OTOACOUSTIC EMISSIONS: A REVIEW OF STUDIES FROM 1978-1994 WHICH CAN BE DONE ON CELESTA-503

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1994

TO

MY BROTHER

DEEPAK SHARMA

CERTIFICATE

This is to certify that the Independent Project entitled: 0T0ACOUSTIC EMISSIONS: A REVIEW OF STUDIES FROM WHICH CAN BE DONE ON CELESTA-503 is the bonafide work done in part fulfilment for first year M.Sc, (Speech and Hearing) of the student with Reg. No.M9311.

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CERTIFICATE

This is to certify that this Independent poject entitled: OTOACOUSTIC EMISSIONS: A REVIEW OF STUDIES FROM WHICH CAN BE DONE ON CELESTA-503 has been prepared under my supervision and guidance.

Mysore
May 1994

Dr.(Miss) S.Nikam,
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DECLARATION

I hereby declare that this Independent Project entitled: **0T0ACOUSTIC EMISSIONS: A REVIEW OF STUDIES FROM WHICH CAN BE DONE ON CELESTA—503** is the result of my own study undertaken under the guidance of Dr.(Miss) S.Nikam, Director, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore
May 1994.

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INTRODUCTION

Otoacoustic emission is the emission of sound energy from the ear, which can be detected at the eardrum by a miniaturized sensitive microphone. How is it possible for the ear to produce the sound energy, is an unbelievable fact.

The phenomenon of otoacoustic emission is now almost established with our increasing and advanced understanding of the micromechanical properties of Mammalian Cochlea. Earlier cochlea was considered as a passive organ, converting the mechanical vibrations into neural discharges. But now the electromotile property of the outer hair cell is well established. This motility of the outer hair cell, stimulated by either d.c. or a.c. electricity was first demonstrated by Brownell (1983). Stereocilia of outer hair cell are composed of actin filaments and also contain (myosine (Tilney et al. 1980; Macartney et al. 1980). An interaction of actin and myosin in the stereocilia may account for the hair cells being actively

motile. This electromoti1ity, in turn, sets oscillations in outer hair cells at audible frequencies and hence, otoacoustic emission is produced.

A second hypothesis was suggested by Wilson (1980 c) that during activation the hair cells or supporting cells undergo volume changes, perhaps as a result of solvent following ions passing in and out of the hair cells.

Thus, according to above hypothesis cochlea can be considered to have bi-directional transduction property of - 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 difference limen. Hence according to him some type of active process which enhances the passive mechanical response of the basilar membrane to sound has 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 Also, tinnitus, a perplexing pathological auditory symptom was also unexplained and needed proper explanation. Hearing scientists were trying to study this phenomenon objectively by measuring it with various techniques.

Rhole (1971) reported experimental evidence for nonlinearities in the vibration of the basilar membrane. This nonlinearities of the mechanical response of the cochlea was later on described by Tilney et al. (1980) and Macartney et al. (1980). According to them as discussed earlier hair cells are actively motile, as a result of an interaction of actin and myosine in the streocilia. Ca 2+, which is necessary

for the sensory transduction, enters hair cells when they are activated. CA 2+ ions could then stimulate the interaction, resulting in movement of the streocilia. A similar activation of the interaction by sound could also cause a stiffening of the streocilia, and this may possibly explain some of the non-linearities of the mechanical response of the cochlea.

Later Kemp (1978) reported a most remarkable phenomenon of evoked acoustic emissions and this was an important achievement in the understanding of a cochlear mechanics and also in the tinnitus related research.

Since then various experiments have been 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 an OAEs.

Types of OAEss OAEs can be classified into 2 major types.

1. Spontaneous OAEs (SOAEs) - 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 external auditory meatus (EAM).

2. 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 stimulus used to elicit, EOAEs can be further classified into 3 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 (SFEOAEs)** - 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).

OAEs and Tinnitus: Earlier, when OAEs was discovered, many hearing scientists through that they got the explanation of tinnitus and so started experimenting in order to establish the link between OAEs and tinnitus. They hypothesized that SOAEs are generated due to microlesions of the outer hair cells which does not manifest as hearing loss and tinnitus and SOAEs have same origin or may be they are one and same. But later, this hypothesis was rejected and SOAEs are now considered as a phenomenon observed from normal cochlea and the individuals *are* most often *are* not aware of them Tinnitus, on the other hand, is a pathological annoying symptom due to which the individuals are disturbed. Though some of the studies did find some evidences linking SOAEs and Tinnitus.

OAE experiments and 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 OAEs: TEDAEs 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 100% of 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 **being carried on broadly on two lines:**

(a) Spectral analysis and latency of the response

(b) Finding of the OAE threshold.

TEOAEs are mostly experimented and this test is now 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 of mainly two reasons:

a) SOAEs are not found even in 5051 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 to this, EOEs are 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, otodynamic IL088 hardware and software systems *are* only commercially available instrument in the world. Programmable otoacoustic emission measurement system (POEMS) is also developed for this purpose. Celesta 503 of Madsen and 330 OAEs test instruments of virtual's computer controlled audio diagnostic system are also available. There are other microcomputer based systems but none of them are commercially available.

In India, till this day as we know very little work has been done in the *area* of OAE because of the non-availability of the instrument and computer program to measure otoacoustic emission. But now the scene is going to change because of the arrival of Celesta-503.

As India is an exporter of compute and softwares, our computer engineers along with our audiologists with the help of expected instrument will be in a position to develop appropriate software program so that India will also be able to join hands

with our foreign colleagues in research and development in the field of OAEs and thus in the field of diagnosis and evaluation of hearing loss at an early stage (research and clinical practice).

With this as prime abjective, a review of literature emphasizing the studies and research work which can be done on the coming OAE instrument from MADSEN ELECTRONICS - CELESTA 503, with specifications was felt necessary.

PURPOSE OF THE STUDY

The purpose of this study is to review and enlist those studies or research articles on OAEs which have been done in last 17 years (1978-1994) and which can be undertaken for further studies as independent projects, dissertations or thesis with the help of OAE instrument - CELESTA 503 from MADSEN ELECTRONICS in our Institute ie. ALL INDIA INSTITUTE OF SPEECH AND HEARING.

Along with this, articles are also classified according to following aspects-

1) Into basic experiments and clinical application.
2) Animal and human studies.
3) Different types of OAEs studied.

METHODOLOGY

The journal articles dealing with otoacoustic emission* in human beings and other lower animals which can be done with the help of expected instrument - Celesta 503 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 17 years (1978-1994). The journals in which the articles were found were: (Further, in the results, the following serial numbers are put for the respective journals in Tables).

1. Journal of the Acoustical Society of America.
E. Hearing Research
3. Scandinavian Audiology
4. Ear and Hearing
5. Acta otolaryngologica

6. Annale of Otology, Rhino logy and Laryngology.

7. Journal of Speech and Hearing Research

8. British Journal of Audiology

9. Audiology

10. Archives of Otorhinolaryngology

11. Laryngoscope

12. Clinical Otolaryngol and Allied Sciences

13. Journal of Otolaryngology.

All the journals related to ENT, Audiology and acoustics including the above mentioned journals were scanned and a total of articles were found to be related to the OAE research and clinical work which can be done on Celesta 503. The specifications given for the OAE instrument - Celesta 503 were compared with the specifications of the articles and those articles were selected whose specifications matched the ones given in the catalogue for Celesta 503.

Finally, the articles were divided into two categories-

a) Those related to basic studies

b) Those related to clinical applications.

The articles under 'Basic Experiments' were of studies where the properties of different types of OAEs were explored, the basic instrumentation needed for evoking and recording the OAEs were developed and the various factors related to and affecting OAEs were experimentally identified. They were further subdivided into 5 categories -

1) SOAE (Table 3.1.1)

2) TEOAE (Table 3.1.S)

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 experimental studies where the various types of OAEs 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 divided into 3 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.

The findings *are* discussed in a separate section.

RESULTS

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

Table-3.1.1: Summarizes all the articles related to basic experiments in the area of SOAE in human subjects, which can be done on Celesta-503.

Column - 1: Serial number of the articles.

2: Year of publication

3: The name (s) of the author(s)

4: Serial number of the journal in which the article was published,

5: Purpose of the article.

6: Number of ears (e) and/or subject (s) experimented.

7: Age range of the subjects.

3: Sex distribution of the subjects

9; Normalcy/abnormalcy of the ears experimented.

10: Instruments used by the authors in the experiment with specifications and models of instruments used.

11: Results/conclusions - wherever the authors did not conclusively infer tut 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

12: Remarks.

Table-3.2.1: Summarizes all articles related to Clinical applications in the area of TEOAE in human subjects, which can be done on Celesta-503. 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 which can be done on Celesta-503. The columns are same as described in Table-3.1.4.

Table-3.2.3: Summarizes all the articles related to tinnitus which can be done on Celesta-503.

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

Column 11: Gives the type pf OAE studied.

Table 3.3: Summarizes the major area of focus of research in different types of OAE.

Table 3.4: Summarizes the number of articles (all the two - basic, and clinical) against each author.

Table 3.5: Summarizes the year wise and journal wise break up of experimental articles under each year:

Subcolumn:a) Means the number of articles reporting basic experiment.

b) means the number of articles reporting clinical application

First folumn gives the journal number, which have been assigned earlier.

3.1 BASIC EXPERIMENTS

3.1.1. SOAE

1	2	3	4	5	6	7	8	9
1	1981	Zurek, P.M.	1	A survey search for OAEs and its properties.	365			Both
2	1933	Ruggeo, 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 OHCs upon the basilar membrane vibration.	le			Pathological

10	11	12
Two different ear canal insert probe assembly (A) For Author: (1) S3 (2) Plastic tubing i.d. 1.375 (3) Miniature mic knowles EA1842. (B) For others-GSI Std. Mic. B&K 4131 wave analyzer HP3581 X-Y Plotter.	SOAE were most often found between 1.0 and 2.0 KHz and the sound pressure in the ear canal was less than 200 /μ Pa. The contours of constant suppression exhibits frequency selectivity like that commonly associated with cochlear frequency analysis.	Age and sex distribution not mentioned.
Plastic speculum Beyer DT-48 earphone. Knowles EA-1842 mic. Amplifier (Princiton applied Research CR 4 or Ith&co 1201) 10U + 10U wave analyzer Hewlett Packard 3581A FrT (MSP-3X).	An external continuous tone is able to suppress the SOAE. The 3-dB-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 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
3	1984	Burns E.M# et al.	2	To investigate the interactions among multiples SDAEs	5s		-	-
4	1994	McFadden D et al.	1	To study the effect of moderate dooes of aspirin on OAE	5s			Normal

10	11	12
Knowles transducers EA 1842 Knowles transducers BR.1888$_t$ Grason Stadler Otoadmittance meter earpiece. - FFT (1.25 Hz line spacing) Spectral averaging Zwislocki coupler in KEMAR.	The results of this study demonstrate the highly nonlinear and extremely nature of the active cochlear process.	The study should be repeated with more number of cases with sound experimental design.
Otoadmittance earpiece Grason Stadler Model 1720B Knowles miniature mic. XL-9073. Amplifier High pass filter, 400 Hz High resolution signal analyzer B&K 2033.	SOAE 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 was highly idiosyneratic.	Authors have not controlled the effect of any use of salicyclate containing drugs on the results. These drugs are easily available in market.

1	2	3	4	5	6	7	8	9
5	1984	Robinowitz W.M.et al.	1	To explore the basic properties of SOAEs & their interactions with single external tones.	19e 12s	18-36 yrs	-	Normal
6	1984	Wier, C.C. et al	1	To determine the existence and characteristics of SOAE in a normally hearing popula, tion.	47S	19-60 yrs.	-	Normal

10	11	12
Two probes (a)Prob-1:containing small microphone knowles EA1842 (b) probe 2: containing above mic and a miniature receiver knowles BK 1888 Acoustic resistor knowles BF 1961. Preamplifier signatics 5532; gain 40 dB. Butterworth high pass filter; 400 Hz; 12 dB/oct FFT spectrum analyser Hewlett-Packard 3582A, Audiometric earphone TDH.39	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 2 external tones. This finding is interpre ted as the second tone having suppressed some aspect of the intracochlea influence of the first tone. The growth rate of sec. suppression appears to be near 1 dB/dB	The physical measures of tone on tone suppression 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 1720 B otoadmittance earpiece knowles miniature mic. XL 9073. Low noise pre-amplifiers. High pass	SOAEs were found 38% of the people and 27% of the ears tested.	The results are quiet similar to those reported by Zurek (1981).

1	2	3	4	5	6	7	8	9
7	1984	Zwicker, E et al.	1	To measure the amp, and phase of evoked synchronous emissions, their freq. spacing and level dependence.		24-35 yrs.		Normal
8	'19S5	Strickland E.A. et al	1	To determine the incidence of SOAEs in	71s	5.7 12.9 chl 17-45 days infant	21b-29 g.chr 86-13g infant	Normal

10	11	12
filter 400 Hz, zero gain, 8-pole Butterworth design. Operational amplifiers NE5534AS. Relative spectral analyser Hewlett-Packard 3582A. X-Y plotter.		
Specia11y deve1oped e1ec-tret microphone. Pre-amplifier Tektronix AM 502. Tracking frequency analyser B&K 2020. Small transmitter AKG CE52. knowles BT1754/seunheiser KE4-211 mic. spectrum analyzer HP 3520A Dynamic earphone Beyer DT48.	SOAE, SFOAE and TEOAE results from the.same source, which is located within the cochlea + therefore mirrors theirs hydromechanical characteristics.	If these emission are originated from the same source, then why there is difference in the incidence and waveform of these emissions.
Miniature microphone knowles EA 1842. Grason Stadler impedance probe Wavetek-Rockland 5820 A spectrum analyzer digital plotter.	Thre is no significant difference in the inci-dence of SOAE with age. There is a significant difference in the inci-dence of SOAEs in males and 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 short term stability of OAE freg. in detail.	2s	23-27	1m - 1f	
10	-1986	Cianfrone G et al.	3	To explore the preva lence of SOAE interms of rate of occurrence, freq. spectrum & intra and inter, subject variability.	lOye 52s	18-41	Both	Normal
11	.1986	Probst R et al.	2	To know the efficacy of different stimulus type in eliciting emission and to know the effect of SOAE on EOAE	28o 14s	19-35	7 m 7 f	Normal

10	11	12
Microphone, Princeton Applied Research 4512 real time spectral analyzer.	A statistically significant frequency decrease during the morning hours was observed.	More number 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 analyzer B&K 2032.	SOAE has been detected in 26% of ears & 30.8% of subjects. B/L SOAEs have been observed in 68.8%. Frequencies of the strongest emissions ranged from 1-2 KHz (96.3%). Amplitudes varied from 3-20 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 date available in literature.
Acoustic probe: (a) Miniature microphone knowles BT1751 (b) Miniature earspeaker knowles BK 1985, 2cc.	Two distinct patterns TEOAEs were identified (a) 18% ears showed short broadband CEOAEs lasting less than 20 ms after	Good explanation of the stimuli and instruments used.

1	2	3	4	5	6	7	8	9
12	1988	Bargones J.Y. et al	1	To measure the tuning of OAEs in the deve-loping auditory system by making longitudinal measurements of SOAESTCs in human infants.	34 s	Infant 3wks adults 9 45 yrs.	- S	Normal adults

10	11	12
coupler B&K DB 0138, 1" condenser microphone B&K 4131. Spectral analyzer Hewlett-Packard 3850A, Preamplifier (10U), Band pass filter (0.25 to 6 KHz) Krohn Hite 3343 R, amplifier (10U), LSI-11 laboratory microcomputer FFT, flexible disk.	stimulus onset (b) 82% ears showed CEOAEs lasting longer than 20 ms post-stimulus onset.	
Knowles EA 1842 microphone knowles 1888 driver, Grasn Stadler impedance probe. Function generator Hewlett Packard 3325A Wavetek Rockland FFT analyzer 5820 A.	Cochlear tuning characteristics in 3 weeks old infants are same range as those of adults.	This longitudinal study should be continued further tq get even more knowledge of development. Comparison of EOAE in children with that of the adults is questionable because of 2 groups are not matched. Evidence from 2 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.		To find out the effect of the ext.stimuli on SOAES.	31s	21-31 yrs.	Females	Normal
14	1988	Furst M et al.	1	To study the discrepancy between the two interpretations of the source of DPOAEs in humans.	11e 8s	20-35 yrs.		Normal

10	11	12
Otoadmittance speculum assembly (Grason-Stadler) An electret microphone knowles 1842 PV517. Plastic tube (length 13 mm, 1 mm i.d), soft platic impedandce tip. Preamplifier signetics 5534 op-amp (40 dB). spectrum analyzer (HP 3582A) FFTs-ER-10 mic and preamplifier assemply. ER-34 tube phone frequency synthesizer HP 3325A Attenuator H-P 350D.	SOAEs were detected in 38.7% of subjects and 25.8% of ears screened. The frequency of SOAEs ranged from 1304 to 4666 Hz with 50% emissions 50% above 2K. The amplitude of measured SOAEs ranged from 1.2 to 15.4 dB SPL (mean 6.94 dBSPL; SD 3.35) Bilateral emissions were detected in 33.3% subjects completed suppression contours closely resembled the well documented psy-chophysical tuning curves of the ear. Multiple emissions were present in 66.7% of subjects and 62.5% of ears.	Only females were subjected to the study. Future research should supplement existing daata regarding the behavior of SOAEs and their interaction with external signal across a wide range of subjects.
Acoustic probe (a) two knowles BK-1888 receivers (b) knowles EA-1842 mic. Preampli-fier (40 dB), Band pass filter (400 Hz to 22 KHz, 12 dB/Oct), spectrum analyzer	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	The results can be interpreted qualitatively with a model in which pri. tones produce distortion at their interaction region within the cochlea this distortion propogates to the

1	2	3	4	5	6	7	8	9
15	-1988	Wier CC et al	1	To explore the association between SOAE and DPOAE Under aspirin use.	4s		Male	4
16	.1988	Zizz C.A. et al.	7	To study relatively of SDAE suppression tuning curve measurements.	5s	23-28 yrs.	Female	Normal

10	11	12
Hewlett + package 3582A	frequency. Simultaneous cancella-tion of perceptual and acoustic.distortion was produced rarely.	distortion frequency place where it mediates perception. Detailed specifications of the stimuli used not given.
Modified standard oto-admittance earpiece Grason-Stadler Model 1720B. Knowles miniature microphone. XL-9073.	Aspirin consumption uni-formly reduced the SOAEs to unmeasurable or extremely low levels. Aspirin consumption also	The results indicate that periphral auditory systems of humans + rhesus monkeys are alike in their responses to aspirin.
Two Knowles model .1869 receiver. Amplifier, High pass filter, 400 Hz spectrum analyzer (Nicolet/Wewetek model 444a). Two General Radio Signal generators (Model 11310A).	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 study must be repeated with large sample.
Modified Grason-Stadler acoustic immittance probe assembly. 1720-9640 miniature microphone knowles EA-1842. Minia-	No significant difference between the SOAESTC trials (P>0.05). The mean slope of the SOAESTC low frequency segment was 53.7	The SOAESTC low and high frequency slopes and Q/0 were similar to psychophysical tuning curves data obtained in

1	2	3	4	5	6	7	8	9
17	1990	Van Dijk P et al	1	To demonstrate the synchronization effect of DPOAE (2f1-f2) on SOAES.	4e 4s			

10	11	12
ture earphone knowles ED 1912. 4mm teflon tube (ID=1.35 mm) amplifier. High pass filter 400 Hz 30 dB/real time spectral analyzer B&K type 2033. Oscilloscope (Hewlett Packard (1222A). Amplifier loudspeaker system. Interstate high voltage AM-FM, model F46. Acoustic probe (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 analyzer.	dB/oct. whereas the mean slope of the SOAESTC high frequency segment was 124.8 dB/oct. The mean low to high frequency slope ratio was 2.4 The mean Q10 value was 5.3. When primaries were sufficiently loud (30 dB SPL), phase fluctuated around a constant value-. The emission was constantly synchronized.to Fs lowering primary levels (20 dB SPL) resulted in 360U phase jumps at random moments. The emission occasionally slipped one of synchronization, trying to maintain its own natural frequency Fo.	simultaneous masking and physiological tuning curve data. This behaviour can be described as synchronization of an oscillator, Fo to a sinusoidal force Fs, in the presence of noise. The experiment can be replicated with more. number of cases and with the better design for further evidences and inferences.

