earphone.	Under bone conducted stimulation the evoked potential recorded is purely auditory, with no additional mechanical somatosensory component. Bone conduction stimulated TEOAEs are comparable to conduction stimulated TEOAEs.	The sample size is too small to allow conclusions to be drawn. Clinical application cf bone conduction stimulated OAEs is questionable because OAEs are present in middle ear effusion.
Modified probe danplex ZA 30, weight lOg Knowles BT 1751 microphone. Knowles BK 2615 earphone. Amplifier. Band pass filter (250Hz, 24dB/oct, 5KHz 18dB/oct CED/ALPHA-LSI-2 computer.	The latency and the amplitude of the EOAE response both were unchanged. In some ears frequency content of the dominant part of the TEOAE was changed.	The findings indicate that postnatal changes do occur in the human cochlea. But just with the finding of this experiment, jumping to any conclusion will be a mistake.

1	2	3	4	5	6	7	8	9	10	11
15	1989	Lind O. et al	3	To investigate whether a simple techniques with a single repeated recording at a fixed stimulus intensity coaid give, information enabling to differentiate between high frequency and low/medium frequency hearing losses.	16e	-	-	Patho-logical	125microsec clicks.	Latency
16	1989	Lutman M.E. et al	9	To report an unusual case of profound SN hearing loss accompanied TEOAE.	1s	11y	male	Patho- logical	Click 100micro sec. repetition rate 47/3.	Latency
17	1989	Tanaka.T. et al	5	To study whether OAE might serve as a diagnostic measure of inner ear in children.	266e	6-15y	-	Both	Tone burst,3ms; 1ms rise/fall freq.lOOOHz-2000Hz.	Latency and threshold
18	1990	Bonfils P. et al	11	To study the basic properties of SOAEs and the parameters influencing them.	100e 52s	2h-4d	52M 46f	-	Clicks 0.lmsec. repetiton rate 19/s.	Latency

12	13	14
Acoustic probe. Nicolet pathfinder II system. Digital high pass filter; 400Hz. FFT.	TEOAE may be used as a crude test to identify the need of a hearing aid. TEOAE can be used to evaluate the presence of a lows/medium frequency hearing loss greater than approxitately 40dB. This techniques does not give any infortation about the condition and performance of the auditory system central to the cochlea.	Instruments used has not been elaborately reported and specified. Smaller sample size used. Age and sex of the cases has not been reported.
Programmable otoacoustic emission measurement system (POEMS). ECoch G. ABR.	SN hearing loss coupled with the presence of a TEOAE can be taken as an indication of a retrocochlear lesions.	The findings should be clinically tried for confirmation. Detailed description of the instrument especially of the probe should have helped other investigators.
EION, AA-61B audiometer. EION, RS-30 impedance aduiometer. Acoustic Probe, a) Danavox-SEN-68 earphone, b) Knowles KA1843 microphone. Function generator MF - Circuit, F6 143. Amplifier. Signal processor SAMEI-7S11A.	The mean OAE threshold values of normal hearing and functional hearing loss cases were 5.9dB nHL and 6.2dBnHL respectively. In sensorineural loss the value wasJ noted to increase according to its grade measuring 37.2dB nHL in the group with severe loss higher than 91dB.	These findings suggest that the TEOAE threshold is useful for an indicator of inner ear function in children. The same experiments may be repeated with adults.
A small acoustic probe containing a small microphone and miniature earspeaker-a small plastic tube. Amplifier. Filter-high pass- 25QHz, l6dB/Oct. Averager(Racia BEF2/4). Dynamic signal analyzer.	TEOAEs can be recorded in 98% of the tested ears. No significant difference in the threshold of TEOAEs of neonates between 144 days. There is no significant difference in the threshold of TEOAEs between tales and fetales. TSOAEs exhibited a broad band spectrum with high component frequencies. TSOAEs demonstrating narrowband frequency peaks saperimposed on broadband component had detection thresholds lover than TSOAEs without narrowband frequency peaks.	TEOAEs can be used as a tool for neonatal screening A two stage, time savings protocol for screening peripheral auditory dysfunction in neonates may be proposed - 1. Behavioral tests and/or TEOAEs. 2. ABB.

1	2	3	4	5	6	7	8	9	10	11
19	1990	Lutman M.E. et al	3	To apply Fsp technique to KDAE recording and to establish a suitable criterion value of Fsp for the objective desecrmination of an E0AE threshold.	61s	3-15y		Both	l00micro sec. rectangular click, repitition rate 47/s.	Latency and threshold
20	1990	Norton S.J. etal	4	To determine age related changes in EOAEs ia normal ears and to provide a normative data base for studying clinical populations.		17d-30y	-	Normal	80microsec. retangular pulses rate 50/s at 80dB peSPL.	Latency
21	1990	Norton S.J. et al	4	To explore the link between tinnitus & otoacoustic emissions.	8s	28-69v	In 7f	Normal	Tone burst stimuli at 0.5, 1.0,1.5,2.0, 3.0,4.0,6.0 & 8.0KHz; 2ms rise/fall.	Latency
22	1990	Stevens J.C. et al	4	To investigate whether it is possible to use the I04E to identify the bearing impaired nesborns.	723s	-		Both	l00microsec. rarefaction square saves rate-32.5/s.	Latency

