

Tinnitus: Why we should NOT say NO to our patients!

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Miller School of Medicine, University of Miami



BRRH Grand Rounds
February 11, 2020



Tinnitus



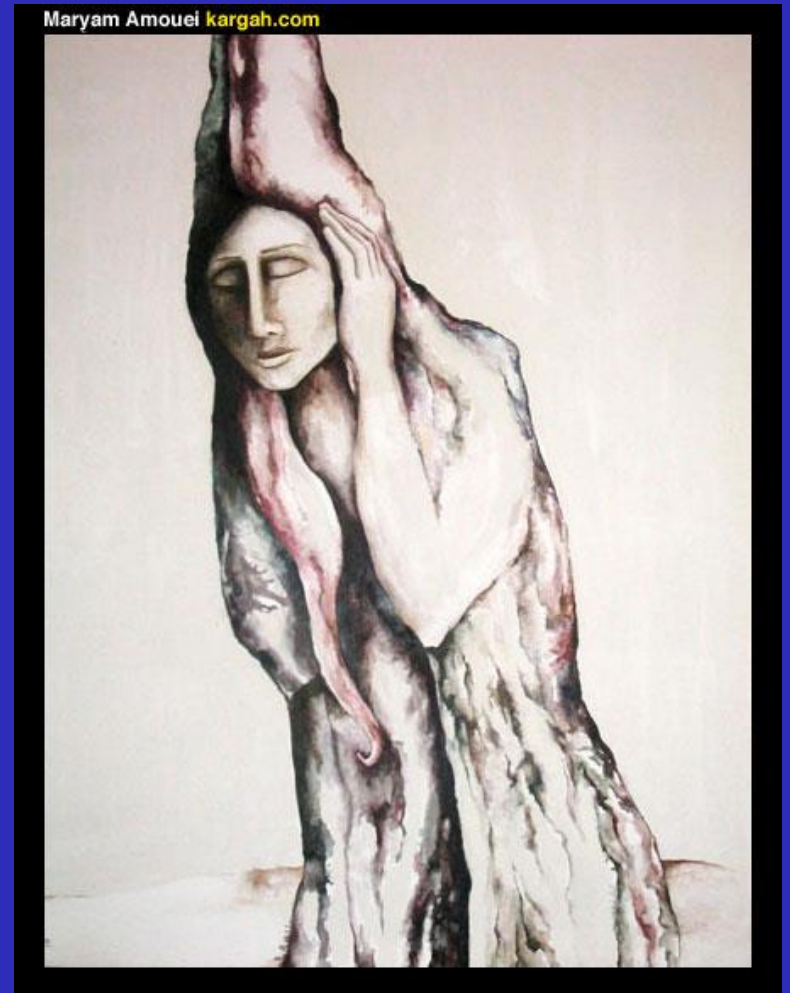
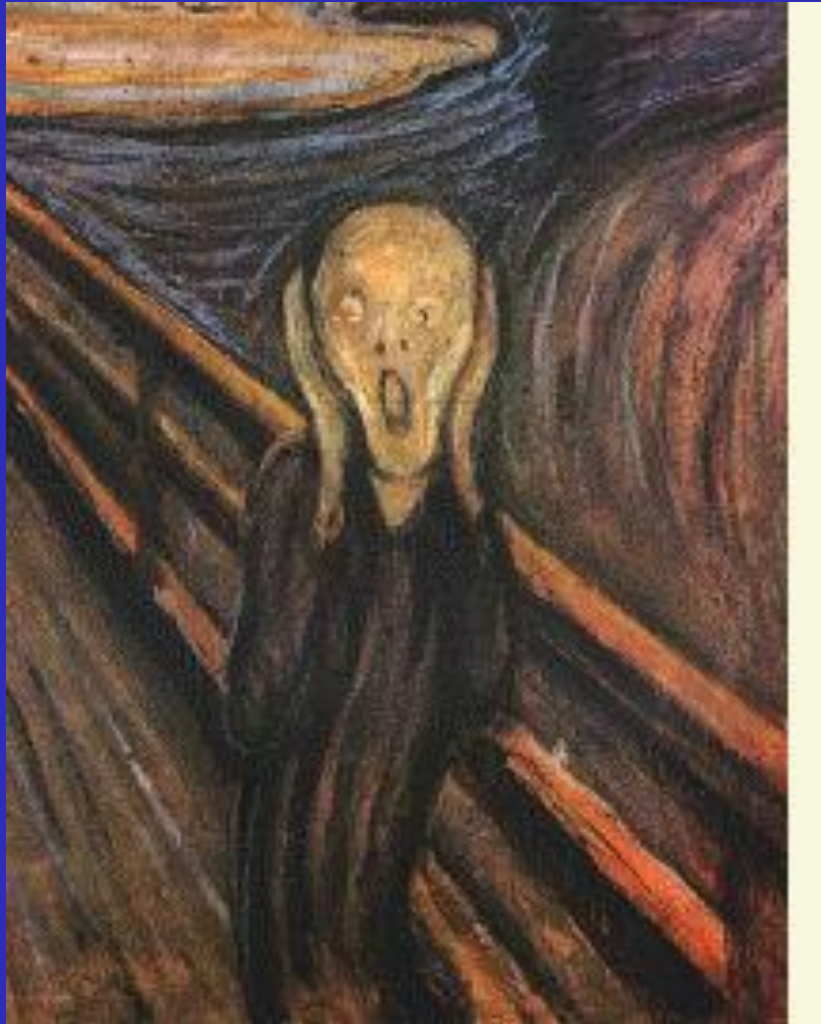
1. Tinnitus: Introduction and History
2. Brief review of the Auditory System
3. Causes of Tinnitus & Theories of Tinnitus Generation
4. The Neuroscience of Tinnitus
 - Electrophysiologic Recordings for Tinnitus
 - Neuroimaging of Tinnitus
5. Tinnitus Studies at FAU
6. Recent Advances in Tinnitus management and treatments