1	2	3	4	5	6	7	8	9
18	1990	Van Dijk P et al	1	To present experimental data on amplitude and freq. fluctuations of SOAES.	10e			
19	1991	Glevis R Long et al	1	To investigate analytically and numerically of a model of SOAEs based on Van der Pol oscillators: Effects of aspirin administration.	4e, 4s	24 36 yrs.	Females	Normal

10	11	12
Sensitive microphone. video tape (Sony SL-C30E video recorder). Pulse code modulation (Sony PCM-f1) Wavetek 178 signal synthesizer Unigon 4512 FFT analyzer Band pass filter B&K . 1623. Heterodyne Band Pass filter B&K 2020. HP 5326 A timer.	Emission amplitude and period both showed small fluctuations (a) A rms/Ao ranged from 0.7 x 10U to 6.3 x 10U for human emissions 1 was 24 x 10U for both freq emissions. Trinsranged from 1.4 to 6.9 x 10U for the 2 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 Godssian noise cannot account for al1 experimental results.
Microphone probe (Zurek. 1981) (Whitehead '89), Etymotic ER-10 low noise microphone, EAR earplug with frequency resolution of 0.1 Hz, B&K 2010 heterodyne analyzer, Tektronix 2230 digital storage oscilloscope, Nova-4 computer.	Suppression and synchronization of SOAE by external tones of different frequencies and levels were obtained while the levels of spontaneous emissions were altered by aspirin administration. Modelling an emission as a single Vander Pol oscillator qualitatively accounts for - 1) reduction of level of	Model not adequate for describing all features of the data. It fails to predict (a) frequency pushing seen when frequency of suppressor is far away from that of emission. (b) More gradual slopes of the growth of suppression curves as suppressing tone increases in frequency above emission.

1	2	3	4	5	6	7	8	9
20 -	1991	David Brass & David Kempt	1	To observe OAEs evoked during a continuous single stimulus tone on humans using a nonlinear residual time domain technique.	2e			

10	11	12
	an external tone to suppress emission. 2) broadening of frequency locking tuning curve of an emission whose level is reduced. 3) pulling of an emission whose level is reduced.	Introduction of noise, nonlinear stiffness and incorporation of Fander Pol type damping in a full cochlear model necessry if basic interpretation of spontaneous emission is to be further evaluation.
Probe, 2 miniature lou-speakers (Knowles BP 1712), miniature micro-phone (Knowles EA 1843), tubes, acoustic resistors two 12-bit digital to analog converters (DAC) antialias filtering, attenuators, one 12-bit analog to digital con-verter (ADC), 8-bit ADC, IBM compatible PC-AT computer, CED spectrum signal processing soft-ware routines.	Residual found at the stimulus tone frequency has the latency and a saturating input-output growth functions indica-tive of an OAE. Out of the 2 methods used in experiment continuous time domain residual method has advantage for the observation of stimulus frequency. OAEs and for relating these to any DPs simultaneously generated.	If it can be shown that the amplitude transfer function nonlinearity givig rise to the residual is of this form then this will provide further incidence that the residual is caused by an OAE.

1	2	3	4	5	6	7	8	9
	1991	Annie M et al		To clarify the clinical relevance of SOAEs and to define .the hearing loss level (&,freq.) at which absence of SOAE is found.	126 e 63 s		33 f 30 m	Patholo-gical
22	1992	Miriain Furst et al	1	To investigate the effects of noise expo-sure on the threshold microstructure war on SOAE & on amp. & freq. of SOAE being measured.	60 e 30 s	20-30 yrs.	5 f	Normal

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Small probe (Etymotic Research ER-10B), low-noise preamplifier (Etymotic Research), high resolution signal analyzer (Hewlett Packard 3561A) for FFT analysis.	An incidence of 18.25% of the cases (23 out of 126 ears). SOAE were not found when hearing loss at 1 KHz exceeded 10 dB. Presence of SOAEs seems to indicate a good cochlear functioning, atleast in the mid frequencies.	Although incidence of SOAEs is marked lower than that of EOAEs, SOAEs recording is shown to be a good test, rapid, non invasive for audio logical screening, the presence of SOAE confirming a hearing threshold of less than 10 dB at 1 KHz, the absence being inconclusive.
Acoustic probe, micro-phone (Knowles EA-182) earphone (Knowles BK 1851), spectrum analyzer (HP-3582 A), computer (PDP 11/23). Clinical audiometer (Siemens SD 25), Oscillators (Wave/ Distortion analyzer PAR TM model 110)	1) A temporary reduction in the SOAE frequency and amplitude and alters reversibly the threshold microstruc-ture in the vicinity of SOAE. The diffe- rence between minimum and maximum in the threshold microstruc-ture is reduced and the frequency that yields minimum threshold decreases.	More extensive research required in order to character ize quantitatively the origin of nonlinear stiffness.

1	2	3	4	5	6	7	8	9
23	1992	Piere Bonfils et al		To study the basic properties of SOAEs & EOAEs as a function of gestational age (in preterm neonates)	134 e 67 s			

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	2) Threshold at SOAE frequency is most sensitive to noise exposure. 3) Intense stimulation causes relatively small increase or decrease in threshold at frequencies near SOAEs.	
Small acoustic probe incorporating small microphone (Knowles B11751), amplifier (Medelec AA6 MK 3), high resolution signal analyzer (Hewlett Packard 366 A). For EOAE recordings -> ILO 88 otodynamic analyzer measuring system (Stimuli clicks with flat acoustic spectrum for frequency .5-5 KHz.	(1) EOAEs recorded in 93% of tested ears. (2) SOAE recorded in 61% of tested ears. (3) No statistical significant variations of EOAE amp. with gestational age. (4) EOAE spectrum did not vary with age. (5) 2 main factors influencing EOAE amplitude were SOAE presence and fast	Here no modification in SOAE or EOAE properties recorded as a function of age between 32-41 weeks of gestational age. A number of infants at risk for hearing loss are preterm babies screening for EOAEs an objective, rapid, nontraumatic technique may prove useful in evaluating peripheral auditory dysfunction in preterm neonates.

1	2	3	4	5	6	7	8	9
24	-1992	M.J.Penner & R.R.A. Coles		To explore the effects of aspirin on tinnitus of a patient for whom two contralateral SOAEs caused binaural tinnitus.	Is 2e	52 yrs	Female	
25-	1992	A.Moulin L Collet et al.		To investigate the influence of contra-lateral auditory stimu-lation on DPOAE recorded in humans.				

10	11	12
	fourier transform spectrum, especially lower limit of spectrum. Thus maturation of OHCs properties appears to be complete at 32 weeks of gestational age.	
Sensitive miniature microphone (Etymotic model ER-10), Ext. PTs (Farvell signal generators, type DSG 2), 2 independent (Etymotic ER-3) insert earphones Hewlett Packard dynamic signal analyzer (model 3561A).	Aspirin seemed to provide an acceptable palliative for the patient's SOAE caused tinnitus.	
	There is a decrease in DPOAEs intensity for all at levels of contralateral BBN well below acoustic reflex threshold and in subjects without acoustic reflex. Moreover the influence of	Contralateral acoustic stimulatione ffect on DPOAEs provide a new means of functional exploration of medial efferent systm in humans. The effect is more ample at low primary frequency levels.

1	2	3	4	5	6	7	8	9
26-	1992	W..Kohler et al		To study long term observation of SOAEs	22 e 15 s			
27 -	1993	Wendy A. Harrison et al	I	To investigate whether studying effects of contralateral acoustic	11s		8F,3M	Normal

10	11	12
	transcranial trans-mission could be ruled out since no effect was found when contralateral Broad band noise applied to the altered ear of totally unilaterally deaf patients.	Moreover DPOAEs are stronger and show more . irregular. Input output . functions patterns in the vicinity of an SOAE, the influence of contralateral auditory stimulation studied on DPOAEs rcorded at 10 Hz, 50 Hz, and 150 Hz from an SOAE frequency.
Open system -> B&K 4145 Microphone(Fritze 85), closed system -> high sensitivity micro-phone (B&K 4179) (Free Cleriksen "84), B&K 2033 Fourier analysis.	In analogy to age-related high frequency Hearing loss, SOAEs recorded at the lower frequencies. This was associated with another phenomenon: precise frequency data available for 13 SOAEs (7 subjects) from the first examination showed SOAEs frequencies dropped slightly in all subjects.	
Probe assembly (Etymotic Research ER-10-B micro-phone/preamplifier	Systematic changes in frequency and amplitude of SOAEs observed for	Could not rule out effects of the acoustic reflex.

1	2	3	4	5	6	7	8	9
				stimulation on SOAEs is appropriate means of inferring aiivo-functions in humans.				
28	-1993	Martin L Whitehead et al.		To determine if there are racial differences in the prevalence of SOAEs.	20s	18-36 yrs	10F 10M	Normal

10	11	12
system), rubber eartip (Grason-Stadler), Spectrum analyzer (Wavetek/Rockland 5820A) Next computer, A/D (Digital ears), synthesizer/function generator (Hewlett Package 3325A), White noise generator (Elgenco), small transducer (Etymotic Research ER-2 tube phone).	increasing levels of Broad band noise for all subjects. Frequency shifts were always positive, whereas amplitude shifts were variable. No apparent pattern of tuning was seen, such that tones with a particular frequency relationship to the SOAEs induced greater changes in SOAEs.	
Miniature microphone (Etymotic Research ER 10A), low noise microphone preamplifier (Etymotic Research ER 10-72) + measuring amplifier (B&K 2610), dynamic signal analyz'er (Hewlett Packard, 3561A), computer based digital immittance system (virtual corporation 310).	Significant differences in the occurrence of SOAEs were found between 3 racial groups with negroes expressing more SOAEs than caucausian and Asians demonstrating an intermediate number of these emissions. More emissions recorded from females than male ears and significant correlation of the number of emissions in the 2 ears of an individual was also noted.	Findings support further efforts to perform a larger study of racial differences in SOAE properties in order to address mor compltely the notion of a genetic component in the determination of SOAE characteristics.

3.1.2- TEOAE

1	2	3	4	5	5	7	8	9	10
1	1978	'Kemp,D	1	[1] To report the experimental investigation of some what unconventional cochlear emissions by specially designed technique and instruments.	15s			both	200 /usec. rectangular pulse,repetition rate 16/sec.
2	1979	Wit, H.P et al.	1	To investigate the influence of stimulus freq. upon the magnitude of the response.	9s	23-		Normal	1.7, 2, 8, 4,2 KHz and bandwidth 600-900 Hz, repetition rate 16/sec,

11	12	13	14
Latency	Acoustic probe; 15 cm long; 1cm diameter (a) Miniature mic (b) Miniature earphone signal averager, computer.	New auditory phenomenon DAE 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 explanatory in nature are required to explore properties Of TEOAE.
Latency	Knowles K 1671miniature mic with spectrum analyzer obiquitous UA-6B Modified Princlton applied research type TDH9 signal average (100 memory points) or datalab type DL 400 digital averager (1024 memory points) High pass filter 500 Hz, 14dB/Oct.	Stimuli of higher f req. generate much smaller emissions than stimuli of lower freq. at the same stimulus level for low response levels the relation between stimulus level and response level is approx,lie ear. High response levels rise approx. as the cube root of stimulus level. A tuning curve could be derived by suppressing emissions with a second steady tone.	Sex distribution of subjects not reported. The same experiment with large sample should be repeated.

1	2	. 3	4	5	6	7	8	9	10
	1981	Wit H.P et al.	1	To study the properties of the freq. spectra of EOAEs recorded from human ear canal.	4s	22-30 yrs		**normal**	1.7, 2.8, 4.2 KHz & bandwidth 600-900 Hz
4	1983	Ruggero M.A. et al.	2	To cite an evidence for the hypothesis that SOAEs & TEDAEs are due to disruption of active feedback mechanisms of the DHCs upon basilar membrane vibration	le	-	-	Pathological	Clicks or tone pips (3.375 ms. steady? 1.25 ms. rise/fall time.
5	1983	Zwicker E.	2	To investigate the differences reported in the literature regarding the the slope of the relation between stimulus level ft emission level	-	23-58 yrs	-	Normal	Sinusoidal cycle/short tone burst/ Genvelops repetition rate 23-43/ sec.

11	12	13	14
Latency	Sensitive condenser mic. plastic tube 3.5 mm i.d. Amplifier band pass filter (0.5-4 KHz, 24 dB/oct) spectrum analyser ubiquitous UA-6B Oscilloscope Datalab DL 400 signal average low pass filter (Krohn-Hite 334 3, 96 dB/Oct)	The 2 procedures (viz. real time recording & calculation of the spectrum of time averaged emission) give diff. Input-output curves or TEOAE. Ihe real time spectral recording procedure can be used to measure tuning curves or to study the distortion product $2f1-f2_2$.	The results indicate that sharply tuned emission generators are present in the human cochlea.
Latency	Plastic speculum, Beyer DT-48 earphone, Knowles A-1842 mic, amplifier (Princeton applied research CR 4 or Ithaco 120l)10^2 - 10^4, wave analyzer Hewlett Packard 358/A, FFT (MSP-3X)	An external continuous tone Is able to suppress the SOAE. The 3 dB-ISO suppression curve is broadly tuned and displaced, relative to the SOAE towards higher frequencies. An audiogram notch exists at frequencies just below that of the SOAE.	Author explain these findings in terms of disruption of active feedback mech. of the OHCs upon BM vibration.
Latency	MIc, sennheiser MKH 110/ 1with- low freq# cut-off at 0.3 Hz, earphone DT 48s, amplifier, octave band filter, transformer	EOAE level is directly proportional to the stimulus level till 20 dBSL above which EOAE saturates SOAE lying in the same freq. range	Third conclusion gives the evidence that masking is the cochlear (peripheral Phenomenon)

1	2	3	4	5	6		8	9	
6	-1994	Zwicker E. et al	l	To measure the amplitude and phase of evoked synchronous emissions. their freq. spacing and level dependence.		24-35 yrs		Normal	No specific mention
7	-1986	Antonelli Aetal.	L 3	To analyse the intra-subject stability of the TEOAE. To study the influences of the relative position between head and body on the TEOAE.		mm		Normal	Click-100 /usec Burst-5 ms 500/usec.rise fall time 21/sec
8	-1986	Probst Retal	2	To know the efficacy of different stimulus type in eliciting emission & to know the effect of SOAE on EOAE.	28c 14s	19-35 yrs	7m 7f	Normal	Click 0.1 ms pulses. Tone burst 0.5.1, 1.5 and 3 KHz rise/fall 2 cycles.

11	12	13	14
		as EOAE influences above relation SSPs are images of MPPs.	
Latency and threshold	Specially developed electret mic, preamplifier Tektronix AM502. Tracking freq. analyser B&K 2020, small transmitter AKG CK 52, Knowles BT 1754/ Senheiser KE4-211 mic, spectrum analyser HP 3580A, dynamic earphone Beyer DT48,	SOAE, SFOAE + TEOAE result from the same source, which is located within the cochlea and therefore mirrors their hydramech. characteristics.	If these emissions are originated from the same source, than why there is difference in incidence and waveform of these emissions.
Latency	Probe manufactured in cooperation with Amplaid SPA, Band pass filter 200-5000 Hz Butterworth, Floppy disks, Amplaid MK7 software system.	TEOAE waveforms are stable over time. A decrease in amplitude and a time shift of evoked emissions whenever the subjects position was changed.	No.of cases, age and sex distribution was not mentioned.
Latency	Acoustic probe (a) miniature mic. Knowles BT 1751 (b) Miniature ear speaker knowles BK 1985. 2 cc coupler B&K DB 0133, 1" condenser mic, B&K 4132, spectral analyses Hewlett-	Two distinct patterns TEDAEs were identified a) 18% ears showed short, broad band CEOAEs lasting less than 20 ms after stimulus onset (b) 82% ears showed click	Good explanation of the stimuli and instruments used.

1	2	3	4	5	6	7	8	9	10
9	1937	Norton S.J. et al.	1	To obtain systematic data on relationship between tone burst freq. and intensity & EOAE characteristics in a group of normal ears.	7s	22-28 yrs	Fe-ma-les	Normal	Tone burst 0.5, 0.75, 1.0- 1.5 & 2KHz of 8.0# 5.6, 4.0, 4.2 & 4 ms respect. repetition rate 23/sec.
10	-1987	Van Dyk P et al	3	To determine whether Kemp echoes are useful techniques to define cochlear functioning	2l0e 120s	18- yrs.		Normal	Clicks

11	12	13	14
	Packard 385OA, preamplifier (103), Band pass filter (0.25 to 6 KHz), Krohn Hite 3343 R, amplifier.	evoked emissions lasting longer than 20 ms post-stimulus onset.	
Latency	Wavetek rockland 5820 A spectrum analyzer *DPC.* Programmable digital attenuator, acoustic probe, etymotic research ER-2 earphone, Knowles EA 1842 Mies, amplifier 40 dB gain, high pass filter 400 Ha, Microlet 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 EOAEs are a property of normal cochleas and are generated at places appropriate to their frequency along the cochlear partition.
Latency	Peters AP 200, small probe, mic, 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 and hearing graduate course. No specifications of the stimuli used provided. This finding limits the

1	2	3	4	5	6 [1] 7		8	9	1o
11	-1987	Zwicker E et al.	1	To elaborate on the co-rrelation of the 3 values	1s	62 yrs		-	Tone burst 1300 Hz > :200 ms; + 3 dB SPL.
12	-1983	Long GR et al		To explore the relation-ship between OAE (both	4s			—.	For TEOAEs— 30/usec pulses at 20 dB SL KHz half cycle at 20 dB SL for SOAEs-PTs range 1000 Hz. in 60 & 10 dB SL

1!	12	13	14
			useful application of this techniques as a method to evaluate cochlear functioning.
Latency	Mic, KEY Sennheiser, DT-48 earphone, MKH 110/1 Sennheiser mic.	The course of the SPP is a mirror image of that of MPP.	Similar results were found in animals.
Latency threshold	Probe (Grason Stadler Otoadmittance earpiece) a) Knowles E&-1843 transducer. b) Knowles BT-1752 transducer. 'Ampfi er Wavetek-Rockland 753 A Brickwall filter (500 to 5500 Hz) Wavetek 5820 A spectirum analyzer. B&K 2010 heterodyneslave filter Nova 4x computer.	SOAE gradually diminished and then disappeared during drug regimen. EOAE & 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 accmpanied by the eventual decrease in sensitivity.	The study should be repeated with a better experimental resign on a large sample. These findings are similar to the findings of McFadden and Plattsmier (1934)

1	2	3	4	5	6	7	8	9	
13	1988	Rossi G et al.	5	To study the EOAEs thro BC ed, stimulation. To study the role of ossicular chain in the transfer of EOAE to the eardrum.	10s	18-		Both	1000 Hz tone burst, 5 ms rise/fall time lms repetition rate 31/sec.
14	1988	Rossi G et al.		To explore the possibility of using the bone conducted stimuli evoke TEOAE.	24e 24s	19-24 yrs	Both	Normal	1KHz tone burst; 3 ms. rise/fall time lms. repetition rate 31/s.