12	13	U
POEMS: 1) Ear probe: (a) Miniature microphone. (b) Miniature loudspeaker. Microphone preamplifier. Filter. AD converter. Click generator. Microcomputer (either Acorn, BBC Master 128/IBM PC)	Calculation of the Fsp statistic as a quality estimator for EOAEs can be incorporated in practical measurement apparatus. An Fsp of 2.0 or more indicates that a signal is present with a 2% probability of error. When two consecutive averages both exceeded an Fsp of 1.6 the probability of error was below 10%.	This iethod is such less prone to Type I errors, and so this can be applied for the objective determination of TEOAE threshold.
ILO 88 hardware and software. Zenith 159 computer with as 8087 mathcoprocessor. 12 bit DAC. Probe (a) Miniature earphone. bj Miniature microphone. Digital atenuator. 12 bit ADC. High pass filter 200Hz. Band pass filter 600-6000Bz. 512 fast fourier transfrorm.	EOAEs can be used (a) as a screening tool for cochlear dysfunction across individuals. b) To aonitor changes over time in cochiear status within an ear.	Only by conducting both cross sectional and longitudinal clinical trials of EOAES in large population we can cocfirm these findings.
EB 2 tubephone. Acoustic probe (Etymotic Research Et.l08). Hewlett Packard 3561A dynamic signal analyzer. Locally built variable gain (20-80d!) battery powered preamplifier. 12-bit ADC. Computer disk. Oscillator.	Oscillating EOAEs and tinnitus are related to a conon underlying pathology rather than the eiission being the source of tinnitus.	The detection of SOAEs and/or ringing EOAEs in ears with sloping losses, a history of noise eiposure and tonal tinnitus, light provide an objective iethod of evaluating tinnitus treatient. Large scale clinical trials are needed to validate the above conclusion. Bore no. of feaales have been taken in the saiple.
Snowies electronics ED 2950 miniature earphone. Knowles electronics BT 1751 miniature microphone. Tubing. Z 80 computer.	The proportion of HICD infants producing recordable TEOAE is 80%. Selectivity of TEOAE to the ABB is 84%. Sensitivity of TEOAE to the ABB is 93%. This is quicker to perform as compard to ABB.	This technique seess to be cost effective, less tine consuaing and highly sensitive tool for neonatal screening. But we need to do soae lore studies in order to establish it as a neonatal screening test.

1	2	3	4	5	6	7	8	9	10	
23	1990	Tanaka.T. et al	4	To determine whether or not EOAE are useful as a clinical test.	420s	13-357	12m 8f	Both	Tone burst of 3ms; lms rise/fall b/w 1 & 2 KHz.	Latency and threshold
24	1991	Collet L. et al	9	To examine the relation between power spectra of KOAEs and audiograms.	150s	7-82y	93m 57f	Patho-logical	Unfiltered 80microsec. click.	Latency
25	1991	Dolben P. et al	3	To test a commercially available EOAE instrument and to describe a reliable and simple technique to record EOAI in newbons.	56s llle	A20-307 M38-42w	-	Both	-	Latency
26	1991	PrieVe.B.A. et al	7	To report the unexpected findings of EOAEs from bilateral severe to profound SN hearing loss.	1s	33y	female	Patho-logical	Tone burst sinusoid of .5,1.0,2.0 & 4.0KHz with 5.64, 4.00, 2.92 42.00ms respectively. Clicks-100 microsec. Repetition rate 25/s.	Latency

12	13	14
RIOH, AA-61BH-audiometer. Impedance audiometer BIOS, ES-30. Probe, a) RION, RK63B earphone. b) Knowles 1843 Microphone Function generator HF Circuit FG-143. Amplifier. Signal processor SANEI 7 S11A. Band pass filter (0.8-3.0KHZ).	The detection threshold of EOAE was elevated in ears of inner ear impairment with profound SN hearing loss. The mean interaural difference of EOAE threshold were near 35dB in unilateral inner ear impainents with profound hearing loss. There was a positive correlation between the interaural difference of audiometric threshold and that of emission threshold in sudden deafness ears with various degrees of hearing loss. The incidence of continuous emission was 30% in nornal hearing ears and it »as close to 90% in ears with bilateral or uni-lateral dip type hearing loss.	There is a clinical usefulness for the EOAEs in evaluating cochlear function and in predicting noise susceptibility.
Otodynamic 1LO 88 software and hardware.	EOAE spectrum and SN hearing loss are significantly positively correlated. However, it is not possible to establish an audiogram by knowing only the spectrum analysis of EOASs.	1) The details of instrument used not available. 2) Rise/fall the of click not mentioned.
IL088. Two probes the smaller light weighted for babies and larger one for adults.	IL088 should be used for obtaining the EOAE when best recording conditions are let. Such results can be considered good enough for clinical use as a clinical test for adults and for neonatal screening purposes.	Sex distribution of cases not reported. Detailed describtion of the procedure and instruments not reported. Stimuli used in experimentation and its specif-ications not mentioned.
Custom designed system. Insert aicrophone Etymotic EE-10B. Knowles 1710 transducers for tone burst. Etymotic EE-3A earphone for clicks. Amplifier. 16-bit ADC.	It is a strange finding and the authors suggest that the subject may have a group of surviving outer hair cells in some regions of her left cochlea with corresponding inner hair cell or neural damage.	Hence, we can say that the E0AE is the true indicator of the site of cochlear lesion.
Commercially available system, Otodynamics IL088.		