Tinnitus

Malady of the 21st Century



Tinnitus



Tinnitus

Historical Perspective

- In some of the world's oldest medical texts people complain about noise in their ears (evidenced in papyrus scrolls from ancient Egypt, clay tablets from Assyria)

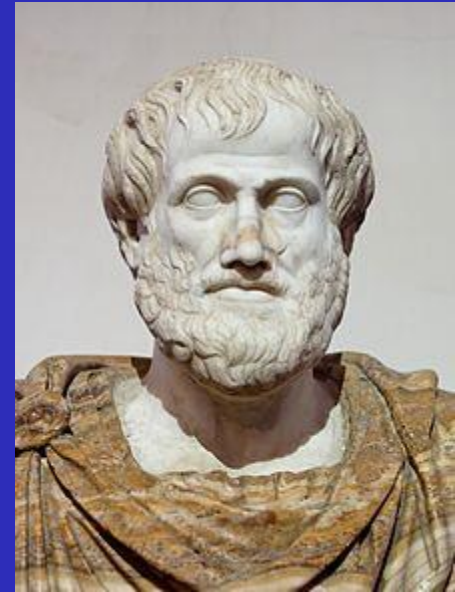


The word Tinnitus first coined by:
Gaius Plinius Secundus, or Pliny
the Elder, AD 23, Como

Tinnitus

Historical Perspective

- Aristotle in the 5th century BC:
"Buzzing in the ears ceases when a greater sound drives out the less"



Tinnitus

Historical Perspective



Avicenna

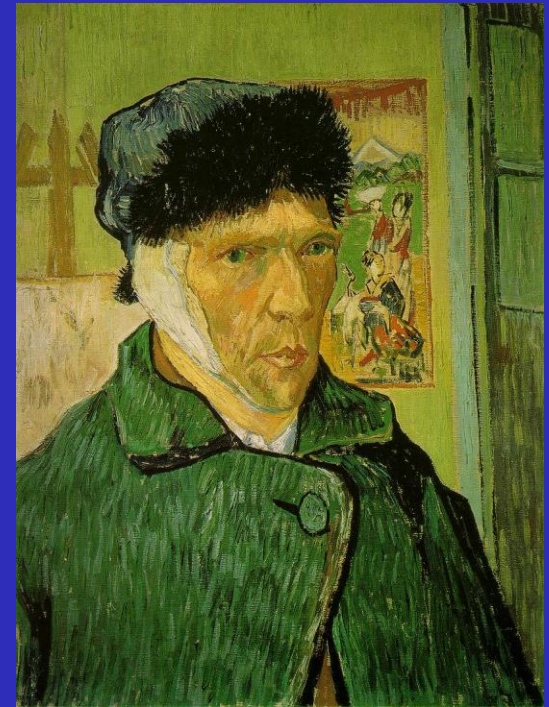
Born: AD 980, Bukhara, Persia
Died: December 10, 1037, Hamedan



Jean Marc Gaspard Itard

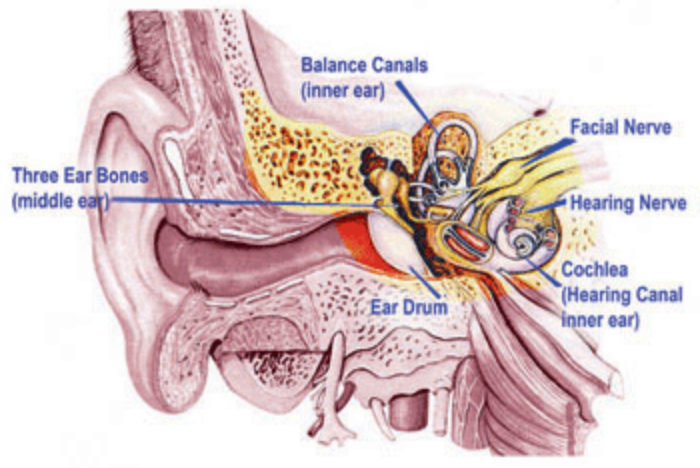
Born: April 24, 1774, Oraison
Died: July 5, 1838, Paris