11	12	13	14
Latency and threshold	Amplaid MKVT system 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 subjects with U/L Otosclerosis before surgery no EOAE could be elicited by ACs from the otosclerotic ear, whereas they could be recorded by BCs. After stapedectomy. EOAEs could be obtained by ACs, too.	Results suggest that the ossicular chain is imp. but not essential in the transfer of the TEOAE to the eardrum. Further studies are required for more evidence.
Latency	Amplaid MKVT. Amplaid Echo Probe for AC. Radioear B71 vibrator for $BC_{\#}$ Quest mod. 215-45-12 phonometer FFT.	The morphology of BCEOAE behaves in the same way as that of AC EOAE. By contrast with ACEOAE whose mean threshold is the same as that of the subjective tonal threshold for the same stimulus presented by the same stimulation modality. BCEOAE threshold on average is about ID dB HTL Higher.	The last finding early demonstrates but not an essential role in the transfer of TEOAE from the inner to external ear.

1	2	3	4	5	6	7	8	9	10
15	1989	Rossi G et al	3	To cite an experimental evidence for active intracochiear mechanisms as the core of TEOAE.	11s	12-26		Pathological	Tone bursts 3 mse rise/fall time lms freq 0.5, 1& 2 KHz repetition rate 31/sec.
16	1990	Collet L et al	6	To investigate the age factor in relation to EOAEs.	166e 93s	60-83 yrs-		Normal	Unfiltered rarefaction click 100ms rate 22.7/s.
17	1991	Harris Fp et al	9	To assess the amount of variability in the level and spectrum of TEOAEs from normal ears.	10s	31.5 yrs. Mean	5m 5f	Normal	80/us rectangular pulses.

11	12	13	14
		ACEDAE can not be obtain ad in otosclesotic subj ects whereas they appear after surgery. BCEOAE are obtained before surgery and increase in amplitude postoperatively.	
Latency	Amplaid MK VI system Amplaid Echo probe Knowles B&K 2606 ear phones. Knowles BT 1757 mic. Quest Mod. 215-45-12 Phonometer FPT.	TEOAE could be super-imposed by a passive intra-cochlear mechanism,	
Latency	Tandy WM 063T mic. Knowles K 2912 earphone Band paff filter 200-7000 Hz. Nicolet pathfinder II apparatus	When age increases the presence of EOAEs by age group and the freq. peak in spectral analy-sis decreases & EOAE threshold increases.	Sex distribution not mentioned. This find-ing should be used, while interpreting the clinical results.
Latency	IL088 otodynamic ana-lyzes. Portable com-puter compaq III foam E.A.R. type eartip.	The amplitude for TEOAEs is stable over successive short-term measurement variability	This is one of the pro-perties whey TEOAEs can be considered as a potential test for

1	2	3	4	5	6	7	8	9	10
19-	1991	Byan S et al	8	To cite an experimental evidence for collect effect	4s	25-40 *yrs*		Both	C1ick repe— tition 50/s

12		13	14
		within individual spectral bands was approximately ldB from 0.9 to 4.1 KHz and was slightly greater for 0.7 KHZ.	cochlear function. The experiment should be repeated with a large sample.
Latency	Otodynamic ILO acoustic emission analyzer. A probe for the NTE containing loudspeaker A probe for TE containing a) mic, (b) ear~ speaker.	Collect effect was demonstrated in all the normal subjects. The amp. and phase changes, though small, were easily identified using he difference response techniques.	Further research is required to investigate the neural significance of the presence or absence of the collect effect in retrocochlear pathologies. The same experiment may be repeated in clinical setting with more number 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 audioldgical and vestibular test battery to add information about the integrity of the cochlea and the status of the medial efferent system.

1	2	3	4	5	6	7	8	9	10
19	1993	David Brass et al	l	To observe evoked OAEs during continuous single stimulus tone made on humans using nonlinear residual time domain technique.	2e				
20	-1992	.Hauses S R. et al	6	To study the influence of General anesthesia on TEOAEs in humans.	20s	18-52 yrs.	20f,	Normal	80/usec reatangular pulses; Rate-20 ms; stimulus level- 75 80 dB SPL.
21	-1993	'Thornton A.R.D.	8	To study the new techniques and application of CEOAEs.	12e 6s		-	normal	Clicks presentation rate - 338 to 840/s stimulus

11 12		13	14
-	Probe, 2 miniature loud speakers (Knowles BP 1712), miniature mic (Knowles EA 1843), tubes acoustic resistors, two 12 bit digital to analog convertors, one 12-bit ADC, 8 bit ADC IBM compatible PC-AT computer, CED spectrum signal processing software routines.	Residual found at the stimulus tone freq, has the latency and a saturating input-output growth functions indicative of an OAE. Out of the 2 methods used in expt. continuous time domain residual method has adv. for the observation of stimulus freq. OAEs and for relating these to any DPs simultaneously generated.	If it can be shown that the amp. transfer function non-linearity giving rise o the residual is of this form then this will provide further incidence that the residual is caused by an OAE.
Latency	ILO 88 otodynamic . analyser in combination with portable computer (pyramid computers. freiburg, Germany)	Amplitude of TEOAEs .reduced during general anaesthesia in 9 of 10 patients in N20 group and in 7 of 9 patients in non N2o group and average decrease of amp. after first 10 min. greater in N20 group than non N20 group.	Differential frequency effects imply a ME effect for greater reduction of TEOAE amp. in N20 group due to gas diffusion into ME. Decrease in non N20 is because of presence of additional factors affecting response during GA.
Latency	Otodynamic Ltd. IL088 system (normally at 50 clicks/s) in both its linear and non-linear model.	There is a significant . reduction in test time which in turn helps responses to be recorded	Further experimentation needed to ascertain the exact parameter values .involved.

1	2	3	4	5	6	7	8	9	10
									level 2-65+75 dBSPL Bandwidth 100-5000 Hz.
22	1993	Thornton A.R.D.	1	To study high rate OAEs	16e	6 adl.(26 yr MA) 3 Negates 3 days MA	-	Normal	Clicks stimulation rate 840/s
23	1993	Meric C. et al	5	To compare the influence of an auditory attention task & of repetitive measures on peripheral auditory system, using EOAEs	24s	18-43 yrs	15 f 8m	Normal	Non-filtered clicks stimulus level-66 dBSPL (+3dB), bandwidth -500-6000 Hz.
24	1993	Norman,M et al	8	To investigate the influence of noise bandwidth on contralateral masking of CEOAEs.	20s	21-46 yrs.	10f 10m	Normal	Non-linear click stimulus at 75 dB SPL, 5-20 ms.

11	12	13	14
	Nicolet Spirit averager POEMS probe.	and deconvolved to produce an uncontaminated response.	
Latency	Same as above.	Use of maximum length sequences (MLSS) to EOAEs enables the test to be performed in few secs.	
Latency	Knowles 1712 transducer stimulator. Knowles 1843 mic. (B type probe. otodynamic Ltd,) Otodynamic ILO 88.	Increase in EOAE amp. during 2nd, and 3rd session with linear saturation around last measurement. No attention effect identified. time effect present. EOAE amp. of subjects presenting SOAEs compared with those without SOAEs significant diff. found showing particularity of cochlear emitting SOAEs.	Further experimentation needed with 2 groups of subjects like some seated and others lying down. Also the duration between recordings can also be varied.
Latency	Otodynamic ILO 88 OAE analyzer, GSI-16 audiometer	Amount of suppression increases with bandwidth of noise, particularly	Suppression shows no significant correlation with age, sex or abs. level of

11	12	13	14
	Medresco OL 575 ALG 1/76 insert earphones.	for noises centered around 1 & 2 KHz WBN produced greater suppression than NBN large intersubject variability.	emission. The possibility that it may show some correlation with other effects in which the efferent pathway are thought to be involved remains to be investigated.

3.1.3 DPOAE •

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3.1,3 DPOAE

1	2	3	4	5	6	7		
1	1384	'Burn E. ;M etal.	2	To investigate the interactions among multiple SOAEs.	5s	-	-	,No specific mention.
2								

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Spectral analysis.	Knowles transducer EA 1842. Knowles transducer BR 1898. Grason Stadler otoadmittance meter earpieces. FPT (1.25 Hz line spacing) spectral averaging Zwislocki coupler in a KEMAR.	Highly nonlinear and extremely complex nature of the active cochlear process.	This study should be repeated with more no. of cases with sound expemental design.
Spectral analysis	Acoustic probe a) 2 Knowles BK-1999 receivers b) Knovle's EA-1942 mic. Preamplifier (40 dB) Band pass filter (400 Hz. to 22 KHz, 12 dB/oct) spectrum analyzer Hewlett and Packard 3592A	Ears tended to exibit all or none of the emission types that were sought. The magnitude of SFOAE & DPOAE showed a similar dependence on freq. simultaneous cancellation of perceptual and acoustic distortion was produced rarely.	The results can be interpreted qualitatively with a model in which petones produce distortion at their interaction region within the cochlea, their distortion, propagates to the distortion freq. place where it mediates perception. Detailed specification of the stimuli used not given.

1	2	3	4	5	6	7	8	9	10
3	1988-	Wier CC et al. . ,	1	To explore the associa- tion between SOAE & DPOAE. under aspirin use.	-	4s	-	M	-	At & around SOAE freq; within iOO Hz, f2/fl 1, 15.
		Gaskill SA et al	1	To investigate (i) the dependence of DPOAE level an stimulus parameters & & (ii) the relationship between DPOAE level and auditory sensitivity.	34	s	15-50 yrs	19f 15m	Normal	2 pri.tones, *fl &* f2, 100s continuous freq.sweep from 500-5500 Hz.

11	12	13	14
Spectral analysis and thresh-old.	Modified Standard oto-admittance earpiece. Grason-Stadler Model 1720 B. Knowles miniature mix XL-9073. Two knowles model 1869 receiver Amplifier, High pass filter 400 Hz spectrum analyzer (Nicolet/wavetek model 444a)	Aspirin consumption considerably reduced the SOAEs to unmeasurable or extremely low levels. Aspirin consumption also reduced the amp. of the DPOAEs But did not eliminate them entirely. 'The amp, of DPOAE and its change with aspirin consumption were related to both the proximity. The general radio signal generators (Model 11310A)	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.of the frequency of the SOAE and to the level of primaries producing the DPOAEs.
Spectral analysis and threshold	Perspex metal probe specially designed. a) two 1712 loudspeaker $ 1643 mic. Philips: PM 5193 function'generator. Amplifier. Spectrum analyzer, Hewlett Packard 3561A PPT. BBC microcomputer with IEEE interface.	The frequency ratio f2/fl at which DPOAE level is maximal varies only slightly across freq. & subjects, The avq. optimal ratio is 1,225, Beyond- the max. the DPOAE level declines with increasing f2/fl ratio at fates ofc upto 250 dB/oct.	

1	2	3	4	5	6	7	8	9	10
5	1991	Hanser R 1 et al.	To determine		20e 10s	22-32 yrs.	5m 5f	Normal	2 pri.PTS f1 &f2 (f2 fl) 3M=lKHz# 2 KHz, 2 KHz & 4 KHz, f2/fl 1.25, 1.23, 1.21 respectively.

11	12	13	14
		As the level of one stimulus is increased relative to the other, DPOAEs grow, saturate and in roost cases show a bend over. Maximum distortion is generated when L1 exceeds L2.	
Spectral analysis and threshold	Two channel freq. synthesizer (Hewlett-Packard 3326A). Two insert earphones Etymetic Research, ER-10, Preamplifier Etyrnotic research ER-10-72 Amplifier custom built. High pass filter, 400 Hz, signal analyzer Hewlett Packard 3561A FFT. Personal computer Macintosh II.	The level diffs.L2-Ll generating maximal OPOAE amplitudes dependent on L1 and on the GM Freq. of Fl and F2 L2-L1 evoking maximal mean DPOAE amps, was -10 dB For GM freqp.of 1&2 KHz with L1= 65 dB SPL and 0 dB with Ll=65 dB SPL & 0 dB with L1= 75 dB SPL. The mean slops 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 4 KHz for Ll=65 dB SPL and from 0.48 at 1KHz to 0.7 at 4 KHz for L1-75 dB SPL.	The complexity of the interrelationships among parameters & additional factors originating from the characteristics of individual ears, such as middle ear mechanics. Possible influences of central nervous system and other types of OAEs needs to be addressed to understand the variability in the amp. of DPOAEs.

1	2	3	4	5	6	7	8	9	10
6	1991	Lonsbury Martin B.L. et al.	1	To study the influence Of aging on the generation of DPOAEs.	60e 30s	31-60 yrs	15m 15f	Normal	Equilevel (Ll= L2) Pri.tones. f2/fl- 1.21
7	1991	'Rickman M.D. 'et al.	1	To investigate electrophysiological evidence of nonlinear DPs to 2-tone stimuli.	1s	36 yrs;	-	Pathological]	fl = 510 and 800 Ha. f2/fl of 1.16, 1.26, 1.36 and 1.46

11	12.	13	14
Spectral analysis and threshold.	Grason Stadler E3262A attenuator. Wavetek 116 signal generator. Telex 1470 audiometric speakers. Artificial ears B&K 4152 acoustic probe. Two Etytnotic research ER-2 Earspeakers. Etymotic research ER-10 mic. Preamplifier etymotic research 10-72. computer.	When compared to emissions in young ears. DPOAEs accurately tracked the systematic deterioration of HF hearing in aging individuals.	The instrument used is not described in detail. This rinding can be clinically, applied while interpreting the EOAE findings in aged cases. Further research is wanted with the pathological cases.
Spectral analysis.	—	Time domain summation and substraction of separately collected evoked responses to rarefaction & condensation signal performed to demonstrate electrophysiological difference tone (f2-fl) and cubic diff. tone (2fl-f2) responses reflect then exqpected quadratic and cubic nature.	Suggestions for development of clinical application of assessing auditory nonlinearity using this methodology are provided.

1	2	3	4	5	6	7	8	9	10
8	199 3,	Brown , A.M. et al.	1	To investigate: acoustic distortion as a measure of freq. selectivity. Relation to psychophysical equivalent rectangular bandwidth.	8s	-	-	Normal	Fixed f2 of 4 KHz, stimulus level 40dBSPL, veried fl at 55 dBSPL; f2/fl-l.2 bandwidth 2837 -3960 Hz.
9	199 3	Kimberley B.P. et al;	1	To measure human cochlear travelling wave delay using DPE phase responses.	36e 18s	' -	9f 9m	Normal	f1 at 60 dBSPL, 11 DPE measures for f2=10KHz & 4 DPE measures for f2=lKHz, f2 at 45 dBSPL freq. 8 f2 -500 -10000 Hz f2/f1=1.1 to 1.3.
10	199 3	ne, N.J. et al.	' 1	To investigate fine structure of 2fl-f2 acoustic DP changes with pri.level.	10s	24-36 yrs.	-	normal	f2/fl=1.2 pri. level varied between 45-65 dB SPL.

11	12	13	14
Spectral, analysis and thresh- , olds.	Probe-2 knowles BP 1712 miniature loudspeaker, Knowles EA 1S43 mic, ᴹLock-inʷ amplifier (B3-K35210). Macintosh II ci using software package "Excel".	In 6 subjects for whom . good rep eatable levels of distortion measured a sig. - we correla- tion found between tuning of distortion peak and psychophysical. bandwidths at f2.	Further study required to know precise causal relationship between tuning of distortion peak and obj.measure of freq. selectivity.
Spectr al. analysis	Packard-Bell PC, plug, in signal processing ' board (Ari el DSP-i6 version G), 2 insert earphones (Etymotic PR-2 a low noise mic. (Etymotic ER-10 B) soft ware program (CUBDISP-I)	Estimates of travelling wave delay from ear canal to F2 place varied from about lms for 10 KHz place to 3.5 ms for the 0.78 KHz place. Data supporting use of DPE phase responses as estimates of coch. travelling wave delay.	Whether the source of reduced intra-subject cochlear variability is on the basis of physical coch.length or on the basis of functional coch. attributes are not known.
Spectral analysis.	16 bit waveform synthe- sizer (pragmatic 2211 A -3X), 2 earphones (Etymotic ER 2), 2 tubes low noise mic. probe (Etymotic ER 10B) Spectrum analyzer (Hewlett Packard 3561 A) MS DOS computer.	At freqs. below 4 KHz. as primary level incre- ases, sharpness of ADP fine structure is not sig. reduced & pattern gradually shifts to lower freq. At freqs. above 4 KHz flattening of pattern is observed	No sig. reduction of sharpness in ADP fine structure at pri. freqs. of around 4 KHz & lower This inconsistency suggest fundamental diff• in generation mechanism for ADP as compared to that of auditory threshold

l	2	3	4	5	6	7	8	9	10
11									
	1993	Avan,P. et al.	9	To investigate freq. specificity of human DPOAEs	25e nor-mal 50e path	7-.42 nor-mal -23-170 path		Both	f2/fl-l.23 at 1,1.5,2.4,6, 8 KHz stimu-lus int.62-72 *dB* SPL.

11 12		13 14	
		at high levels. ADP peaks can shift to valleys with increasing level & vice. Thus small shifts in pri. freqs. can result in sig. change in shape of ADP I/o function.	
Spectral analysis and threshold,	Probe (Etymotic research ER 10B) in miniature mic & 2 loud-speaker (ER-2), artificial ear (B&K 4153, half inch mic. B&K 4165 home made coupler) 2 channel synthesizer (Hewlett Packard 890 YA), spectrum analyzer (Kewlett Packard 3561A freq. span 1KHz, spectral resolution 2.5 Hz) PC-AT computer with a Hewlett Packard 82321 Processing Board.	. Amplifier of DPOAE evoked by low int. pri. tones was strongly correlated only with aud. threshold at their mean freq. and DPOAE disappeared for local hearing losses larger than about 30 dB. DPOAE amp. did not depend on basal coch. state confounding effects of ME transmission and aging not significant in this set of expt. when elicited by higher tones. DPOAE exhibited more complex and non local behavior and their sensitivity to hearing loss decreased. Results suggest that low pri. intensities when used DPOAE patterns provide freq. specific information on local coch1ear state.	It would remain to be shown that f2 place was indeed normal in this number of cases and this question needs further work.