1	2	3	4	5	6	7	8	9	10	11
27	1991	Robinson P.M. et al	8	To investigate the effect of change in external auditory meatus air pressure on EOAE.	21s			normal	Clicks; repetition rate 40/s.	Latency
28	1991	Stevens J.C. et al	8	To investigate whether it is possible to use the EOAS to identify the hearing impaired newborns	723s	-	-	Both	Click; 100 microsec. (Rarefaction)	Latency

12	13	14
Institute of hearing research, POEMS. Peters type AP 51 Typano»eter.	In general KOAE response was reduced by the application of a positive or negative pressure.	The authors have tried to explain these changes in the line of pressure changes due to anesthesia, the expedient can be repeated with more no.of cases for further evidence.
Knowles electronics ED 2950 miniature earphone. Knowles electronics BT 1751 miniature microphone. Tubing. Z 80 computer.	The proportion of NICU infants producing recordable TSOAE is 80%. Selectivity of TEQAE to the ABR is 84%. Sensitivity of TEOAE to the ABR is 93%. This is quicker to perform as compared to ABR.	This technique seems to be cost effective, less time consuming and highly sensitive tool for neonatal screening. But we need to do some more studies in order to establish it as a neonatal screening test.

3.2.2

DPOAE

1	2	3	4	5	6	7	8	9	10	11
1	1990	Harris.H.P. et al	7	To determine if DPOAE amplitude is associated with puretone behavioural threshold.	4Qe 40s	18-4Qy		Both	2 puretone flM2; f2/fl= 1.19tol.2!	Spectral analyiis and tbreswld
2	1990	Lonsbury Hartin.B.L. et al	6	To collect parameteric measures of DPO&Es in normally hearing subjects to proTide a baseline against which otoacoustic activity in impaired ears could be compared.	44e 22s	21-30y	12M lOf	Normal	2 equilevei puretones f2/fl=1.21; 2fl-f2 b/w 0.75-5.75KHz.	Spectral analysis and threskld
3	1990	Lonsbury Martin B.L. et al	6	To investigate the Uo possibilities that sight account for an ear inability to generate DPQAEs (i) frequency specific anosalies in the forward and/or reverse aiddle ear transeission of the acoustic signal, (ii) Subclinical pathologic changes in cochlea and/or liddle ear.	44e 22s	21-30y	12B lOf	Normal	For DP0AE- 2 equilevel pure tones f2-f1= 1.21; 2fl-f2 0.75-5.75KHz. For SFOAE- continuous sweep frequency pars-tone from 400Hz to 2EHz;2min.	Spectral anslyfis and thresiold

12	13	13
Probe a) EE-10 microphone b) Two ER-2 earphone. Qua Tech HSD-10C waveform synthesizer. Grason Stadier 200-CD oscillator. ER10-72 low noise Microphone preamplifier. Custom made IOW noise amplifier. High pass filter system; 30dB/Oct;400Hs. Signal Averager B&K 2033. Oscilloscope. Amplifier loudspeaker.	DPOAEs Were reduced in amplitude or were absent in ears with high frequency hearing loss. The differences occurred at frequencies above 1500Hz. Comparing results from 750to8000Hz within the same ear revealed a frequency related correspondence of elevated behavioural threshold to reduced DPOAE amplitude.	These results imply that the measurement of DOPAEs has clinical potential as a means of detecting hearing loss by frequency.
Beltone 10-D screening audiometer. Microcomputer controlled (Apple, Macintosh Plus) tympanometer (Virtual 310). Hicrocoiputer system digital equipment corp-11/23. TBO channel frequency synthesizer Hewlett-Packard 3326A. Attenuators, Wavetek 5P. Probe a) Etymotic Research EE-2 earphones, b) Etyiotic Research ER-10A. Microphone. Etyiotic Research ER-10-72 preamplifier Measuring amplifier B&K 2620. Hewlett -Packard 3561A signal analyzer.	The average DPOAE audlogram demonstrated a bilobed contour having a low frequency maximum at approximately 1.5KHz and a high frequency peak that plateaued at about 5.5KHz. The tso maximum regions were separated by a minimum around 2.5KHz. The average I/O functions exhibited detection thresholds at primary levels between 35 and 45dB SPL. The dynamic range of the emitted response between detection threshold and maximum amplitude varied over a 40dB extent of the stimulus level dimension. Approximately one third of the ears exhibited DPOAE audio-grams in which emitted responses sere significantly reduced in restricted regions tested by low, Medium or high frequencies. Mean age did not explain the differences noted between the tso types of normally hearing subjects.	DPOAEs from normal ears can be characterized as having a set of relatively uniform properties against which the status of at unknown ear can be determined.
Same as described by the authors in Annals of Otol. Rhinol. & laryngol. 1990,Vol.99 Suppl.147, 3-14.	None of the examined features of acoustic immittance provided an explanation for the discrete low amplitude DPOAE regions observed. The presence of SOAE & SFOAE in the irregular ears indicated that the emission generation and reverse cochlear transmission were operating normally within the region of reduced DPOAEs. The simultaneous presence of SFOAE, but not SOAE, appeared to reduce the detection thresholds & increase the amplitudes of low frequency DPOAEs.	He still have one question unanswered whether the standard f2/fl ratio of 1.21 and the equilevel (L1=L2) paradigm is ideal for generating the most optimal DPOAEs for the ears showing diminished DPOAEs over the low to liddle frequency region.

1	2	3	4	5	6	7	8	9	10	11
4	1990	Martin.S.K. et al	8	To assess the clinical usefulness of DPOAE testing by comparing the response parameters of emissions in ears with known hearing loss to those in normal ears.	103e			Patho-logical	Equilevel (ll=L2) primary tones F1&F2	Spectral analysis and threshold
5	1990	Smur:ynski J. et al	10	To deaonstrate a correlation that light exist between DPOAE characteristics and hearing impairment of a different configuration and to evaluate the DPOAEs as a clinically useful method of assessing cochlear function.	52e 27s	21-41y	-	Both	2 sinusoidal signal, 3sec	Spectral analysis and threshold
6	1991	Bonfils P. et ai	ti	To measure distortion product otoacoustic emissioas in a clinical setting.	51e	18-28y		Normal	2 Puretones fl-f2	Spectral analysis

12	13	14
As described in previous report by the authors Annals of Otol.Bhinol. 4 Laryngol.Vol.99. Suppl.147 (1990), Part-I, 3-14.	Tests of DPOASs promise to satisfy a number of requirements important to clinical testing, including objectivity measurement procedure, test -retest reliability. Simple subject preparation, readily available instrumentation and relatively brief examination period. The fine resolution of DPOASs within the stimulus frequency & level domains also permits an accurate confirmation of the pattern of hearing loss. The ability of DPOAEs to assess the sensory component of sensorineural disorder may contribute to the eventual understanding of the complicated pathogenesis of many cochlear diseases.	Age range and sex distribution cf cases not reported.
Custom made probe, a) Knowles EA1842 microphone. b) TWO knowles 1716 earphone. Two oscillators Hewlett Packard 239A. TBO attenuators Hewlett Packard 350D. Sweep frequency save analyzer Hewlett Packard 3580A. I-T recorder Hewlett Packard 7035B. Ariel DSP-16 signal processing and interface board. IBB PC/AT personal computer. Switching system Wavetek 601. Kohn Hite 3342 filter.	All normally hearing ears demonstrated detectable DPOAEs provided that the primary tone level was above a certain value. Hearing impaired ears produced substantially reduced DPOAEs compared with normally hearing subjects when the primary frequencies fl and f2 corresponded to the region of hearing loss.	The DPOAE provide frequency specific information about cochlear function, which after further development, may form a basis of a noninvasive objective method of evaluating ccchlear function.
FFT Acoustic probe consisting, a) one Knowles BT1751 microphone. (b) too miniture earphones Knowles BK2615. Two channel frequency synthesizer. Hewlett - Packard HP8904A. Attenuators - Hewlett Packard HP355.	The DPOAE input-output functions presented two separate portions for the f2/fl ratio ranging from 1.18tol.26. Below 60dB SPL, a saturating portion with a SPOAE detection threshold at 36dB SPL, and above 66dB SPL, a linear portion. with DPOAEs below 512.5Hz no more saturating plateau could be observed.	DPOAE measurement in a clinical setting must be done with precise stimulus values (a) f2/fl ratio near 1.22 and (b) primary intensities below 60dB SPL. Active mechanisms are absent below 725Hz in human. Sex distribution could have been considered that we could have got different norms (possibly) for both sexes.

3.2.3

TINNITUS RELATED

1	2	3	4	5	6	7	8	9	10	11
1	1982	Tyler R.S. et al	8	To explore the relationship between tinnitus & SOAE	45s			Normal-20, Tinnitus-25	No	SOAE
2	1987	Penner H.J. et al	7	To explore whether an observed SOAK can be the physical basis of an audiable tinnitus.	23s			Both	For tinnitus matching gated sine wave lOmsec rise/fall time	SOAE
3	1989	Bonfils P.	11	To deteraine some basic features of SOAEs relative to i) the age and sex of normal subjects (ii) audiometric threshold and EOS thresholds with SN loss subjects.	234 e	2days-40years	- -	Both	For TSOASs rarefaction clicks 0.1ms rectangular pulses; repetition rate 19/s	SOAE + TEOAKs
4	1990	Norton S.J. et al	4	To explore the link between tinnitus 4 otoacoustic emission	5s	28-69	Ii7f	Normal	Tone burst stimuli at 0.5, 1.0, 1.5, 2.0, 3.0,4.0,5.0, and 8.0 KHz; two cycle plateau; 2ms rise/fall; intensities from 10 to 70dBSPl in lOdB Steps for TEOAS.	SOAE & TSOAE
5	1990	Plinkert P.K. et al	5	To demonstrate the relationship between SOAE and tinnitus.		37year	lm-	Norrmal	No	SOAE