Table - 3.1,2: Summarises all the articles related to basic experiments in the area of TEOAE in human subjects which can be done on Celesta-503.

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

10: Stimuli used to elicit the TEOAE.

The specifications mentioned wherever it was reported in original articles,

11: Gives whether the article measures latency of the freq. specific responses or threshold of TEOAE.

12 to 14: Same as described in Table 3.1.1. under columns 10 to 12.

Table - 3.1.3: Summarizes all the articles related to basic experiments in the area of DPOAE in human subjects which can be done on Celesta-503,

Column 1 to 10 & 12 to 14 : Same as in Table 3;1.2:

11: Gives whether the articles does the spectral analysis or threshold measurement of DPOAE,

Table3.1,5: Summarizes all the articles on animal studies which can be done on Celesta-503.

Column 1 to 5: Same as in Table 3.1.1,

6 : The animal subjected to experimentation.

7 to 11: Same as in Table 3.1.2 under columns 6-10 respectively.

12: Anaesthesia used during OAE measurements.

14 to 16: Same as in Table 3.1.2 under columns 12 to 14 respectively,

3.1.4: ANIMAL STUDIES

3.1.4: ANIMAL STUDIES

1	2	3	4	5	6	7	8	9	l0	11
1	1991	Schmiedt R.A. et al	2	To investigate the cochlear origins of the TEOAE and DPOAEs with the aid of coch0-lear microphonic recordings.	Mongolian Gerbil (Meriones Unguiculatus)	20s	4-12 mns		Normal	TEOAE:50/us -200 /us clicks or 2 ms tone pips with .75 ms rise fall time? stimuli . rate 10/s.

12	13	14	15	16
Intraperitoned injections of urethane (1.5g/kg) or sodium pentobarbital (40 mg/kg)	TEOAE & DPOAE	Beyer DT-48 or TDH-49 earphone1/2 condenser mic (B&K 4134) or Knowles mic(EA-1842) Single micropipette in scala media and a wire electrode at the RW (for cochlear microphonics).	Stimulated acoustic emissions in the form of echoes to transient stimuli are not present in the earcanal of the anesthesized gerbil. Acoustic emissions in the form of DPs by-two tones are present in the earcanal of the anesthesized gebril at levels 20-40 dB greater than those found in a small cavity. The levels of acoustic and CMDPS are resistant to death by anoxia for atleast i-2 hours. Elimination of the ADPs is also concurrent with the total disappearance of the negative EP & the CM response to fundamental tones.	No mention of the stimuli parameters for DPOAE. It is an invasive technique so cannot be replicated with human beings.

1	2	3	4	5	6	7	8	9	10	11
2	1981	Zurek P.M. *et* al.		1	Search for acoustiq emission in the ears of chinchillas	Chinchill-as	23s	- -	11 nor-mal 6 path logi ical	Suppression tone near the SOAE freq.
3	1931	Zwicker E et al.		2	To establish the presence or absen-ce of acoustical responses in guinea pigs & to compare their properties to those found in the case of man.	Guinea pigs	7s 10e	-	- -	single peri-od 45 /sec. for EOAE
4	1932	Wit H.P. et al.		2	To show that EOAEs occur in monkey ears also.	Monkey	5s	Male	-	0.2-5 KHZ driven with electrical pulse of 0.1 in seg repeti-tion rate 40/s.

12	13	14	15	16
Diabutal (sodium pentobarbit -ol Ketaset (Ketamine hydrochlo- ride).	SOAEs	Earpiece from Stadler 1720. Miniature mic. Knowles electronics (EA 1842). wave analyzer (Hewlett Packard 3581A). X-Y recorder (Hewlett Packard 7035 B)	The absence of SOAE in 26 ears of 17 healthy chinchillas. Two chinchillas demon- strated continuous narrow band OAEs after exposure to noise	Human ears are ex- posed to noise & hence this findings leads us the recon- sider whether the SOAE is a normal phenomenon. This may be because of microl esions in the organ of corti due to noise exposure.
Neurolepta- analysis.	TEOAE	Earphone DT 48s mic-2; amplifier. octave band filter transformer.	Acoustical responses are readily measur- able in the guinea pig & can be esta- blished as such by single criteria such as nonlinearity. hypoxia sensitivity and low frequency suppression.	The specification of instruments & their models are not mentioned.
Ketalar 20 mg/kg.	TEOAE	Miniature mic. Knowles BL 1671 Amplifier. High pass filter 500 Hz. FFT switch second high pass filter 400 Hz 24 dB/oct.	Like human ears and ears of others ani- mals species these monkey ears also eraitt, 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 Bood description of instruments.

1 2 3 4		5	6 7	8	9 10	11
5 1982	' ZurekP.M et al.	1 To assess the usefulness of measures of ADPs for .disclosing the presence of cochlear disorders.	Chinchilias	-	- Both	3 paid of Pri tones. l.f1=1150 Hz? f2-1250 Hz. 2.f1=3680 Hz f2=4010 Hz. 3.fl=3680 Hz f2=4815 Hz.
6 1934	Brown A.M. et al.	2 To investigate the origin & mode of emission of the 'ADP#	Mongolian gerbils (Meriones ungrioula-	- Ger- bil 6-8 mths	- nor- mal	. 2fl-f2

12	13	14	15	16
		Data lab DL 4000 averager. Digital tape recorder. Computer-FFT algorithm.		
Diabutal 60 mg/kg intraperitonically	DPOAE	Two knowles miniature earphones. One knowles miniature mic. Grason Stadler otoadmittance meter 1720. Two oscillators. Two attenuators. Programmable attenuator two. Amplifier wo wave analyser. Hewlett-Packard 3581 A. Computer PDP 8/1.	When fl & f2 were in between 30 & 90 dBSPL 2fl-f2 and 2f2-fl DPS were 30 to 50 dB below pri.tone levels, Noise exposure that caused temporary or permanent hearing loss produced corresponding temporary or permanent reduction in DPOAE. levels. In the absence of cond. impairment DPOAE levels can be used as a sensitive indicator of hearing sensitivity & the condition of the cochleq.	This can be introduced as a test of differential diagnosis in our clinical practise.
Nembutal Droperidol	DPOAE	Knowles transducers (2 lousspeakers and one mic)	The cubin difference tone 2fl-f2 responses from the gerbil can be	No.of subjects & sex for both animal and human groups not

1, 2	3	4	5	6	7	8	9	10	11
			Whether the DPOAE is similarly produced in gerbil and man.	and normal man.					
7.	1984,	Clark W.W., et al.	2 To bring together salient features of otoacoustic. cochlear histopathological and behaviour threshold shift observations to aid in undeorstanding the mechanisms underlying SOAE.	Chinchilla	56e	-	-	28 noise exposed ears 28 unexposed ear	Freq.of the SOAE (1)with a bandwidth 30 Hz.suppression experiments (2) with a bandwidth 300 Hz. for recovery function

12	13 14	15	16
	Second mic in meatus via. a 4 mm long lmm i.d. tube. Insulated silver wire with an exposed & chlorided tip in the round window region as electrode to monitor CM.	used as a model for the humans 2fl-f2 response. This response can be used to obtain information about cochlear freq. selectivity. DPOAE is a valuable tool for non-invasive monitoring of cochlear activity over a wide frequency range in both species.	not mentioned. Age range (mean age) of human subjects not mentioned. The auditory pathology of the gerbil subjects not investigated. The specification of stimuli used not mentioned.
Diabutal SOAE 60 g/kg i.p) sodium putobarbita	Earpiece Reason Stadler 1720 with a knowles electronics mic EA 1842. Sweep freq have analyzer (Hewlett Packard 3580A) X-Y recorder (Hewlett Packard 7035B) Oscillator (Hewlett Packard 2394) attenuators (Hewlett Packard 350) Earphones (Knowles 1716)	Two cases of SOAEs have been found among 28 chinchillas ears after noise exposure. No cases of SOAEs have been found among 28 un exposed ears.	Small sample size so the results can not be generalised Good description of instruments.

1	2	3	4	5	6	7	8	9	10	11
8	1994	.Ruggero M. A. et a l.	2 ,To report *very* intense SOAE pro- 3uced, by both ears,of a dog..	,An American Eskino Dog	1	5 mths	Male,	Path olo- gical	No stimuli	
9	1935	Doian T,G. et al.	To explore the possibility of mechanical changes being associated with long-term adaptation by examining changes in the amplitude of DPOAE foil.sound exposure.	Cat		Adult	Nor- mal		Two equi-level continuous tones for DPOAE tone bursts for AP.	

12	13	14	15	16
Atroplne sulphate (0.04 mg/kg sodium Thiamylal (18 mg/kg Halothane.	SOAE	Plastic speculum Beyer DT-48 earphone. Knowles EA-1482 mic. Amplifier, Oscillo-scope. Wave analyzer Hewlett Packard 3S81 A ABR.	Intense (59 dB SPL) SOAE are produced by both ears of a 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 cochlea.
Sodium pen-tobakbital (50mgAg body wt) Intaperiton-cally;	DPOAE	Oscillators, TDH-39 earphone General Radio (900 wave analyzer)	Sound exposure can alter the mechanical response of the cochlea to two tone input. Both DPOAE and action potential one reflec-tions of the same underlying cochlear process. Adapter effectiveness is strongly influenced by the state of the middle ear.	By removing the anti-resonance of the ME. cavities and the build up of negative pressure by opening the bullat removing the septem, the study should be reported.

1 2 3		4 5 6			7	8	9	10	11
10 1985	Horner K.C et al.	1	To evaluate the relation between cochlear dysfunction and particular features of BPOAE.	Mice	20 , 15-norl.328 , 35 . days Hg. imp muta. nt mice	-		both	2fl-f2 at equal level
11 1985	'Kossl M. et al.	2	To investigate the' properties of EOAE in the Mustache bat. comparison of this EOAE with human EOAE. To investigate the relation between echolocation freq. uencies and pro perties of the hearing system.	Mustache Bat(Pteronotes Parnelli)	15	-	-	-	I series:continuous tones sweeping from 10 to 120 KHz with a 100 or 1000 Hz/s sweep speed. II.series: phase locked tone bursts and clicks.

12 13		15	15	16
Urethane (2 mg/g body l	DPOAE	Knowles electronics microphone (EA 1751) B&K 2608 amplifier spectrum analyzer. Hewlett-Packard 3580A), B'K 4134 mic. 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 level. In the hearing impaired mutants the level was dependent on the particular type of auditory dysfunctions associated with the mutations.	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 thi s data applicable to the human beings.
Nembutal or Halothane	SFOAE TEOAE & SOAE	B&K 4135 (1/"4) mic. Condenser loudspeake' HP 3594A oscillator HP 3590A wave analyzer. Wavetek 12 freq. generator. Bell & Ho well tape recorder. VIcko-22-16. PDP 11/23 microcomputer. Glass insulated tungsten electrodes.	EOAE can reach an amplitude as large as 70 dB SPL and occur in the freq. range most important for echoic—cation. A sharp max. of the amplitude of cochlear microphonic potentials at about 6 2 KHz could be correlated with the anission freq. In one bat EOAE response changed to a SOAE	There is no mention of auditory normalcy/abnornalcy and its measure-Bent before or at the time of emission recording EOAE converting into SOAE is something of important consequences and it should be further experimented

1 2 3	4 5	6	7 8	9 10	11
1..2 1995 .Martin G.K. et al.	2 Incidence of SOAEs in non-human primates (Monkey)	Monkeys	51	1.5-13.9 49m Nor-mal ,12f mths	NO stimuli
1.3 -1987 Lenior M et al.	2 To investigate how acoustic emissions develop during the cochlear maturation.	Wistar Rats.	82s	11-40 days	TWO continuous pri.freqs

12	13	14	15	16
			Freq. and amplitude of the EOAE responses reversibly decreased often exposure for 1 min. to continuous sounds of more than 85 dB SPL with freqs. of about 2.5 to 7.5 KHz above the BOAE freq.	
Ketanlne MCL, Vetalar 20 mg/kg.	SOAE	Knowles, 1834 mic. probe tube 2.8 mm ID 15 mm 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 5.0% of the monkeys were found to have SOAES.	Only light anesthesia used possibility of anesthesia reducing SOAE amplitude is not ruled out, sample comprised of 80% of made.
Nambutal intraperi- ton eal 50 mg/kg	DPOAE	Probe, mic. Knowles 1842. Two knowles 1850 earphones catheter, 8 mm long 0.5 ram i.d. 2 freq. generator. attenuator. Tektronix Preamplifier AM 502 spectrum analyzer	Adult like patterns of the acoustic responses were achieved by day 18 for 2fl-f2 = 3KHz, by day 20 for 2f 1-f 2-5 KHz and by day 28 for 2fl-f2 = 7 KHz. The fact that the 2fl-f 2 OAEs reached	*The* similar experiments with the human newborn and children should be done.

1	2	3	4	5	6	7	8	9	10	11
14	1990	.Brown A.M-. et al#	1	To explore the similarities between rodent and human responses using moderate to low levels of sound stimulation.	Guineapig (Pigmented)	20	-	-	-	Tone pulses 10 ms rise/ fall .5 ms.

12	13	14	15	16
		B&K 2033. 1/2" B&K mic. 4134 artificial ear.	adult characteristics from low to high freqs. is not consistent with the development of the tuning properties of the basilar membrane. The long development of the 2f1-f2 OAES at 7 KHz suggests that the organ of corti undergoes subtle changes well after the end of its apparent maturation.	
Hypnorm . DPOAE (0.25 m/Kg)' & Diazepam (25 mg/kg)	Probe accompanying 2 knowles, 1712 loud speakers and knowles 1842 mic Hewlett Packard spectrum analyzer (3561 A)		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 levels sound is compared. Although underlying process is the same, human response is more structures and less predictable.	Number of human beings in the comparison group not mentioned. Age range and sex of the guinea pig not mentioned.

1	2	3	4	5	6	7	8	9	10	11
15	**1990 Van P.**	Dijk et al.	1	To present experimental data on amplifier and frequency fluctuations of SOAE-	Human Frog (Rana esculants)	8e human 2e frog	-	-	-	Not stimuli

12	13	14	15	16
Not mentioned.	SOAE	Sensitive microphone videotape (Sony SL-30E Video recorder) pulse code modulation Sony PCM-F1). Wavetek 178 signal synthesizer Unigon 4512 FFT analyzer. Band pass filter B&K 1623 Heterodyne band pass filter B&K 2020 HP 5 326 A timer.	Emission amplifier and period both showed small fluctuations. (a) Arms/Ao ranged from 0.7×10^{-2} to 6.3×10^{-2} For human emission. (b) Trms ranged from 1.4 n 6.9×10^{-7} for the 2 frog. emissions. There was a positive correlation. (R= 0.9) between Arms/Ao and Trms.	Authors compare these results with that, of second order oscillator and observe that an oscillator with linear driven by white Gaussian noise cannot account for all experimental results.

1	2	3	4	5	6	7	8	19	10	11
16	1992	Chertoff N, et al.	7	To describe the properties of averaged auditory evoked potential distortion products in Guinea pigs'.	Pigmented guinea pigs (cavia Porcellus) Wt-200-250 gms.	20 -		-	Normal	f2/fl=1.12 to 1.52., pri. freq. (500-2000 Hz).All two-tone signals had 20 ms. linear rise fall time, and 160 ms. plateau.
17	1992	Whitehead M.L. et al	1	To provide independent .evidence for the existence of more than 1 DPOAE source & to determine the contributin of each to the ear canal 2f1-f2 signal.	Rabbits from both pigmented & albino Newzealand strains.	-	12 wks		Normal	1.source of distortion dominant over 60-70 dBSPL at mod.pri.freq. separations & at all stimulus lvls when pri.tones are closely spaced. Other dominant below 60-70dBSPL at mod.pri.freq. separation & stimulus levels when pri.tones widely spaced*'

12	13	14	15	16
Ketamine (50 mg/kg) & Xylaine (5 mg/kg)	DPOAE	Earphones (Nova) speculum, 3 an piece of polyethelene tubing, probe mic, (Knowles,ER 7),mic equalizer (Knowles equalizer (Knowles *4-72),* measuring amplifier (B&K type. 2610, spectrum analyzer (Hewlett Packard Dynamic signal analyzer 3561 a).	The amplitude of AEP cubin diff. tone (AEP-CDT) increased with increasing f2-fl ratio For 500 Hz f1 pri. & remained constant for 800 Hz and 1700 Hz f1 pri. AEP diff. tone (AEP-DT) was larger & frequently identified than'AEP-CDT). Amp. of AEP-DT decreased with an increase in f2-fl ratio. Decrease more pronounced for low freq. fl pris. than high freq. fl pris.	Study provided a description of ADPs in normal animals and provide a baseline for future studies determining the effects of coch. damage on auditory nonlinear mechanisms measured with AEPs.
	DPOAE	Measurement probe, dual channel synthsizer computer, attenuators, 2 dynamic earspeakers (Beyer DT-48), probe tube, inch condenser mic (B'K 4166), dynamic signal analyzer (Hewlett-Packard 3561 A), lock in amplifier (Ithaco 3961 B)	By varying stimulus parameters it may be possible to independe--ritly study the two generator mechanisms.	It is not dear whether high level DPOAEs result from passive. macromechanical properties of cochlear partition or from one energy-requiring process. Also it is not clear whether there are discrete low and high level DPOAE sources in human ears.

1	2	3	4	5	6	7	8	9	10	11
18	1992,	Allen, J.B, et al.	1	To measure coch. amplifier gain as a function of position along the basil at membrane	Cats-	Adul	-	-		
19-1992		Littman, T ' A. et al.	1	To determine the influence of tonic efferent input on eoch. mechanics by transecting entire OCB in guinea pigs and Observing changes in tuning curves & acoustic DPA.	Pigmented guinea pigs wt.250-500 g.	- Young[1]	both sex	-		

12	13	14	15
DPOAE	Earphone, probe mic, transducer/ micro-electrode.	Total gain of coch. amplifier over the range of positions measured , must be less than 10 dB, Thus there is no cochlear amplifier. Cochlea must achieve its freq. selectivity by some other means.	
DPOAE	Oscillators (Hewlett Packard 200 CD)/ attenuator sets (Hewlett Packard 350 D), 2 inset receivers (Etymotic ER-2) probe mic (Etymotic ER-lOA) Preamplifier (Etymotic ER-1072) signal analyzer (Hewlett Packard 3561 A).	No consistent changes in tuning curves or in growth functions of DPS. Measures reflect cochlear mechanical non-linearities. Tonic OCB input is not necessary for grossly normal cochlear mechanical functions in the 10 KHz region of guinea pig cochlea.	It seens unlikely that efferents are involved in establishing set point for cochlear operation.