12	13	14
Electret condenser microphone 11MM diameter diaphragm. Amplifier Tube 25.5mm length, 3.5MM i.d. Otoadmittance probetip. Revox A77 tape recorder. 8-bit Analog to digital converter. PDP 11/60 Microcomputer.	There was no clear relationship between the pitch of tinnitus and the spectum of emission.	
Laboratory computer, Sine wave oscillator, Miniature microphone Etymotic model ER-10, 1.35mm i.d. coupling tubes two. 3.80mm i.d. probe tubes, Two insert phones Etymotic ER-2 Wavetek 380/A Spectrum analyzer.	SOAE and tinnitus apear to be independent because(i) Audibility of tinnitus was not affected by suppressing the SOAE. (ii) SOAE was unchanged while masking the tinnitus by a high frequency tone.	Even though they could not get any association between SOAE and tinnitus for these subjects there light be an association in others. Hence farther studies are required.
Acoustic probe; length 3.5cm; Weight 20g. (a) Knowles BT 1751 microphone. (b) Knowles BK 2615 earspeaker. Impedance probe protector, Medelec AA 6MK 3 amplifier; gain 10^4 for SOAE High pass filter; 250Hz, 16dB/oct for SOAEs. Band Pass filter; 250Hz to 80Hz, 16dB/Oct towards low freg and 6dB/Oct towards high freq. High resolution signal analyser Hewlett Packard 3661A.	The incidence of SOAEs, decreased froa 68% in the group of infants less than 18 lonths old to 0% after the age of 70 years old. *to* Stat.Diff.in SOAE incidence found b/w participants with or without tinnitus. In the group of subjects with SN loss, the incidence of SOAEs decreased linearly with increasing click threshold or the detection threshold of TEOAE.	Instruments & stinli used are described very much in detail. Age range of abnormal group not mentioned. Sex distribution of cases not mentioned.
ER2 tubephone. Acoastic probe (Etymotic Research ER-10B) Hewlett Packard 35E1A dynamic signal analyser. Locally built variable gain (20-80dB) battery powered preamplifier. 12-bit ADC. Computer disk. Oscillator.	Oscillating EOEs and tinnitus are related to a common underlying pathology rather than the emissions being the source of tinnitus.	The detection of SOAEs and/or ringing SOAEs in ears with sloping losses, a history of noise exposure and tonal tinnitus might provide an objective method of evaluating tinnitus treatment Large scale clinical trials are needed to validate the above conclusion. More no of feaales have been taken in the sample.
Miniature microphone model no.870429B Etymotic Research. Spectrui analyser one Sokki Model CF 940. Sine wave generator Hewlett Packard HP8904A. Sennheiser earphone. Audiometer Philips HP 3741/30 with Beyer DT 48 earphone.	Following evidences indicate the correlation between, tinnitus and SOAEs: Simultaneous occurrence and supperession of both phenoaena. The pitch of tinnitus and the frequency components of the SOAE correlated. In a playback of the recorded SOAEs their frequencies were described to be identical with the tinnitus pitch.	Just on the basis of findings of simple case, we can not really conclude anything.

3.3

REVIEW AMD RKLATED ARTICLES

l	2	3	4	5
1	1955	Bekesy V.G.	1	Paradoxical wavetravel along the cochlear partition.
2	1976	Duval AJ III	6	Delineation of cochlear glycogen by electron microscopy.
3	1979	Kemp D.T.	3	The evoked cochlear mechanical response and the auditory microstructure-evidence for a new element in cochlear mechanics.
4	1982	Browneil W.E.	2	Cochlear trasduction: An integrative model and review.
5	1982	Qibian G.L. et al	2	Cochlear microphonic evidence for mechanical propagation of distortion products f2-fl and 2fl-f2.
6	1982	Moore B.C.J.		Cochlear echoes.
7	1982	Pickles J.O.		Active movements in the cochlea: The evoked cochlear mechanical response.
8	1982	Siegel J.H. et al	2	Efferent nerual control of cochlear mechanies? Olivocochlear bundle stimulation affects cochlear biomoechanical nonlinearity.
9	1983	Browneil W.E. et al.	1	Acoustically evoked radial current densities in sala tympani
10	1983	Kemp D.T. et al	-	An integrated view of cochlear mechanical nonlinearities observable from the ear canal.
11	1983	Rutten W.L.C. et al	-	Critical behavior of auditory oscillators near feedback phase transitions.