1	2.	3	4	5	6	7	8	9	10 .	11
20	1199 2	Whitehead M.L. et al.	1	To investimate physiological vulnerability of .DPOAEs in each of the two 2fl-f2 DPOAE-response region identified on basis of differential parameter properties.	Pigmented Newzealand strain rabbits.				-	2fl-f2, stimulus level 45-75 dB SPL.
21	199 3	Khama S.M et al.	8	To measure mechanical vibrations of Heusen'.s cells with a laser heteradyne interferometer in guinea pig temporal bone.	Guineapigs					
22-	199 3.	Rabillard G. et al.	8	To investigate changes in 2fl-f2 DPOAEs foll.	Guineapigs wt.200-300g:					

12	13	14	15	16
Lethal anoxia ethacrynic acid gentamycin	DPOAE	Head mount device. measurement probe. dual channel freq. synthesizer, computer, attenuators, 2 dynamic ear speakers (Beyer DT-48) speculum probe tube, 1/2" condenser mic (B&K 4166), dynamic signal ana-Iy2er (Hewlett-Packard 3561 A) or lock in amplifier (Ithaco 3961B)	Low and high level 2fl-f2 DPOAE arise from discrete sources. Low level DPOAE source is an active micromechanical process elimination of both high and low level DPOAEs reveal presence of third. residual 2fl-f2 DPOAE component, approx. 75-80 dB below stimulus tone levels, they may reflect true passive distortion response of the cochlea.	Mechanisms of generation of low level DPOAEs and role of active cochlear process in the generation of DPOAEs remain obscure.
Plexiglass tank filled with tissue culture raedl um through which 02 was bubbled	SOAE	386 based computer system coupled to a 16 bit D/A converter for freq. tuning curve.	Spontaneous vibrations noticed, which originated at the OHCs and are supposed to be the sources of SOAE in ear.	
Urethane (1.6 g/Kg i.p) flaxedial(.6 mg/100 g im)	DPOAE	Probe containing 2 emitters (Knowles 1850) & 1 receiver (Knowles .1757) computer controlled	DPOAE remains affected for a certain time after the metabolic perturbations were removed.	Comparison of behavior of DPOAEs and of other coch. parameters give good indications on the way different

1	2	3	4	5	6	7	8	9	10	11
				alterations in coch.metabolism						
23	-1993	Manley G.A. et al	1	Investigate the general characte-ristics of DPOAEs in bobtail lizard	Bobtail Lizards (Tiliqua-rugosa)	20	adults	-	-	Pri.fl tones (fl=0.455. 0.705; 1.005; 1.4, 1.9, 2.8 & 4.0 KHz) SPL of both pri.tones raised in 5 dB steps from 20-70 dB **SPL**

12	13	14	15	16
		spectrum analyzer (Hewlett Packard 3561 A) IEEE 488 bus A/DC, glass micro-pipette, WP 1KS-700 amplifier, oscillo-scope, digital volt meter.		experimental proce-dures affect the functioning of coch-lea during and after their application.
Diazepam ("Valicum" 2mg/kg Initial dose) and phenobahbi-tol ("Nem-butal" 25 mg/Kg. i.p. Alcuronium chloride "Alloferin"[1] #5 mg/kg i.m.	DPOAE	Hewlett Packard 3325 *A* freq. synthesizer. nanual attenuators, 2 Beyer DT 770 head-phones, 7 cm plastic tubes, B&K 0.5" mic B&K 2660 low noise preamplifier HP 3561 *A* signal dynamic analyzer (DSA) IEEE 488-1305 System.	DP from high freq. segment bore a remar-kable to ADP of mammals in many details. inspite of substantial structural and micro-mechanical differences between these hearing organs, suggesting it is the characteristic of HCs themselves that are important factors for determining DP generations. Also characteristics of ADP produced by low level pri.tones were determined by tuning characteristics of hearing organ at HC level.	

1	2	3	4	5	6	7	8	9	10	11
24	-1993	Koppl C. et al.	*1*	To investigate suppression tuning characteristics of DPOAEs in Bobtail lizard.	Bobtail Lizards (Tiliqua Rugosa)	10				2fl-f2 & sf2-fl, pri.fl tones (fl= 0.455# 0.75, 0.005, 1.4, 1.9, 2.8 & 4.0 KHz)
25	1993	Mills D.M et al.	1	To investigate the vulnerability and adaptation of DPOAEs to endo-coch. potential (EP) variation.	Gerbils		60-90 days			fl=6.8; f2=8 KHz (f2/fl=1.18) 2fl-2f2, 3fl-2f2, 2f2-fl & f2.fl

12	13	14	15	16
Pentobar-bital and Diazapam.	DPOAE	Same as above	Suppression tuning curves of DP generated by low level Pri,tones resemble those from mammals and field in-formation concerning integrity of hearing organs.	Mechanism generat-ing DP patterns are based on basic HC props, and not on their acce-ssory structures.
Furosemide	DPOAE	Thermocouple, ref. electrode (world precision Instru-ment, MERE 2), Ety-motic mic/probe tube assembly (ER-108), rubber tube, tra-cheal camnula, retrac-tors micropippette. computer (Macintosh II fx) digital sig-nal processing board (spectral inno-vations), 3 channels for ADC & 2 for DAC, attenuators, 2 Ety-motic ER-2 trans-ducers, Etymotic ER-10B mic, coupler, AC/DC preamplifier (Grass pl6).	Emission at 2fl-f2 and 3fl-2f2 at low stimu-lus levels were vul-nerable to changes in $EP_{\#}$ EP decreased smoothly, re ached a minimum *1 1/2* hours after inj. then recovered slowly over several hours. Recovery with inter-preted as an adaptive effect with a time constant of about 15 min.	

1	2	3	4	5	7	8	9	10	11
26	1993	Canton B. et al.	1	To measure auditory brainstem responses, DPOAEs, HC loss and. forward masking tuning curves in waltzing guinea pigs.	Waltzing guineapigs	Ins	.2,9, 15, 30 days	-	normal.

12	13	14	15	16
-	POAE	2-channel synthesizer HP 8904A, Beyer DT 880 headphones. Etymotic Research ER-10B probe, ER-10B mic. HP 3582 A spectrum analyzer.	ABR threshold shift increases as postnatal; day increases. DPOAE amp. as function of PI; amp. increased with postnatal day and also with stimulus level. Prominent alteration occurs in 3rd row OHC, then 2nd and then 1st tuning curves show decrease in sensitivity with increasing age.	

CLINICAL APPLICATIONS

3.2.1 TEOAE

[a]

1	2	3	4	5	6	7	8	8	10
1	1980	Johnsen N.Jet.al .	3	To describe instrumental set up & method adopted by the authors for the signal analysis.	25	29-42 yrs.	1m If	Both	Click,rarefaction pulse of 2 KHz repetition rate 10/s.
2	1982	Johnsen N.J. et al.	3	To obtain normative data for the CEOAEs in young adults & to investigate the influence of posture on the emissions.	10s	21-42 yrs	6f 4m	Normal	Clicks of 2 KHz repetition rate 10/s

11	12	13	14
Latency & threshold	. Probe Danplex ZA30, wt. log. Knowles BT1757 mic. knowles B&K 2615 ear-phone amplifier. Band pass filter (250 Hz^1 24 .dB/oct. to 5 KHz, 18 dB/oct) CED/ALPHA LSI-2 computer Floppy Disc.	Recording from a normal threshold subject served as an eg. and a clear response could be traced down & below the psychoacoustic thresh-old. The threshold was ele-vated and the response pattern altered when a SN hearing loss was induced by ingestion of acetylsalicylate. No response could be recorded from a deaf ear within intact eardrum and mobile ossicular chain.	We cannot generalize these findings of the study as because single case is not enough to generalize. Hence study with more number of cases should be repeated.
Latency	Same as **above.**	A clear response could be traced down to or below the psychoacou-stic threshold in all ears. Response pattern diffe-red from one ear to another (intra & inter subject variability). Both the methods applied. to get group latency were almost identical.	Sample size is small hence generalization not possible.

1	2	3	4	5	6	7	8	9	10
3	1983	Johnsen N.J# et al.	3	To point out the possibility to develop the recording of EOAEs into a neonatal screening test.	20s	48-96 hrs	llf 9m	Normal	Click, rarefaction pulse of 2 KHz repetition rate 10/s

11	12	13	14
		The individual input output functions exhibited nonlinearity. The latency vs. freq. relationship was ambigous. TEOAE demonstrated high stability of response pattern from the individual ear response pattern unaffected by posture.	
Latency	Same as before.	A clear and reproducible response was identified from all ears at 50 dB att. The echo group latencies & amp. were within the same range as in normal adults and the amp. input out-out curves exhibited a clear nonlinearity. Final conclusion is that the recording of TEOAE could be applicable us a sereening procedure in newborns#	A follow-up of these children will give confirmatory results. So a prospective study with more number of neonates are required. It is difficult to clearly diagnose a child as normal just based on otoscopy and tympanometry ABR could have been done. For a better estimate of hearing status.

1	2	3	4	5	6	7	8	9	10
4		995	Elberling C et al'	5 To evaluate the TEOAEs in response to various tonal stimuli in normal hearing adults. To evaluate the type I errors.	100s	48 - 96 vrs		Normal	2 KHz click or a tone burst repetition rate 20/s.
5	19		Bray P et al	8 To determine if the advaneed cochlear echo techniques developed could acquire a valid OAE recording from the typical child pt, with typical noise present.	105	64 - 55 73 yrs.		Both-	

11	12	13	14
Latency	Probe (a) miniature mic, (b) receiver (earphone) Amplifier. Band pass filter (250 Hz, 24 dB/oct, and 5 KHz, 18 dB/oct. computer.	Evoked activity from each ear contains energy intpreferential freq. bands & change of stimulus freq. has only a minor effect on the power spectra. Significant information is obtained by the click rather than by tonal stimuli. Omission amplitudes were of the same order of magnitude as those previously found in normal hearing adults. Cochlear echo can be recorded in normal hearing newborns with an extremly low rate of type I error.	Precise description of the instrument used is not given. Testing time can be reduced markedly by increasing the repetition rate and reducing the number of test runs
Latency	Knowles 1712 miniature Knowles 1843 miniature mic. Brasstube 2 mm ext. dia lmm internal diameter. 11 mm length. 2.5mm Heine speculum C.A. ALPHA 2/40 microcomputer CED 502 analogue	The subject noise problem in acoustic cochleography can be solved and that a properly engineered test device could be useful addition to the audiometer test battery for children not just neonates.	The field trial is neccessary. less expensive microcomputer should be utilized to make it cost effective.

1	2	3	4	5	6	7	8	9	10
6	1987	Tanaka Y et al	5	To ascertain whether OAE is clinically applicable for evaluating the degree of impairment in hearing loss.	52s	-	30m 22f	Patho-loaical	Tone burst, 3 ms; rise fall 1 ms.

11	12	13	14
	interface 80 M byte Whichester disc, with 100 KHz writing speed DMA CRT display 502 DAC		
Latency and threshold	RION AA - 61BN audiometer, RION RS-30 impedance audiometer. Acoustic probe, a) Danavox, 5 MW-68 earphone. b) Knowles EA 1843 mic. amplifier. Signal processor SANEI 8U16.	TEOAE are excellent in reproducibility# The interaural diff. is a useful indicator in U/L SN hearing loss. The interaural diff, 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 TEOAE is clinically applicable in the differential diagnosis of SN 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
7	1988	Bonfils Petal	5	To summarize the results of TEOAE obtained in adults and infants both with normal hearing and other pathological conditions.	330 e	-	-	Both	Clicks-lOO /usec. repetition rate 21/s.
8	1988	Johnsen N.J. et al.	3	To obtain normative data from newborns and to discuss the practical and methodological problems related to recording of EOAE#	100 s	48-96 hrs	43f 57 m	Normal	Click rate: faction pulse of 2 KHz repetition rate 20/s.

11	12	13	14
Latency and threshold	Miniature mic. Knowles BT-1751. Earspeakers Knowles B&K 2615, length of probe 3 cm. Wt. of probe - 20 g. spectrum analyzer Hewlett Packard.	TEOAEs can be clinically used for (a) Obj. assessment of SN hearing loss (b) Staging Meniere[1]s disease by recording glycerol induced changes (c) Diagnosis of retrocochlear pathology (d) Screening of auditory function in infants.	TEOAE is easy to use. noninvasive rapid and objective audiological procedure.
Latency	Same as described by authors in Scandinavian Audiology 1983, • Except-Madsen ZO70 Impedance motor.	No significant difference 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 amp. the main freq. component or the waveform correlation between the two 70 dB and recording in each ear. A significant correlation between left and right ears was found for the amplitude and freq. of the emissions. Envelop techniques was the most simple and reliable techniques of determining latencies.	TEOAE recording can be used as a screening test in newborns. A propective study evaluating the false positive and false negative cases will further confirm the worth of TEOAE as a neonatal screening.

1

1 2	3	4		6	7	3	9	10
	1988 Stevens, J.C.	8	To study the potentiality TEOAE in.detecting hearing impairment.	67 e 37s	16 85 yrs	20m 17f	both	100/usec unipolar sq. wave rarefaction interstimulus interval 80 msec.
10	4989 Bonfils Pet al	6	To determine the clinical applicability of EOAEs as objective indicators of cochlear disease.	137 e	14-74 yrs		Both	Rarefaction clicks 0.1 ms repetition rate 19/s

11	12	13	14
Latency and threshold	PT audiometer Kamplex AC4 or Peters AP6. Knowles Electronics ED 2950 miniature earphone. Knowles Electronics BT 1751 miniature mic. Analog filters	*The* level of stimulus required to obtain a recordable emission was found to be correlated with the psychoacoustical 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 groups and impaired group can not be compared because they are not matched as per age.
Latency and threshold,	Acoustic probe; length 3.5 cm, wt. 20g. a) Knowles BT1751 mic. b) Knowles B&K 2615 earphone. Impedance probe protector Madelec AA6 MK3 amplifier, gains 1000 to 10000. Band pass filter, 250 Hz, to 8 KHz, 16 dB/oct towards high frequency 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 much in detail.

1	2	3	4	5	6	7	8	9	1o
11	1939 p	Bonfils	11	To determine some basic features of SOAEs relative to (i) age & sex of normal subjects (ii) audiometric threshold and EOAE threshold with SN loss subjects.	284 e	2d-4o y	-	Both	For TEOAES rarefsction clicks 0.l ms repetition rate 19/s.
12	1989	Collet L etal	10	To specify OAE charac in relation to SN hearing loss	148 e 76s	42.3	51m; Y: 25f	Path.	Rarefaction clicks? 100 /usec. repetition rate 22.7/s

11	12	13	14
Latency and thresh-old.	Same as above for TEOAES for SOAEs: gain 10 . High pass filter 250 Hz, 16 dB/oct.	The incidence of SOAEs, decreased from 68% in the group of infants less than 18 months old to *0%* after the age of 70 year old. No stat. diff. in SOAE incidence found between partici-pants with or without tinnitus. In the group of subjets with SN loss, the incidence of SOAEs decreased linearly with increased click thresh-old or the detection - threshold of TEOAE insignificant difference in SOAE incidence found between participants with or without tinnitus.	Instrument and stimuli used are described very much in detail. Age range of abnormal group not mentioned sex dis-tribution of cases not mentioned.
Latency and threshold	Acoustic probe (a) Tandy *M* O63T mic. (b) Know-les K 2912 earphone band pass filter 2OO to 7000 Hz. Amplifier, $4x10^4$ Niclet pathfinder II apparatus.	There is highly stat. significant correlation between EOAE threshold and hearing loss at *1KHz*- The presence of EOAE indicates middle freq. Functional integrity of OHcs of corti.	Absence of TEOAE is harder to interpret.

1	2	3	4	5	6	7	8	9	10
13	11999	Collet L et al	3	To ascertain whether evoked potential recorded under BC stimulation are purely auditory or contain an additional mechanical somatosensory component. To study he existence of BC stimulated OAE.	30s	18-35y	5lm 25f	Path	same as above.
14-	1989	Johnsen N.J. et al.	3	To study the developmental changes in the BOAEs recording if any.	20s	—	-	Normal	Clicks of 2 KHz repetition rate 20/s.
*1*5	1989	Lind 0 et al.	3	To investigate whether a simple techniques with a single repeated recording at a fixed stimulus int. could give, info, enabling to differentiate between high freq. and low/medium freq. hearing losses.	16e	-	-	Path	125 /usec. clicks

11	12	13	14
Latency	Nicolet pathfinder II apparatus. BC vibrator specific to ABR & MLR Silver, Silver chloride cup electrode. Specific to TEOAE Probe (a) Tandy WM O63T mic. (b) Knowles K2912 earphone.	Under BC stimulation the evoked potential recorded is purely auditory with no additional mechanical somato-sensory component. BC stimulated TEOAEs are comparable to conduction stimulated TEOAEs	Tne sample size is to small to allow conclusions to be drawn. Clinical application of BC stimulated OAEs is questionable because OAEs are present in ME effusion.
Latency	Same as earlier used by this author.	The latency and the amp. of the EOAE response both were unchanged. In some ears freq. content of the dominant part of the TEOAE was changed.	The findings indicate that postnatal changes to occur in the human cochlea. But just with the findingg of this experiment, jumping to any coalusion will be a mistake.
Latency	Acoustic probe Nicolet Pathfinder II system' Digital high pass filter 400 Hz. 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 low/medium freq.	Instruments used has not been elaboratory reported & specified. Smaller sample size used.

1	2	3	4	5	6	7	8	9	10
16-	1989	Lutman M.E. et al.	9	To report an unusual case: of profound SN hearing loss accompanied TEOAE.	1s	lly:	M	Path	Click 100 /usec repe- tition rate 47/s
174 1	1989	Tanaka, Y et al	5	; To study whether OAE :might serve as a diag- nostic measure of inner ear in children.	266 e	6- 15s		Both	Tone burst. 3ms; lms; rise fall freq. lOOOHz - 2000 Hz.

11	12	13	14
		hearing loss greater than approximately 40 dB. This techniques does not give any information about the condition and performance of the auditory system control to the cochlea.	Age and sex of the cases has not been reported.
Latency	Programmable OAE measurement system (POEMS) EcochG. ABR.	SN hearing loss coupled with the presence of 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 investigation.
Latency and . Threshold	Same as earlier used by author.	The mean OAE threshold values of normal hearing loss cases were 5.9 dBnHL a nd 6.2 nHL . respectively. In SN loss the value was notedj to increase according to its grade measuring 37.2 dBnHL in the group with severe loss higher than 91 dB.	These findings suggest that the TEOAE thresholds is useful for an indicator of IE function in chr. The same experiments may be repeated with adults.

1	2	3	4 .	5	6	7	8	9	10
13	1990	Bonfils Petal.	11	To study the basic properties of EOAEs and the parameters influencing them.	100e[1] 52s	2h-4d	52m 46f		Clicks 0.1 msec, repetition rate 19/s.
19-	1990	Lutman M..E. et al.	3	To apply Fsp tech.to EOAE recording & to establish a suitable criterion value of FSP. For the obj. determination of an EOAE threshold	61s	3-15 yrs	-	Both	100/usec. rectangular click, repetition rate 47/s

11	12	13	14
Latency	A small acoustic containing a small mic & miniature earspeaker - a small plastic tube Amplifier. Filter-high pass-250 Hz 16 dB/oct. Averager (Racia RFF2/4). Dynamic signal analyzer.	TEOAEs can be recorded in 98% of the tested ears. No significant difference in the threshold of TEOAEs of neonates between 1 & 4 days. There is no significant difference in the threshold of TEOAEs between males and females. TEOAEs exhibited BB spectrum with high component frequencies. TEOAEs demonstrating NB freq. peaks superimposed on BB component had detection thresholds lower than TEOAEs without NB freq. peaks.	TEOAE can be used as a tool for neonatal screening. A two stage time saving protocol for screening peripheral auditory dysfunction in neonates may proposed. 1. Behavioural tests and/or TEOAEs. 2. ABR.
Latency and threshold	POEMS: (l) Earprobe: a) Miniature mic. b) Miniature loudspeaker Mic. preamplifier Filter. AD converter Click generator. Microcomputer (either Acorn BBC Master 128 (IBM Pc)	Calculation of Fsp stat. as a quality estimator for EOAEs can be incorposted in practical measurement apparatus. An Fgp of 2.0 or more indicates that a signal is present with a 1%	This method id much less prone to Type I error & so this can be applied for the obj. determination of TEOAE threshold.

1	2	3	4	. 5	6	7	8	9	10
20-	1990	Norton S.J. et al.	4	To determine age related changes in EOAEs in normal ears & to provide a normative data for studying clinical populations.		17d 30y		Normal	80 /usec. rectangular pulses rate 50/s at 80 dB pe SPL
21	1990	Stevens J.C. et al.	4	To investigate whether it is possible to use the EOAE to identify the hearing impaired newborns-	723 s			Both	100 /usec. rarefaction square waves rate-32.5/s

11	12	13	14
		probability of error. When 2 consequetive averages both exceeded an Esp. of 1.6 the probability of error was below 10%.	
Latency	ILO 88 hardware and software Zenith 159 computer with an 8087 microprocessor. 12 bit DAC probe (a) Miniature earphone (b) miniature mic. Digital attenuator 12 bit ADC, high pass Filter 200 Hz, Band pass filter 600-6000 Hz 512 FFT.	E&AEs can be used (a) as a scr. tool for coch. dysfunction across individuals. b) 1b monitor changes over time in coch. status within an ear.	Only by conducting both cross sectional and longitudinal clinical trials of EOAEs in large population, we can confirm these findings.
Latency	Khowles electronics ED 2950 miniature earphone Knowles electronics BT 1751 miniature mic. tubing. Z 80 computer.	The proportion of NICU infants producing recordable TEOAE is 80% Selectivity of TEOAE to the ABR is 84% sensitivity of TEOAE to ABR is 93%. This is quicker to perform as compared to ABR.	This tech. seems to be ease effective less time consuming and highly sensitive tool for neonatal screenings But we need to do more studies to esta. it as neonatal scr. tool

1	2	3	4	5	6	7	8	9	10
22	1990	kanaka Y et al.	4	To determine or not EOAE are useful as a clinical test.	420 s	13-35 y	12m 8f	Both	Tone burst of 3 ms; 1 ms. rise/fall between 1& 2 KHz,
23	1991	Collet L et al.	9	To examine the relation between power spectra of EOAE & audiogram.	150s	7-82y	93m 57f	Patho,	Unfiltered 80 /usec. click.

11	12	13	14
Latency	Same as used by another; previously except - Bad pass filter (0.8-3.0 KHz) used.	The detection threshold of EOAE was elevated in ears of IE imp. with profound SN hearing loss. The mean interaural difference of EOAE-threshold were near 35 dB in U/L IE imp. with profound hearing loss. There was a positive correlation between the interaural diff. of audiometric threshold and that of emission threshold in sudden deafness ears with various degree of hearing loss. The incidence of continuous emission was 30% in normal hearing ears and it was close to 90% in ears with B/L or U/L dip type hearing loss.	There is a clinical usefulness for the EOAEs in evaluating coch. function and in predicting noise susceptibility.
Latency	Otodynamic ILO 88 software & hardware.	EOAE spectrum and SN hearing loss are significantly positively correlated. However, it is not possible to establish an audiogram	The details of instrument used not available. (2) Rise/fall time of click not mentioned.

1	2	3	4	5	6	7	8	9	10
24 -	1991	Dolhen P etal	3	To test a commercially available EOAE instrument and to describe a reliable and simple techr nique to record.EOAE in newborns.	56s lle	R20-30y N3842w		Both	
25-	1991	Prieve B.A. et al.	7	To report the unexpected findings of EOAEs from b/L severe to profound SN hearing loss.	Is	33y	f	Path	Tone burst sinusoid of 0.5, 1, 2. & 4 KHz with 5.64 4.0, 2.82, & 2.0 ms. resp. Clicks-lOO/usec. repetition rate 25/s.

I !	12	. 13	14
		by knowing only the spectrum analysis of EOAEs.	
Latency	ILO 88 2 prob[1] s the smaller light weighted for babies and larger one for adults.	ILO should be used for obtaining the EOAE when best recording conditions are met. 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 description of the procedure and instruments not reportea. Stimuli used in experimentation and its specifications not mentioned.
Latency	Custom designed system Insert mic. Etymotic ER-10B, Knowles 1710 transducers for tone burst Etymotic ER-3A earphone for clicks. For Clicks Amplifier 16 b i t ADC Commercially available system, Otodynamic IL088	It is strange finding and the authors suggest that the subject may have a group of surviving OHC in some region of her It. coch. with corresponding IHC or neural damage.	We can say that EOAE is true indicator of site of coch. lesion.

1	2	3	4	5	6	7	8	9	10
26	1991	Robinson P.M. et al.	8	To investigate the effect of change in EAM air pr on EOAE.	21s			Normal	Clicks; repetition rate 40/s
27	1992	Naeve S.L. et al.	1	To study the effect of ear canal air pressure on EOAEs.	9s	23-43 yrs	3m 6f		
28	1992	Baldwin M et al	13	To assess the value of OAEs as an obj.screening test for normal peripheral auditory function in infants.	Ills	6-15y		Both	Click at 85 dB SPL peak with band width of 5KHz.

11	12	13	14
Latency	Institute of Hearing Research, POEMS, Peters Type AP61 tympanometer.	In general EOAE response are reduced by the application of a positive or negative pressure.	Authors have tried to explain these changes in the line of pressure changes due to anesthesia. The expt, can be repeated with more number of cases for further evidence.
Latency	Computer controlled system (Otodynamics ILO 88 Version *l)* 0.08 ms rectangular electrical pulses, probe, mic, monometer of cli.acoustic immittance sys. 2-cm^3 coupler (HA-1-ANSI) S3.7-197 3), computer controlled aural acoustic immittance system (Virtual M310).	Ear canal air pressure is like a high pass filter with a cut-off freq. of 2600 Hz and slope of 4 dB/oct, Ear canal pressure reduced the reproducibility of emission waveform, rendering it indistinguishable from background noise.	A high false alarm rate may occur in normal hearing patients with intratympanic air pressures that are significantly difference from ambient pressure
	POEMS system, otodynamic ILO 88 system.	In the 3 groups selected OAE testing was found to be useful.	

1	2 3	4	5	6	7	8	9	10
29	1992 Collet t et al.	9	To study the effects of contralateral white noise on click evoked emissions (CEE) in normals & SN ears and to explore medial alivocochlear system.	61s	nor. 18-30 yrs **SN** case 27-66 yrs	28m 33f s	Both	Clicks of 80 Xusec. duration click rate 50/s and analysis time 20 ms.
30-	1992 Kok M.R et al.	9	To study the growth of EOAEs during first days of postpartum and in adults.	20e 15s of new born 10 of adults.	51 hr 42-107 hr. 19-51 yr	11m 4f		Click with duration of 80 /usec.

11	12	13	14
Latency	Amplaid 45s stimulator & telephonics TDH-49 earphones.	The contralateral suppresses CEEs in pathological ears probably due to medial olicochlear system.	Paradoxical clinical cases need to be investigated and discussed.
	ILO 88 (Otodynamic, London Software Version 3.0)	EOAEs in newborns grow stronger in the first days of postpartum. From 3 to 51 hours of age EDAE was 50% whereas in same ears from 24 hours. EOAE were 100%. Compared with adults the response in newborns appear stronger and contain more high freq. energy.	Studies on input output functions need to be done.

1	2	3	4	5	6	7	8	9	10
31	1192	Harris tf.P. •et al.		To assess TEOAEs in patients with Meniere[1] s disease	31s	20-77 y	• 14f , 17m	Path	Click stimu- , li BO/us rectangular pulses at the rate of 50/s level of sti- muli 86 dB SPL, 1KHz tone burst at 74 dB SPL
32	--1992	Gobsch H et al	3	To study the behavior of delayed EOAE under for- ward masking paradigm.	8s	21-49y	3f 5m	Normal	Clicks of int. 10 & 20 dBSL, 100/us width white noise as masker dura- tion 50 ms. At between masker & click at 5,20,10, 40 ms.

11	12	13	14
Latency	ILO 88 otodynamic analyzer.	Using click stimuli responses present in 29/31 in non-menieres disease ear and in 26/ 31 in menieres disease ear. Using tone burst as stimuli responses present in 30/31 in non menieres disease ear and in 28/31 in manieres disease ear.	How the changes in affected ear may alter TBOAE in opposite ear is not known. To what extent measurement of TEOAE provides diagnostic information cannot be answered
Latency and threshold		At masker levels corresponding to the subjective post-masking threshold of the clicks, the delayed EOAEs were unaffected ie had no noticeable alterations compared with click stimulation without masking.	Effect described must be considered in relation to subj active SL, because delayed OAEs making was started at masker level corresponding to subjective post masking threshold measurement at constant absolute masker levels are needed to differentiate betweek central and peripheral contributions in this case.

1	2	3	4	5	6	7	8	9	10
33	1993	Lutman M.E. et al.	8	To assess the reliable identification of CEOAEs using signal processing techniques.	1102i a 2040 e	-	-	-	Clicks at 70 & 60 dB SPL. waveform starting 5ms after click onset & ending 15 ms after click onset.
34-	1993	Vohr B. R et al	8	To determine the feasibility of establishing a valid cost effective method of screening new born hearing using TEOAEs	1850 s	24-48 hrs			
35	1993	Prieve B.A. et al.	1	To analyse TEOAEs in normal hearing & hearing impaired ears.	113s	4-81 yrs		Both	Clicks at amp. of approx. 80 dB SPL.

11 . 12	13	14
Latency	A cross correlation coefficient greater than 0,5 was approximately criterion to distinguish pass from fail.	
Latency . ILO S3 otodynamic and analyzer. threshold)	TEOAE was shown to have significant pot, as a newborn screening tool. In a sample of 1850 infants, SN hearing loss was identified in 11 infants using TEOAE	
Latency ILO 88 OAE analyzer.	Analysis for freq. specific bands showed separation of normal & hearing imp, ears depended on freq, with best identification at 2 & 4 KHz. for broad band TEOAEs, TEOAE level.	They did not describe the false alarms and misses associated with criterion value. TEOAE will be valuable for clinical use because of their repeatability and identification of hearing impaired.

1	2	1 3	4	5	6	7	8	9	10
36	1993	.Foraum H etal	8	To examine the feasibility of using EOAEs as an in-patient check of hearing status in children recovering from bacterial meningitis.		16 yrs		Path	500 Clicks at 70 & 60 dBnHL
37	-1993	Kok M.R et al	9	To study CEOAEs in health; newborns and in. adults.	110v	2-2 38 hr. & 7. 55 yrs	603m 504fr	Normal	Click -with duration of

11	12	13	14
		TEOAE to noise and % reproducibility were found to identify hearing loss equally well, based on measurement of area underlying relative operator charac. . curves.	
	POEMS	All children subsequently found to have SN hearing loss who were tested with EOAE, failed screening test. Conclusion can be the technology currently available for measurement of EOAE after meningitis is not a practical method for pre-discharge check of hearing.	
Latency	ILO 88 otodynamic analyser audio stimulator (Madelec AS 10), an echoic chamber (B&K type 4222), B&K type 2218 stimulus level measurer, Rubber and Silicon tube.	Recording were successful in adults compared to aeonates still EOAE recording for scr# purposes seems feasible because of.higher response levels than adults	Until a mass examination of combined ABR and EOAE is done reliable values for specificity are lacking

1	2	3	4	5	6	7	8	9	10
38	1993	Wada M	i 9	:To study the relation-ship between EOAEs and ME dynamic characteristics.	23e 12s		mm	Normal	Tone burst signals of about 3 ms. duration between .5-2.0 KHz at .1KHz
39 [1]	1993	Stover L	1	To study the effects of aging on OAEs	42	20-80 yrs		Normal	

11	12	13	14
Latency	Computer (NBC PC 9801 NS-20) Function generator (NF,1940) attenuator (TPA-401),amplifier, probe mic. probe earphone dual channel FFT analyzer (Onosokki CF. 350).digital recorder (Sony DTC-1000 E5).	EOAEs are detected most distinctly at the ME resonance freq. and that EOAEs are most detectable in normal subject whose ME mobility is moderate.	Conclusion is not applied to case when clear SOAEs are obtainable.
Latency and threshold	For TEOAEs-Quikki D/A, 2 digital attenuators and a crown D75 amplifier, Etymotic ER 2 transducer, sound delivery tubes, etymotic ER 20 insert mic. assembly, HP 3561A spectrum analyzer or RC electronics 15c-16 computer scope I/A Board, Zenith 159 PC-XT or 386 computer for ADPs-14 bit D/A,IThaco 4302 variable filter, Wilsonics PATP programmable digital attenuators, Crown D75 amplifier, etymotic	No age effect independent of hearing sensitivity on any type or parameter of OAEs.	Hearing sensitivity must be included as a controlled variable in order to accurately assess intrinsic aging effects. It remains unclear how much frequency effect is due to hearing sensitivity and how much to aging.

1	2	3	4	5	6	7	8	9	10
40 -	1993	Lafre-neire D et al.	11	To characterize the OAEs from neonatal and infant subjects at risk for hearing loss.	44e 29s			Both	Stimulus level con-stant at 65 dB SPL for fl & f2; f2/fl - 1.2 for CEOAE stimu-lus at 82 + 4 dB SPL.
41 -	1993	Johnson W#J.		To record EAOEs in diff, types of hearing loss.	28s	10 77 yrs.	13f 15m	**Bath**	2 KHz click RR 20/s.

11	12	13	14
	ER 2 transducer, ER 10 mic assembly, Ithaco 144L preamplifier, BEL PDP 11-73 computer. SOAE - ER-2 or B&K.		
	DPOAE-digital system based on Ariel DSP-16 board in IBM PC/AT computer. CEOAE - ILO 88 otodyna-analyzer. Tympanometric measurement - Grason Stadler MEA, model 33, version II, ABR- Biologic Navigator system.	CEOAEs & DPOAEs were found to be decreased or absent in subjects with suspected central hearing loss.	OAEs combined with ABR can provide a freq. specific evaluation of coch.function and help to determine anatomic site of pathologic lesion. Exact nature of emissions in these subjects not known.
Latency and threshold. •4,		In ears with flat losses and with identified CEOAEs no one had a hearing loss exceeding 40 dB HL in mid f requenc" In ears with flat losses and without CEOAEs, no one had hearing loss less than 30 dB. In ears with sloping hearing losses threshold at 1 & 2 KHz were imp. for generation of CEOAEs.	—

1	2	3	4	5	6	7	8	9	10
42	1993	Williams E.A. et al.	3	To study effects of contralateral acoustic stimulation on OAE foll.vestibular neurectomy.	1s	43y	f	Path	80/usec, 1click, at rate of 50/s 260 clicks at stimulus levels of 81 dB SPL & 61 dBSPL.
43	1993	Holtz, et al.	5	To monitor the effects of noise ensure using TEOAEs and to compare the sensitibility of the	147 e	20-23 y	M	Normal	80 /usec. clicks at rate of 50/s stimulus levels of 81 dB SPL & 61 dB SPL#

11	12	13	14
Latency and threshold	Otodynamic Ltd. ILO 88 OAE analyzer	Lack of inhibition in the operated ear due to sectioning of alivo-cochlear bundle within inf. vestibular nerve, emoving efferent control of receptor cells	OAEs recorded during contralateral acoustic stimulation may provide rapid, non-invasive means of investigating function of efferent auditory system.
Latency and threshold	ILO 88 otodynamic analyzer hardware & software, probe, min.mic. (Knowles BP 1843) and transducer (Knowles BP 1712), disposable foam ear tip (EAR), Macintosh II computer.	Results revealed sig. changes in response amplitudes in freq. range from 2-4 Hz. Comparison of TEOAE testing and PT thresholds revealed TEOAE to be more sensitive. It is also less time consuming.	How does individual susceptibility and noise trauma correlate is not known. Moreover testing has been conducted in relatively crude way.

2	3	4	5	6	7	8	9	10
44	1993 Stevens J.C. et al	8	To evaluate CEOAE in newborns.	s	-	-- .		-
45 -	1995 Ryan S. et al.		To investigate the influence of contralateral acoustic stimulation on CEOAEs in humans.	3s 6e	25-30 yrs.	-	Normal	clinic stimuli at rate of 50/s

11	12	13	14
Latency & threshold	Knowles electronics ED 2950 miniature earphone, tubing, Knowles electronics type BT 1751, miniature mic.	Sensitivity and specificity of OAE test for ABR test were 93% & 34% resp. CEOAE is considered as initial method to screen for hearing impaired, test failures being followed by ABR.	The main problem requiring further study is the fact that only a small proportion of those failing ABR in the neonatal period will be found in later life to have a permanent hearing impairment.
	Otodynamic ILO 88 OAE analyzer,	Collect effect demonstrated in all normal subjects. Although the changes in amp & phase were small, they were easily identified using diff. response which was result of digital substraction of response recorded with contralateral BBN from the control response.This technique could thus be used to test for function in medial efferent systemic mod. levels of contralateral BBN stimulation.	Further research is required to investigate neural significance of presence or absence of collect effect in Betero-cochlear pathology

3-22. DPOAE

1	2	3	4	5	6	7	8	9	10
1	l990	[1] Harris H.P. et al.	7	To determine if DPOAE amplitude is associated with PT behavioural hreshold.	40e 40s	18-40y	-	Both	2 PT f1, and f2; f2/fl = 1.19 to 1.21.
	1990	Lonsbury Martin B.L. et al.	6	To collect parametric measures of DPOAES in normally hearing subjects to provide a baseline against which OAE activity in impaired ears could be compared.	44e 22s	21-30y	12m 10f	Normal	2 equilevel PTS f2/fl. 1.21; 2fl-fl between 0.75-5.75 KHz.

11	12	13	14
Spectral analy-sis and threshold	Probe a) ER-10 mic. b) Two ER-2 earphone. Qua tech, WSD 10c wave-form synthesiser. Grason Stadler 200 CD Oscillator. KR iO-72 low noise mic. pre-amplifier. Custom made low noise amplifier. High pass filter system; 30 dB/oct, 400 Hz, signal averager B&K 2033 oscilloscope amplifier loudspeaker.	DPOAEs were reduced in amplitude or were absent in ears with high freq, hearing loss. The differences occured at frequeicies above 1500 Hzr comparing results from 750 to 800 Hz, within the same ear revealed a freq. related correspondence of elevated behavioral threshold to reduced DPOAE amplitude.	These results imply that the measurement of DPOAEs has clinical potential as a means of detecting hearing loss by freq.
Spectral arialysis and threshold ;	Beltone 10-D screening audiometer, Micro-computer controlled (Apple, Macintosh Plus) tympanometer (virtual 310), microcomputer system digital equipment Corp 11/23, Two channel freq synthesiser Hewlett-Packard 3336 A Attenuators, Wavetek 5p. Probe a) Etymotic resear ch ER-2 earphones, b) Etymotic research ER-10A, mic, Etymotic research ER-10-72 preamplifier	The average audiogram demonstrated a bilobed contour having a low freq, max, at approxly. 1,5 KHz and a high freq peak that plateaued at about 5,5 KHz, The two maximum regions were separated by a min. around 2,5 KHz, The avg, I/o functions exhibited detection thresholds at pri.levels between 35 and 45 dBSPL. The dynamic range of the emitted response between detection threshold and maximum	DPOAEs from normal ears can be characterized as having a set of rela-tively uniform properties against which the status of an unknown ear can be determined.