1	2	3	4	5
12	1983	Schloth E. et al	2	Mechanical and acoustical influences on spontaneous otoacoustic emissions.
13	1983	Sutton Q.J. et al	-	Modelling cochlear echoes: The influence of irregularities in frequency mapping on summed cochlear activity.
14	1983	Wit H.P. et al	-	Two aspects of cochlear acoustic emissions-Response latency and minimum stimulus energy.
15	1984	Kemp D.T. et al	2	Ear canal acoustic and rond window electrical correlates of the 2fl-f2 distortion generated by the cochlea.
16	1984	Rosowski J.J. et al	2	Cochlear nonlinearities inferred from two tone distortion products in the earcanal of the alligator lizard.
17	1985	Guelke R.W. et al	2	A mechanism for stimulated acoustic emissions in the cochlea.
18	1985	Zurek P.M.	1	Acoustic emissions from the ear. A summary of results from humans and animals.
19	1986	Fritze W. et al	3	Our present experience on spontaneous cochlear emissions.
20	1986	Geisler C.D.	2	A model.of the effect of outer hair cell motility on cochlear vibration.
21	1986	Kemp D.T.	2	Otoacoustic emissions, travelling waves and cochlear mechanisms.
22	1986	Kemp D.T. et al	3	Acoustic emission cochlegraphy-practical aspects.
23	1986	Lire D.J.	3	Cochlear micromechanics in understanding otoacoustic emissions.

1	2	3	4	5
24	1986	Wilson J.P	3	Otoacoustic emissions and tinnitus.
25	1986	Zenner H.P	2	Motile responses in outer hair cells.
26	1986	Zwicker E.	1	Otoacoustic emissions in a nonlinear cochlear hardware model with feedback.
27	1987	Leake Jones P. et al	2	Uptake of horse raddish peronidase from perilymph by cochlear hair cells.
28	1988	Furst M et al	1	A cochlear model for acoustic emissions.
29	1988	Neeley S.T. et al	1	Latency of auditory brainstem responses and otoacoustic emissions using tone burst stimuli.
30	1988	O-Uchi T. et al	5	Study of the so called cochlear mechanical tinnitus.
31	1988	Zenner H.P.	5	Outer hair cells as fast and slow cochlear amplifiers with a bidirectional transduction cycle.
32	1990	Bilger R.C. et al	7	Genetic implications of gender differences in the prevalence of SOAE.
33	1990	Bonfils.P et al	4	Clinical significance of otoacoustic emissions. A perspective.
34	1990	Brownell W.E.	4	Outer hair cell electromotillty and otoacoustic emissions.
35	1990	Kemp D.T. et al	4	A guide to the effective use of otoacoustic emissions.

		3	4	
6	1990	Lonsilury-Martin.B.L. et al	4	The clinical utility emissions.
37	1990	Martin G.K. et al	4	Otoacoustic emissions in Human Ears Normative findings.
38	1990	Zwicker E. al	9	Delayed evoked otoacoustic emissions: An ideal screening et test for excluding hearing impairment in infants.
39	1991	Lonsbury-Martin B.L. et al	7	Clinical applications of otoacoustic emissions.
40	1991	Shehata W.E. et al	5	Effects of salicylate on shape, electromotility and membrane characteristics of isolated outer hair cells from guinea pig cochlea.
41	1991	Talmadge.C.L. et al	1	Are spontaneous otoacoustic emissions generated by self sustained cochlear oscillators?

3.4

INSTRUMENTS

1) MICROPHONES

1) Knowles EA-1842	- 17
2) Knowles BT-1751	- 15
3) Knowles EA-1843	- 6
4) Knowles 1834	- 1
5) Knowles 8L 1611	- 2
6) B & K 4166	- 1
7) B & K - 4135	- 1
8) B & K 4134	- 1
9) Tandy WM 063T	- 3
10) ER-10	- 9
11) ER 870429-B	- 1
12) XL-9073	- 3
13) Senneheiser MKH 110/1	- 2
14) Senneheiser KE-4-211	- 2

(ii) EAR SPEAKERS

1) Knowles BK 1888	- 4
2) Knowles 1712	- 3
3) Knowles K2912	— 3
4) Knowles 1850	- 1
5) Knowles 1752	- 1
6) Knowles BK 1985	- 1
7) Knowles BK 2606	- 1
8) Knowles 1869	- 1
9) Knowles BK 2615	- 9
10) Knowles ED 1912	- 1
11) Knowles BP 1851	- 1
12) ER-2A	- 10
13) Beyer DT-48	- 8

(ill) **COMPUTERS**

1) Amplaid MK7	- 1
2) Amplaid MK6	- 3
3) BBC Microcomputer	- 1
4) Macintosh II	- 1
5) ILO88	- 6
6) PDP11/23	- 1
7) PDP 8/1	- 1
8) PDP 11/60	- 1
9) Nova 4X	- 1
10) Nicolet 1170	- 1
11) CA ALPHA 2/40	- 1
12) CED/ALPHA LSI-2	- 5
13) Corp - 11/23	- 3
14) POEMS	- 3
15) IBM PC/AT	- 1
16) Z-80	- 2

(IT) SPECTRUM ANALYZERS

1) Wavetek 5820A	- 4
2) Wavetek 4449	- 1
3) Wavetek 3801A	- 1
4) HP 3561A	
5) HP 3580A	- 4
6) HP 3582A	- 4
7) HP 3590A	- 1
8) HP 3850A	- 1
9) HP 3581A	- 4
10) HP 3661A	- 2
11) B&K 2032	- 1
12) B & K 2033	- 4
13) B & K 3033	- 1
14) Nicolet Pathfinder II	- 5
15) General Radio 1900	- 1
16) Unigon 4512	- 2
17) Ubiquitous UA-6B	- 2
18) Datalab DL 4000	- 1
19) Prinecton AR 4512	- 1
20) Racia REF 2/4	- 1
21) Sokki CF 940	- 1
22) SANEI 7S11A	- 1