1	2	3	4	5	6	7	8	9	10
3	-4990	Lonsbury Martin B.L. et al	6	To investigate the two possibility that might account for an ear incbility to generate DPOAEs (i) freq. specific anomalies in the forward and/or reverse" ME transmission of the acoustic signal (ii) subclinical pathologic changes in cochlea and/or ME.	44e	21-	12m	Normal	For DPOAE-2 equilevel PTS f2/fl=1.21; 2fl-f2=0.75 -5.75 KHz for SFOAE-continuous sweep freq. PT from 400 Hz-2 KHz. 2 min.

11	12	13	14
-		varied over a 40 dB extent of the stimulus level dimensions. Approximately l/3rd of the ears exhibited DPOAE audiograms in which emitted responses were significantly reduced in restricted regions tested by low, medium or high freqs. Mean age did not explair the differences noted between the 2 types of normally hearing subjects.	
Spectral analysis and threshold.	Same as described by authors in Annals of Otol. Rhinol. & Laryn-gol. 1990, Vol.99, Suppl. 147, 3-14.	None of the examined features of acoustic immittance provided an explanation for the discrete low amp. DPOAE regions observed. The presence of SOAE & SFOAE in the irregular ears indicated that the emission generation and reverse cochlear transmission were ope-rating normally within the region of reduced DPOAES. The simultane-our presence of SPOAE	We still have one ques-tion unanswered whether the std. f2/fl ratio 1.21 and the equilevel (L1=L2) paradigms is ideal for generating the most optimal. DPOAEs for the ears showing diminished DPOAEs over the low to middle freq. region.

1	2	3	4	5	6	7	8	9	10
4 -	1990	Martin G. K» et al.	6	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 (L1-L2) and threshold.

11	12	13	14
		but not SOAE appeared to reduce the detection thresholds and increase the amplitudes of low frequency DPOAEs.	
Spectral analysis and threshold.	As described in previous report.	Tests of DPOAEs promise to satisfy a number of requirements impt. to clinical testing, including objectivity measurement procedure, test-retest reliability. Simple subject prqparation, readily available instrumentation and relatively brief examination period. The five resolution of DPOAEs within the stimulus frequency and level domains also permits an accurate confirmation of the pattern of hearing loss. The ability of DPOAEs to assess the sensory component of SN disorder may contribute to the eventual understanding of the complicated pathogenesis of many cochlea diseases.	Age range and sex distribution of cases not reported.

1	2	3		5	6	7	8	9	10
5	1990	Smurzynski J. et al.	10	To demonstrate a correlation that might exist between DPOAE characteristics and heaping impairment.	52e 27s	21-41-yrs		Both	2 sinusoidal signal, 3sec.
6	1991	Bonfils P. etal	10	To measure DPOAEs in a clinical setting.	51e	18-28 yrs.	-	Normal	2 PTS fl-f2

11	12	13	14
Spectral analysis and threshold	Custom made probe (a) Knowles EA 1842 mic. (b) Two knowles 1716 earphones. Two oscillators Hewlett Packard 239A. Two attenuators Hewlett-Packard 350 D. Sweep frequency wave analyzer Hewlett Packard 3580A. X-Y recorder Hewlett Packard 7035B. Ariel DSP-16 signal processing and interface computer. Switching system wavetek 601. Kohn Hite 3342 filter PFT.	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 freq. specific information about cochlear function, which after further development, may form a basis of a non-invasive objective method of evaluating cochlear function-
Spectral analysis	Acoustic probe consisting a) One knowles BT 1751 mic. (b) two miniature earphones Knowles BK 261! Two channel freq.synthesiser Hewlett-Packard HP 890 A. Attenuaters-Hewlett Packard HP 355.	3 The BPOAE input-output functions presented 2 separate portions for 5 the f2/fl ratio ranging from 1.18 to 1.26. Below 60 dB SPL a saturating portion with a DPOAE detecting threshold at 36 dB- SPL and above 66 dB SPL, a	DPOAE measurement in a clinical setting must be done with precise stimulus values, (a) f2/fl ratio near 1.22 and (b) pri. intensities below 60 dBSPL Active mechanisms are absent below 725 Hz in human. Sex distribution could have been considered

1	2	3	4	5	6	7	8	9	10
7	1991	Spekter Z et al	11	To study DPOAE and CEOAE in normal and hearing impaired children and in adults.	26s	4-lOy & 22-29y		Both	CEOAE-clicks of rectangular pulse of 90/usec.

11	12	13	14
		linear portion. With DPOAEs below 512.5 .Hz no more saturating plateau could be observed.	so that we could have got diff. norms for both sexes.
Spectral analysis and thresholc	Earprobe containing Etymotic research ER-10B mic. and 2 ER-2 earphones. Digital system based on Ariel DSP-16 board and IBM PC/AT computer, 16-bit DAC on ariel board. Proton AM-300 amplifier, wavetek model 617 attenuators, IEEE 488 Bus, insert earphones. Grason Stadler tympanometry eartip, low noise miniature etymotic research ER-1013 mic, Krohn Hite 3342 system for high pass filtering ADC converter of DSP-16 board. For CEOAE-ILO 88 system	Measurement of DPOAEs in 13 children ears with normal hg. showed higher levels of emission in the 700-1400 H_z & 5.7 HH-regions relative to data obtained in 10 normal adult ears. 22 ears of children with SN hearing loss demonstrated agreement between PT audiograms and DPOAE audiograms.- Measurement of CEOAE revealed avg. level of emission in 15 normal hearing children slightly lower than previously obtained in newborns, but slightly higher than that of adults.	DPOAE & CEOAE can promise to be valuable tool in assessment of coch.function though CEOAE method at spresent cannot provide information for high freqs. above 5 KHz.

1	2	3	4	5	6	7	8	9	10
8	1991	Lafre-niere, D. et al.	10	To study DPOAE and CEOAEs in healthy new-borns and adults.	37 s 5Se	2-6 day & 22-29 y	“”	Normal	For CEOAE stimuli click of 80 /usec rectangular pulses at rate of 50/s at 82 SPL

11	12	13	14
Spectral analysis and thresh-old#	Custom made probe containing mic (EA 1842; Knowles Electronics Inc, itasca III) and 2 earphones (1716, Knowles Electronics *Inc),* commesicially available probe (Etymotic Research Inc, Elk Groove Village, ill) low noise mic (ER-1OB) 2 insert earphones (ER-2) for DPOAE - Digital system based on signal processing and interface board (DSP-16; Ariel Corp), computer (IEM PC/AT compatible, Aiv.IV, NEC Information Syfetem Inc. , Box borough ,Mass) 16-Bit DAc on ariel board. Switching system (601, wavetek San Diego lnc) tympanometry eartip (Grason Stadler), high pass fileter (3342, Krohr Hite Corp) a6-bit ADC of DSP-16 board at sampling rate of 50 KHz amplifier (AM-300 Proton corp).	CEOAEs of newborns had higher overall level & contained stronger high freq. (4.5 to. 6 KHz) spectral components than adults. Low frequency components of click stimuli spec trum were attenuated in neonatal ears exhibiting a high pass slope below about 2.5 KHz w whereas stimulus spectrum was nearly flat in this freq. region in adult ears.	DPOAE can give freq. specific information but is more time intensive, while CBOAE can give a quick assessment but with loss freq. specific info, with further refinement and in conjunction with ABR noninvasive obj. **method of evaluating** coch. and aud. pathwav functions can be used.

1	2	3	4	5	6	7	8	9	10
9	. 1991	Harris P.P. et al.	4	To report CEOAE and DPOAE results with respect to PT audiogram.	-			Normal	L1 6dB> L2. 1-0 or growth functions generated in 5 dB steps. LI decreasing from 70-25 dB fil amp. of 2fl-f2 <3 dB.

11	12	13	14
	For CEOAE - Analyzer . (ILO 88 otodynatnic) , Plug in board for computer (APV IV).		
Spectral analysis and threshold	CEOAE - ILO 88 otodynamic analyzer Ltd. with a compaq Portable III computer. DEOAE - Etymotic research ER-lO mic. system ER-2 insert earphones, preamplifier equalizer. 2 channel synthesizer HP 3326 A, amplifier, Macintose IIX computer. Signal analyzer MP 3561A	1. When CEOAE are judged; to be present upon criteria for level, reproducibility and waveform morphology. there is a high prob. that hearing threshold level is less than 3 dB HL for atleast one freq. 2. Presence of DPOAE produced by high level stimuli may not correspond well with hearing sensitivity. DPOAE generated with lower level puretones may appro x. audiometric results more closely. 3. Thresholds of DPOAE more useful diagnostically than abs. amps, of responses at specific levels of stimulation.	Further investigations need to be done for finding preferred procedure.

1	2	3	4	5	6	7	8	9	10
10	1992	Bonfils P et al	5	To study DPOAEs in neonates.	27e 27s	l-d	-	Normal	*2* Pri.tone fl & f2 pri. level 65 dB SPL# F2/P1= 1.22 for CEOAEs clicks of 80/usec. rectangular pulses with RR of 20/s at peak level of 90 dB SPL.
11	1992	Nelson **D.A.** . et al.	7	To study BPEs & auditory sensitivity in human ears with normal hearing and cochlear hearing loss.	53e 27s			Both	2 stimulating tones (fl & f2)

11	12	13	14
Spectral analysis and threshold	DPOAE - Acoustic probe (Etymotic Research), low noise mic (ER-1OB) 2 earspeakers (ER-2), 2cc coupler (B&K DBO138 *1/2* inch condenser mic (B&K 4166) B&K 26O9 measuring amplifier. EOAEs - ILO 88 to o to-dynamic analyzer, 2 channel freq. synthesizer (HP-89O4A) DPOAE recording - dynamic signal analyzer (Hewlett Packard HP 3561 A)	Neon ates having normal EOAES have large DPOAE. DPOAE amps, in neonates are larger than adults Neonates with atypical EOAE freq. spectrum without low freq. component had normal DPOAE. I/o functions only for HFs (above 2 KHz). DPOAEs could be helpful in association with EOAEs, to precisely evaluate auditory peripheral functions in neonates.	This test provides info. about peripheral auditory status without any clear freq. specificity.
Spectral analysis and threshold	14 bit DAC, 2 etymotic 2A transducers. Etymotic ER-1O, HP 3561 A signal analyzer. IBM/AT computer 1M 53020 microprocessor.	21 of the ears tested exhibited coch.hearing loss. DPES were obtained as a function of stimulus level (DPg growth curves) at 7 freq region between 707 Hz & 5656 Hz. Low level, irregularly	DPE thresholds able to predict abnormal auditory sensitivity with some precision different patterns of DPE growth curves suggest underlying' micromech. diffs. between ears, but the differential

1	2	3	4	5	6	7	8	9	10
12	1993;	Probst R. et a]	8	To clinically monitor OAEs.					TEOAE-Freq. range .7 to 4 KHz using clicks or tone bursts at 60-70 <3B SPL DPOAE- 80 dBSPL for LF stimulus

11	12	13	14
		shaped segments were more frequent in normal hearing ears suggestive of normal low level .active nonlinearities from OHC subsystem. High level, steeply sloped segments were frequent in hearing impaired ears, suggestive of residual nonlinearities from a coch. partition without functional OHCs.	diagnosis value of those patterns remains to be determined.
• Spectral analysis and threshold.		Comparison of results obtained from DPOAE thresholds to those available using PT thresholds indicates greater sensitivity of OAEs for detecting early Coch .damage.	Additional studies will define exact place that OAE will assume in clinical monitoring.

1	2	3	4	5	6	7	, 8	9	10
13	1993	Gianfro-ne G. •et al.	8	To study some effects of tonal fatiguing on" SOAEs and DPOAEs.	2s	30f 45y m.	lrn If	Normal	SOAE-80-90 dB SPL for 5 rain from 500 to 8000 Hz (short term) (Long term) is 15-20 min. DPOAE-55#65, 75 dB SPL, level of pris. 2 growth func-tions for atleast S freqs.d.O, 2.0, 3.0, 4.0 6.0, 3.0 Hz)

11	12	13	14
—	t SOAE - B&K equipment: *1/2"*condenser mic,4166 low noise preamplifier 2660, special high pass filter, 2. channel FFT 2032. DPOAE - virtual OAE model 330 instrument.	SOAEs since originate from active sources within cochlea, show sensitive and early-vulnerability to noise, displaying informative time courses after over stimulation in short (0.65) and in large time (1-10 min) depending on freq. of fatiguing stimulus. In DP grows modifications takes place with in a period of 5-7 min. and depend on freq. of fatiguing stimulus and on closeness between SOAE and DP place. Data suggest that not only interaction place between f 1 and f 2 has to be considered from a biomech and cli. point of view, but also specifie DP place on coch. partition.	No modification of DP-gram and 1-0 functions arise neither when fatigue tone acts at DP specific place close to SOAE nor at interaction frequency place between pris. A further research with more options of DP growth functions and of fatigue tones is necessary to assess and answer the questions.

1 2	*3*	4	5	6	7	8	9	10
14 1193	Probst R.etal.	10	To compare results of -TEOAEs and DPOAEs in normal hearing and hearing impaired population.	83s l66e	-	-	21 norl, hg.(age 25.7 mA) 62 hg.imp (57.4 . mA)	TEOAE-click at 86 dB SPL DPEOAE-tested at 7 discrete freqs.(GM freqs.0.75, 1, 1.5, 2, 3, 4 & 6 KHz), Ll-6dB greater in amplitude than L2.Ll=70-20 dB SPL, f2/fl c 1.22
15 I993	Roede,J et al.	9	To investigate the repeatibility, variability & detectability of DPOAEs in normally hearing humans.	12s	26. y mA	6m 6f	Normal	DPOAEs-fixed levels of Ll=12 of 70 & 55 dB SPL over stimulus range from 0.8-8 KHz in 0.2 octave intervals. 1-0 functions in stimulus range of 0.8

11	, 12	13	t i
	TEOAE = ILO 88 otodymamic analyzer DPOAE - computer (Macintosn IIx)	A high correspondence between the two emission of energy for each emission and audiometric threshold levels at corresponding freqs. suggesting TEOAEs and DPOAEs are largely derived from similar mechanisms. DPOAEs present more often than TEOAEs whenHL across freq greater than 30 dB HL suggesting TEOAE preferable for screening purpose and DPOAE for monitoring cochlear changes clinically.	HP response for most widely used commercial system for measuring. . TEOAEs is limited to 4 KHz ana separation of DPOAEs from background noise below 1 KHz must be improved.
Spectral analysis	DPOAEs - Computer based program (Macintosh IIx) 2-channel 16-bit processor board (audiometer) 2 ear-2 (fitymotic Research earphones, ER-10A probe system, ER-72 preamplifier, custom built low noise amplifier.	A change in DPOAE amp. of more than 6-9 dB depending upon stimulus levels, would indicate a significant change in cochlear status if rendering conds and ME status are stable.	Measurement of DPOAEs can ofter a method of monitoring cochlear status over a range of freqs. approx. an octave higher than possible with TEOAEs.

1	2	3	4	5	6	7	8	9	10
									1, 155, *2*, *3*, 4 & 6 KHz LI from 35-70 dB SPL changing in 5 dB steps & L2 at 6 dB below amp. of LI.
16,	199 3	Whitehead **M.L.** et al.	7	Tq investigate the influence of noise on the measured amplitudes of DPOAEs.					DpOAE-stimulus single, low 2 KHz, PT decreasing in 3 dB steps from 15.5 dB SPL

11	12	13	14
Spectral analysis	Computer-Etymotic ER-2 speaker, Etymotic ER 10 mic, HP 3561A siggal analyzer.	Because of the influence of noise the algorithm for the obj. estimation of detection thresholds of DPOAEs and of the slope of DPOAE - growth functions, will tend to underestimate these values. A simple eq. allowing an estimated correction for the effects of noise on measured DPOAE amp. is presented.	Influence of noise on shapes of DPOAE growt-functions must be carefully determined.

1	2	3	4	5	6	7	6	9	10
17	1993	Gorga M.P. et al.	1	To compare TEOAE and DPOAE in normal hearing and hearing impaired subjects.	180s	chr >3y and adu-lts		Both	
18	1993	Oster-hammel P.A. et al.	3	To study the influence of ME transmission on DPOAEs.	8s 16e	37y mA 22-56 yrs		Normal	DP stimulus Int. of 75 dB SPL at foil. pr, values 0#-100,-200, -300,-400, +100, +200 dapa) at folio test freqs (1,2,4,6,8 KHz) equilevel probes with freq ratio of t.23

11	12	13	14
Spectral analysis and threshold	TEOAE - otodynamic analyzer (ILO 83). DPOAE - CUB DIs system and Ariel DSP 16 signal processing board, 2 ER-2A ear phones, low noise mic. (ER-10B), amplifier.	At 500 Hz TEOAE and DPOAEs were unable to separate normal from impaired ears. At 1KHz both TEOAEs measures were more accurate in identifying hearing status than DPOAEs. At 2 KHz, all OAEs measures performed equally well. At 4 KHz DPOAEs better able to distinguish normal from impaired ears.	Conditions were restricted in scope. It may be that test performance defined as tests ability to distinguish normal and impaired ears would be superior for other stimulus and/or recording conditions.
Spectral analysis.	PC equipped with 486/33 MHz CPU, A/D converter (analogic MS-DAS 12 bit] laser printer (4 plaser Jet 11P) 2 hearing aid receivers (Oticon type AN 270 NR). Madsen Electronics 20-'73 impedance bridge.	Amplitudes of the DPs depend on optimal transmission through the ME and that measurement of DPOAEs should always be preceded by determination of ME pressure.	Careful analysis of ME functions should be done when OAEs are studied.

1	2	3	4	5	6	7	8	9	10
19	1993	**Nielsen** L.H. et al.	3	To study the clinical significance of probe-tone freq. ratio on DPOAEs.	58 lOe	22-42y	2f 3m	Normal	2fl-f2 (fl<f2) GM freq. 0.5,1,2,3, 4#6#8 KHz. F2:P1*1.15 to 1.40
20	1993	Rasmussel A.N. et al.	3	To study clinical signi-ficance of relative probe tone levels on DPOAE.	14e 7s	25-55y	3f 4m	Normal	2 pri.tones (fl & f2) at relative levels (LI, 12), f2/fl= 1.23, GM freq. .5, 1 2,3,4,6,8 KHz. L1-L2 varied from -1OdB through + 10 dB with L2 held

11	12	13	14
Spectral analysis	Computer based system. probe unit, 2 separate receivers, measurement mic.	A single f2:fl ratio between 1.20 and 1.25 provides a reasonable value for clinical use in that it Optimizes the magnitude of DP at 2fl-f2 , provides for sufficient resolution in test f req. range & is applicable to std. clinical test freqs.	This procedure generates results with Ltd. clinical usefulness because resulting GM freqs. will not occur at std. audiometric test freq.s. Also it requires a large number of measurement.
Spectral analysis.	Custom built computer based, a probe unit. 2 separate receivers. measurement mic, FFT.	Maximum amps, of DPS generated when Ll= L2 at all GM freqs except 8 KHz. Reduction of DPOAE with reduction of LI was linear at a rate that gradually increased as a function of GM freq. To a lesser extent the reduction of DPOAE with reduction If L2 was linear but at a rate that systematically decreased as a function of GM frequency. Thus,	When pot. clinical use of DPOAE measurement is evaluated not only test parameter are imp. but individual diffs. are of importance as well.