3.5

MAJOR AREA OF FOCUS

i) SOAB

1) To explore the basic properties of SOAES
    a) Prevalence of SOAEs
    b) Spectral analysis
    c) Intersubject variability
    d) Intrasubject variability
    e) Short term stability
    f) Long term stability - effect of aging
2) Origin of SOAE - various hypotheses and their testing.
3) Interaction among multiple SOAEs.
4) Effect of external stimuli on SOAEs (SOAESTCs).
5) Reliability of SOAESTC measurements.
6) Influence of **aging-**longitudinal measurement of SOAESTCs in human infants.
7) Effect of SOAE on TEOAE.
8) Synchronization effect of DPOAE on SOAEs.
9) Effect of aspirin on SOAE.
10) Association between SOAE and DPOAE under aspirin use.
11) Normative data.
12) Effect of hearing loss.
13) To explore the link between SOAE and tinnitus.

ii) **TEOAE**

1) Explore the properties of TEOAEs.
2) Prevalence of TEOAEs.
3) Origin and mechanism of TEOAE production-different hypotheses.
4) Intrasubject stability.
5) Intersubject stability.
6) Effect of aging-developmental changes.
7) Influence of relative position between head and body.
8) Relation between stimulus parameters and TEOAE characteristics.
9) Relation between stimulus level and response level.
10) Effect of contralateral acoustic stimulation on TEOAE - Collect effect.
11) Suppression of TEOAE.
12) **Role of ossicular chain** in **TBOAB transmission to eardrum.**
13) TEOAE through bone conducted stimuli.
14) **Properties** and **characteristics** of BCEOAE.
15) Effect of hearing loss-both degree and pattern.
16) Normative data for both infants and adults.
17) Differential findings in the children and adults having known cochlear pathology.

18) Methodological problems in recording TEOAEs.
19) To try different techniques of recording TEOAEs.
20) Effect of change in EAM pressure.
21) Comparison of spectral analysis of TEOAE and audiograms.
22) To develop the appropriate and standard instrument to record TEOAE.
23) Determination of TEOAE threshold.
24) Evaluate the type I error.
25) Advanced cochlear echo technique developed for infant and neonatal screening.

(iii) SFOAE

1) To measure the amplitude and phase of SFOAE, their frequency spacing and level dependence.

(iv) DPOAE

1) How DPOAE is generated
2) Effect of stimulus parameters
3) Effect of aging
4) Association of SOAE & DPOAE
   a) Under use of aspirin
5) Normative findings
6) DPOAE characteristic and hearing loss
   a) Comparison of normal and known pathologic ears

(•) TINNITUS

1) To Explore the link between tinnitus and otoacoustic emission.

(vi) ANIMAL STUDIES

1) To explore the presence and characteristics of OAEs in lower animals.
2) To understand the mechanism of different OAES
3) Comparison of OAE in lower animals and human
4) Ontogenic development of DPOAE in rat
5) Relation between cochlear dysfunction and DPOAE responses parameters
6) Effect of sound exposure on OAE
7) Relation between acholocation frequency and cochlear properties in mustache bat

3.6

FREQUENT AUTHORS

Authors	Basic	CA	Review	Total
Lonsbury Martin B.L.	3	3	3	9
Martin G.K.	3	3	3	9
Wit H.P.	7	0	2	9
Kemp D.T.	3	1	4	8
Zwicker E.	4	0	3	7
Bonfils P.	0	5	1	6
Elberling C.	0	6	0	6
Harris F.P.	1	5	0	6
Johnsen N.J.	0	6	0	6
Zurek P.M.	5	0	1	6
Kim D.O.	2	1	2	5
Norton S.J.	2	2	1	5
Probst R.	4	0	1	5
Brown A.M.	3	0	1	4
Burns E.M.	3	1	O ^	4
Collet L.	1	3	0	4
Morgon A	1	3	0	4

3.7

YEAR WISE AND JOURNAL WISE BREAKUP OF EXPERIMENTAL ARTICLES

J.	1978		1979		1980		1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		TOTAL	
No.	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1	1	0	1	0	0	0	3	0	1	0	0	0	4	0	4	0	0	0	2	0	4	0	0	0	4	0	2	0	26	0
2	0	0	0	0	0	0	2	0	1	0	2	0	4	0	2	0	1	0	2	0	0	0	0	0	0	0	0	0	14	0
3	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	2	0	1	0	1	1	1	3	0	1	0	1	5	9
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	1	4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0	0	1	5
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	3	0	0	1	4
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	1	3
8	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	2	1	5
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	2
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	3
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2
Total	1	0	1	0	0	0	5	0	2	3	2	1	8	0	6	1	3	0	5	3	8	3	1	8	5	12	4	6	51	37

DISCUSSION

It was very easy to classify the articles into experimental and review (and related) articles, but the difficulty was felt in finding a dividing point on the continuum of experimental research to classify them into "basic experiments" and "clinical application". Classification is done honestly based on the criteria stated in the methodology but then for some articles, the author was at loss to group them in any class. For example, all the tinnitus related articles could have been classified as "basic experiments" but was put under clinical application because it was related to a clinical symptom "Tinnitus".

Out of 129 articles, 51 are basic experiments, 37 are clinical applications and 41 are review (and related) articles.

Out of 88 experimental articles, only 16 were on lower animals and the rest of the 72 articles were on human beings.

Under "basic experiment" 20 articles were found on SOAE, 18 on TEOAE, 4 on SFOAE and 6 on DPOAE. Under "Clinical application", 28 on TEOAE, 6 on DPOAE and 5 on Tinnitus. It is clear that TSOAE and DPOAE are the only types which are clinically significant. TEOAE is the most frequently studied. There are many articles where more than one type of OAEa, were experimenated but most of the articles were devoted to single type of OAEs.

In terms of instrumentation, only four items are discussed (i) microphone (ii) earspeaker, (iii) computer and software system and (iv) spectrum analyzer. The other less important instruments are not discussed because they are costly as compared to the computer based systems and a single computer can be programmed to replace all the other instruments. But the acoustic probe consisting of microphone and earspeaker (one or two) is essential for any system. Spectrum analyzer is included in our discussion because, till now, not all experiments are done using microcomputer based instrumentation and in those experiments spectrum analyzer is the important instrument.

All the articles have not reported the instruments used in detail. The frequency of use of a particular model is tabulated in Table-3.4 based on whatever information was available in the articles.

We have 14 different models of microphones reported among which Knowles microphones have the highest tallies. EA1842 and BT1751 have their frequency 17 and 15 respectively. ER-10 microphone is used in nine articles.

We have 13 different models of earspeakers reported among which 11 models art from Knowles and other two are ER-2A and Beyer DT-46. Considering the individual models ER-2A has the highest frequency of 10. Knowles BK 2615 is used in nine articles whereas Beyer DT 48 is used in eight articles. But overall Knowles transducers are more frequently used.

We have 16 different models of computers reportedly used among which Otodynamics IL088 has been used in most number of articles (6). CED/ALPHA LSI-2 has been used in five articles. Amplaid, MK 6, Corp 11/23 and POEMS have their frequency 3 each.

He have 22 different models of spectrum analyzers reported among which 7 models are from Hewlett-Packard (HP) and 3 models each from Wavetek and B&K. Considering the individual models HP3561A has the highest tally of 7 and then Nicolet pathfinder II has the frequency of 5. Wavetek 5820 A, HP 3580 A, HP 3582A, B&K 2033 and HP3581A have their frequencies of 4 each. Overall HP analyzers are more popularly used for OAE analysis.

The point to he noted here is that there are few groups of authors who are regularly involved in OAE experimentation and they have more than one (maximum 9) articles to their credit. They have the same set of instruments over a period of time and the same is reported in all their articles, so the frequency of these models in terms of number of articles in which they appear is misleading. The better way would have been to find out the number of different places (laboratories and clinics) where a particular model is being used. The comparative advantages and disadvantages should also be considered while selecting any instrument. But this review being exploratory in nature did not try to collect such information. That may be taken up as a future project.

Major areas of interest of the past experiments have been listed in Table-3.5 under six different headings.

Analyzing, Table-3.6, we find that Lonsbury-Martin B.L., Martin G.K. and Wit H.P. have the highest tally of articles either as main authors or co-authors. First two always work together and they have given equal emphasis to review articles, basic research and clinical application. wit H.P. is more interested in basic kind of experimentation.

Kemp DT has the tally of 8, but most of his articles are not available in our library. Otherwise Kemp DT is not less than any body in contributing to the field of OAEs. He can be considered the father of OAEs. He has all the three kinds of articles in the literature.

Zwicker E, another giant in the field is involved in basic research and related articles.

The authors who have more than 3 articles on their credit are only tabulated in Table-3.6. If we further scan the names in the bibliography, we find that there is a group of experimenters whose nucleus is Bonfils P., which is involved in experimentation in clinical application of OAEs espcially TEOAEs. Another important group nucleated around Johnsen N.J. and Elberling C is also involved in clinical application of TEOAEs. Another significant groups nucleated around Harris F.P., Probst R., Norton S.J., Zurek P.M. also can be identified separately working. Zurek P.M. has interest only in basic experiments.

Analyzing Table-3.7 we find that JASA contains the highest number of articles and those articles are of basic experiment. None of these studies are applied in nature. Then we have Hearing Research and Scandinavian Audiology each having 14 articles. But all the Hearing Research articles are basic experiments whereas 9 articles of Scandinavian Audiology are applied in nature. Other than Hearing Research and JASA all other journals contain articles of applied in nature.

The year 1990 has the maximum number of OAE articles (17). We can also observe the growing interest of experimenters in OAEs. In the beginning, till 1981, only experiments of basic nature were taken up and they were reported only in JASA and Hearing Research and gradually the number of articles of applied nature started growing and other journals also started publishing OAE articles.

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