1 2	3	4	5	6 7	8	9	10
							constant at 75 dB SPL for positive values & L1= L2 =75 dBSPL at 0 dB relative diff#

11	12	13	100
		to maximize the levels of DP for clinical purposes, relative levels of pri, tones should be equal to each other, atleast when overall stimulus levels are around 75 dB SPL and f2:f1=1.23	

3-2.3 TINNITUS RELATED

TINNITUS RELATED

1	1982	Tyler R. et al.	8	To explore the relationship between tinnitus and SOAE.	45s	-	-	20 norls. No. 25-tinnitus.	
2	1987	Penner M.J. et al.	7	To explore whether an observed SOAE can be the physical basis of an audible tinnitus.	29s	-		Both	For tinnitus matching gated sine wave 10msec rise/fall time.
3	1989	Benfils P.	11	To determine some basic	284e	2d-40y	-	Both	For TEOAEs rarefaction clicks 0.1 ms rectangular pulses; repetition rate 19/s

11	12	13	14
SOAE	Electret condenser mic. 11 rnin# diameter diaphragm. Amplifier. Tube 25.5 mm length. 3.5 nun i.d. Otoadmittance probe tip. Revox A77 **tape** recorder 8 bit analog to digital converter, PDP 11/60 micro computer.	There was no clear relationship between the pitch of tinnitus and the spectrum of emission.	
S©AE -	Laboratory computer sine wave oscillator. miniature mic. Etymotic model ER-iO, 1.35 mm i.d. coupling tube two 3.30 mm i.d. probe tubes, two insert phones Etymotic ER-2 wavetek 380/A spectrum analyzer.	SOAE and tinnitus appear to be independent because. (1) audibility of tinnitus was not affected by suppressing the SOAE. (ii) SOAE was unchanged while masking the tinnitus by a high freq. tone.	Even though they could not get any association between SOAE and tinnitus for these subjects there might be an association in others. Hence further studies are required.
SOAE & TEOAE	Acoustic probe; length 3.5 cm weight 20 g. a) Knowles BT 1757 mic. b) Knowles B&K 2615 earspeaker. Impedance probe protector. **Medelee** AA 6MK 3 amplifier.	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.	Instruments and stimuli used are described very much in detail. Age range of abnormal group not mentioned, sex. distribution of cases not mentioned.

1	2	3	4	5	6	7	8	9	10
4	-1990	Norton S.J et.al	4	To explore the link between tinnitus & OAE	8	s 69	28-7f	lm	Normal	Tone burst stimuli at 0.5,1.0,1.5, 2.0, SOAE & TEOAE 3.0,4.0 5.0 & 8.0 KHz two cycle plateau; 2 ms rise/fall; intensities from 10 to 70 dB SPL in 10 dB steps for TEOAE

11	12	13	14
	gain 10^4 for SOAE. High pass filter; 250 Hz, 16 d^B/oct. for SOAEs. Band pass filter; 250 Hz to S KHz 16 dB/oct towards low freq. & 6 dB/oct. towards high freq. High resolution signal analyzer Hewlett Packard 3661 A.	diff. in SOAE incidence found between partici-pants with or without tinnitus. In the group of subjects with SN loss, the incidence of SOAEs decreased, linear-ly with increasing click threshold or the detec-tion threshold of TEOAE.	
SOAE & TEOAE.	ER2 tubephone, osci-llator. Acoustic probe (Etymotic Research ER-iOB) Hewlett Packard 3561A dynamic signal analyzer. Loca-lly built variable gain (20-80 dB) battery powered pre-amplifier, 12-bit ADC computer disk.	Oscillating EOEs and tinnitus are related to a common underlying pathology rather than emissions being the source of tinnitus.	The detection of SOAEs and/or Etying EOAES in ears with sloping losses, a history of noise exposure & tonal tinnitus might provide an objective method of evaluating tinnitus treatment. Large sc&le clinical trials are needed to validate the above conclusion. More no. of females have been taken in the sample.

1	2	3	4	5	6	7	9	10
5	1990	Plinkert P.K. et al.	5	To demonstrate the relationship between SOAE and Tinnitus.	1s	37 yrs	lm	Normal	No

11	12	13	14
SOAE	Miniature mic. model No.870429 B Etymotic Research spectrum analyzer one Sokki Model CF 940. Sine wave generator Hewlett Packard HP 8904 A Sennheiser earphone. Audiometer philips HP 8741/30 with Beyer DT 48 earphone,	Following evidences indicate the correlation between tinnitus and SOAEs simultaneous occurrence and suppression of both phenomenon. The pitch of tinnitus and the freq. components of the SOAE correlated. In a playback of the recorded SOAEs their freqs. were described to be identical with the tinnitus pitch.	Just on the basis of findings of simple case we cannot really conclude anything.

CELESTA 503

The Celesta 503 Cochlear Emissions Analyzer is the most rcent addition to the fine line of audiodiagnostic instrumentation from Madsen Electronics Celesta 503 evaluates both of the 2 broad classes of emissions, spontaneous and evoked, and two of the evoked emission types, transient and distortion product. Tests include amplitude and input/output determinations of evoked emissions, as well as spectral averages of spontaneous emissions.

Celesta 503 cochlear emissions analyzer is operated by an IBM or compatible personal computer via the built-in RS23SC connection, and offers the following unique fetures:

- small, lightweight probe which can be easily disassembled and reassembled for cleaning.
- mounting options for probe assembly, including headband or shoulder harness, significantly reduced noise floor for threshold detection and input/output tests.

The measurement techniques employed in Celesta 503 have several distinct advantages over more traditional audiologic tests.

1. Objectivity - No behavioral response required from patients.
2. Time efficiency - some tests can be accomplied in less than a minute for both ears.
3. Non-invasiveness - No electrodes are required.
4. Sensitivity to cochlear function - useful in the differential diagnosis of cochlear and retrocochlear disorders.

Celesta 503 cochlear emissions analyzer is intended for the following applications:

* Hearing Screening

  Difficult-to-test patients, including infants.

  Industrial

  School

  Geriatric

* Clinical evaluation

  Differential diagnosis

  Monitoring

    Progressive hearing loss

    Ototoxicity

    Noise Induced Hearing Loss.

* Research

Measured properties of cochlear function include signal detection threshold and response amplitude, frequency content and growth.

Equipment supplied ->

Celesta 503 Instrument

1) Signal Processing Unit (SPU)

H) Probe Assembly, including preamplifier.

3) Probe Body

4) Ear tip Assortment:

5) Shoulder Harness or Headband

6) Celesta 503 operating software

7) RSS32C serial interface cable

8) Probe connector cable

9) Power Cord

10) Celesta 503 Operation Manual

11) Calibration Adaptors.

Computer System Requirements-

IBM 386, 486 or compatible personal computer.

Although not imperative, a match co-processor is desirable to reduce the time required for various calculations performed by Celesta 503 software.

Operating System	DOS version 3.1 or later (5.0 recommended).
EGA or VGA monitor	
Keyboard	
Memory	640 KB (2 MB recommened)
Hard Disk	Approx. 350 KB for program files. Approx. 50 KB per patient file per measurment method.
Hard copy output	Dot matrix, ink jet, or laser printer.

Accesory equipment:

Dot matrix, ink jet, or laser printer

children's Headband

711 Coupler

B&.K Calibrator.

General Description —>:

The Celesta 503 cochlear emissions analyzer is a single channel audiodiagnostic instrument designed to measure 2 broad classes of OAEs, SOAE and EOAE. Celesta 503 consists of following:

1. SPU, which houses the power supply and printed circuit boards for signal generation.
2. The probe assembly, which contains the preamplifier.
3. The probe body, which contains a microphone and two receivers.
4. A headset and contrlateral earphone or a shoulder harness and a set of ear tips to stabilize the probe and probe assembly when the probe tip is placed in the external ear canal.
5. Operating software, which delivers signal generation and other instructions to the SPU and collects data from the SPU.
6. Various cords and cable connections, including an RS232C computer interface.
7. Operation manual.

Some test parameters are preprogrammed and stored in nonvolatile memory (NQVRAM) on the printed circuit boards of the main electronics unit. These parameters are retained when the power supply is cut off, but can be reprogrammed or upgraded from a personal computer by authorized prsonnel as necessary. Other test parameters *are* selected from the computer using the keyboard or various function keys.

The signal processing unit has 2 LED displays indicating power on and signal and response transmission (PC com).

STANDARDS ->

Patient safety - fully complies with IEC 601-1.

TECHNICAL SPECIFICATIONS:

DPOAES:

Stimulus	2 sinus stimulus channel
Geometric center	0.5, 0.75, 1.0, 1.5, 2.0, 3.0, 4.0,

Frequencies	6.0, 8.0 KHz.:
Stimulus level range	0-75 dB SPL (Max.70 dB at 8 KHz).
Stimulus 3rd order intermodulation	< - 80 dB
Input sensitivity for stimulus	> 50 dB SPL: 80 - 30 dB SPL < 50 dB SPL: 60 - 50 dB SPL.

PC Readout:800	F Sample	F Max.	Resolution
Point FFT analysis	26.04 KHz	10 KHz	13 KHz
	13.02 KHz	5 KHz	6 KHz

Sound level	+/- 6 dB relative to 500 Hz.
Mic. sensitivity	+/- 5 dB relative to 1 KHz.
TEOAE ->	
Stimulus	3 clicks of the same polarity and 1 click of opposite polarity, at 3 times the amplitude of the 1st click. Pulse width approximately 100 /Usec. Unipolar click.

Simulus level range	0-80 dB peak (-20 to 50 dB nHL).
Stimulus acoustical bandwidth	500-4000 Hz (+6 to -IS dB)
Input sensitivity	Measurement range:
	Time domain: 1 /u Pa/div to lPa/div
	Frequency domain - 30 dB - 10 dB SPL
Mic sensitivity	+/- 5 dB relative to 100 Hz.
SOAE ->	
Input sensitivity	0 - 70 dB SPL
Frequency ranges	500-8500, 500-5000, 500-10000 Hz.
Mic sensitivity	+/- 5 dB relative to 1000 Hz.

Power supply ->

AC 50/60 Hz

100-120 v +/- 10%.

200-240 v +/- 10'/.

Typical computer specifications ->:

Input voltage	100-10 or 220-240 VAC
Frequency	50 - 60 Hz
Input power	50 Watts
Hard copy output	Dot matrix, ink jet or laser printer

Computer Compatibility —>

IBM 386 or 486 PC, or compatible.

Monitor	EGA or VGA
Operating system	DOS version 3.1 or later (S.O. recommended)
Memory requirements	640 KB (2 MB recommended)
Hard disk requirements	Approx. 350 KB for program files. Approx. 50 KB per patient file per measurment method.

TABLE 3.4

FREQUENT AUTHORS

Authors	Basic	C.A	Total
BonfiIs P	1	7	8
Collet L	2	4	6
Johnssen N.J	0	6	6
Zwiscker E	5	0	'5
Probst R	2	2	4
Vandijk P	4	0	4
Whitehead M.L	3	1	4
Wit H.P	4	0	4
Bvrown A.M	3	0	3
Furst M	3	0	3
Lonsbury Martin B.L	1	2	3
Lutman M.E	0	3	3
Norton S.J	1	2	3
Rossi G	3	0	3
Ruggero M.A	3	0	3
Stevens J.C	0	3	3
Tanaka Y	0	3	3
Wier G.C	3	0	3
Zurek P.M.	3	0	3

TABLE 3 .5

J. No.	1978		1979		1980		1981		1982		1983		1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994		Total	
	3	b	a	b	3	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	5	0	3	0	0	0	2	0	6	0	0	0	5	0	5	0	6	1	9	3			47	4
2	0	0	0	0	0	0	3	0	1	0	3	0	5	0	3	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0			18	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	0	0	1	0	1	0	1	0	4			5	14
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	4	0	1	0	0	0	0			1	5
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	1	0	0	0	1	1	1			2	7
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	0	0	0			2	4
?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	1	1	0	1			2	5
8	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	4	7			5	10
9	0	0	0	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	0	2	1	3			2	7
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	2	0	0	0	1			0	5
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	1	0	0	0	1			0	5
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			0	0
13	0	0	0	0	0	0	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			0	1
	1	0	1	0	0	0	6	0	2	3	3	1	10	0	6	1	4	0	4	2	10	3	1	9	6	12	7	8	8	7	15	21				

MAJOR AREA OF FOCUS

(1) SOAE:

1. To explore the basic properties of SOAEs
   a) Prevalence of SOAEs
   b) Spectral analysis
   c) Intel—subject variability
   d) Intra-subject variability
   e) Short-term stability
   f) Long-term stability - effect of aging.
2. Origin of SOAE - various hypothesis 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 SDAEs.

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
14. Effect of noise exposure
15. Effect of contrlateral acoustic stimulation.

(E) TEOAE:

1. Explore the properties of TEOAEs
2. Prevalence of TEOAEs
3. Origin and mechanism of TEOAE production-different hypothesis
4. Intra-subject stability
5. Inter-subject stability
6. Effects of aging - development 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 TEOAE transmission to eardrum
13. TEOAE through bone conducted stimuli.
14. Properties and characteristics of BCTEQAE.
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. Determination of TEOAE threshold

23. Evaluate the type I error

24. Advanced coch. echo, technique developed for infant and neonatal screening.

25. Effect of noise bandwidth on contralateral masking of CEOAEs

26. Comparison of influence of auditory attention and repetitive measures on peripheral auditory system using EOAEs.

27. Study high rate OAEs

28. Influence of general anesthesia on TEOAEs.

29. Assess TEOAEs in Meniere's disease

30. Study growth of TEOAEs in infants and children.

31. Effect of contralateral masking on CEOAEs in normals and Sensorineural hearing loss cases.

32. Assess reliable identification of CEOAEs using signal processing techniques.

33. Relationship between EOAEs and ME dynamic characteristics.

34. Effect of noise exposure.

(3) DPOAES:

I. How DPOAE is generated

S. Effect of stimulus parameters

3. Effect of aging

4. Association of SOAE and DPOAE - under use of aspirin

5. Normative findings

6. DPDAE characteristics and hearing loss - comparison of normal and known pathologic ears; -in adults and children.

7. Electrophysiological evidence of DPQAE

8. Frequency specificity of DPQAE.

9. Measure human cochlear travelling wave delay using DPOAE.

10. Report CEOAE and DPOAE results with respect to pure tone audiograms.

11. Effects of tonal fatigue on SOAEs and DPOAE

12. Investigate repeatability of DPOAEs

13. Influence of noise on DPOAE amplitudes

14. Influence of ME transmission on DPOAE.

15. Clinical significance of probe tone frequency and level on DPOAE.

(4) **TINNITUS RELATED:**

1. To explore the link between tinnitus and OAE.

(5) ANIMAL STUDIES:

1. To explore the presence and characteristics of OAEs in lower animals.

S. To understand the mechanism of different OAEs

3. Comparison of OAE in lower animals and human

4. Ontogenic development of DPOAE in vat.

5. Relation between cochlear dysfunction and DPOAE responses parameters

6. Effect of sound exposure on OAE.

7. Relation between echolocation frequency and cochlear properties in mustache bat.

8. Existence of more than one DPOAE source and contribution of each to the ear canal 2fl-f2 signal.

9. Cochlear amplifier gain as a function of position along basilar membrane using DPOAE.

10. Influence of ionic efferent input on cochlear mechanics and subsequent changes in DPOAE.

11. General characteristics and suppression tuning characteristics of DPOAE in Bobtail lizard.

13. Vulnerability and adaptation of DPOAEs to endocochlear potential variation.

DISCUSSION

It was a difficult task to classify a particular article into "basic experiments" and "clinical application". Classification was done based on the criteria stated in the methodology. But some articles were at a loss to being classified into any of the groups.

Eg. All tinnitus related articles could have been classified as "basic experiments" but were put under clinical application because they were related to a clinical symptom "Tinnitus".

Out of 158 articles, 88 are basic experiments, and 70 *are* clinical application.

Out of 88 basic experiments 26 were on lower animals and the rest of the 62 articles were on human beings.

Under "basic experiments" £7 articles were found on SOAE and all of them were included for this review as there are no stimulus boundation (spontaneous emissions). So all of them can be further studied on Celesta-503.

S articles on TEQAE and 11 on DPOAE were found. Under "clinical application", 45 on TEOAE, £0 on DPOAE, and 5 on tinnitus were found. Though the stimulus specifications for the above given OAEs were not same or were not in the same range as given for Celesta 503 instrument but then also they have been included for review. As the given stimulus parameter in a particular study can be changed accordingly with the instrument (Celesta-503) specification. In most of the studies chosen a particular range of stimulus in not effecting there result directly. So in future research on Celesta 503 these stimulus parameters can be changed accordingly and the same study can be continued.

TEQAE and DPOAE *are* the only types which are clinically significant because as earlier mentioned SOAE may be present and may not be present in normal hearing

individual. TEQAE are the most frequently studied SFOAEs have not been included in the review as no specifications regarding SFOAE have been given in the manual for Celesta-503. Manufacturers have considered SFOAEs detection complicated and time consuming than measurement of TEOAE and so they have not yet incorporated it into clinical tests.

In terms of instrumentation, only 4 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* closely as compared to 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 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 instrument used in detail. So comparative advantages and disadvantages of the instruments used with Celesta 503 is difficult to assess.

But then, further research can be taken on this:
Major areas of interest of the past experiments have been listed in Table 3.3 under five different headings.

Analyzing Table 3.4 we find Bonfils P have the highest tally of articles. He has given more emphasis on clinical application experiments especially TEOAES. Collect and Johnssen have also contributed mainly in clinical application experiments. Zwicker has mainly focused on basic experiments especially on TEOAES. Probst, Van Disk, Whitehead and Wit are other authros whose main focus had been to basic experimental studies. Some of the other authors who have been tabulated include - Brown, First, Rossi, Ruggero, Wier, Zurek in basic experiments and Lonsbury Martin, Lutman, Norton, Stevens, Tanaka in clinical application experiments.

Analyzing Table 3.5 we find that Journal of Acoustical Society of America contains the highest number of articles are those articles are mainly of basic experiment. Then is Scandinavian Audiology whose majority are clinically applied articles. Then is Hearing Research whose majority of experiments *are* basic experiments and none are applied in nature.

Other than Hearing Research and Journal of Acoustical Society of America all other journals have majority of articles which are applied in nature.

The year 1993 has the maximum of OAE articles (36). So we can see the growing interest of researchers in the field of OAE. In the beginning, till 1981 experiments of basic nature were taken up reported maximally in Journal of Acoustical Society of America and then Hearing Research. Gradually experiments clinically applied in nature started growing and other journals also started publishing.

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