Martin Luther, Ludwig van Beethoven & Vincent van Gogh

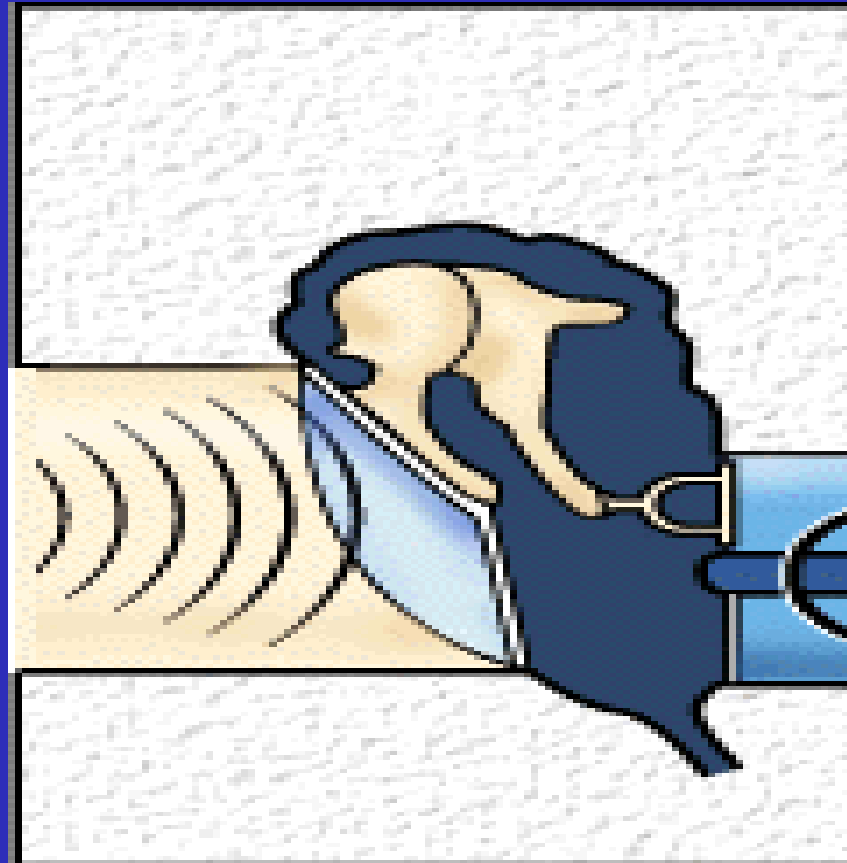


All had Tinnitus!

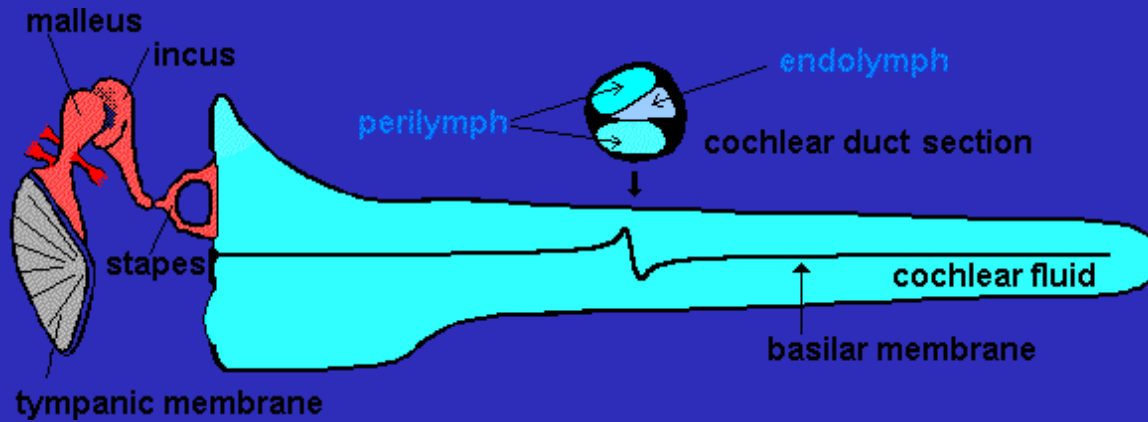
A Brief Review of the Auditory System



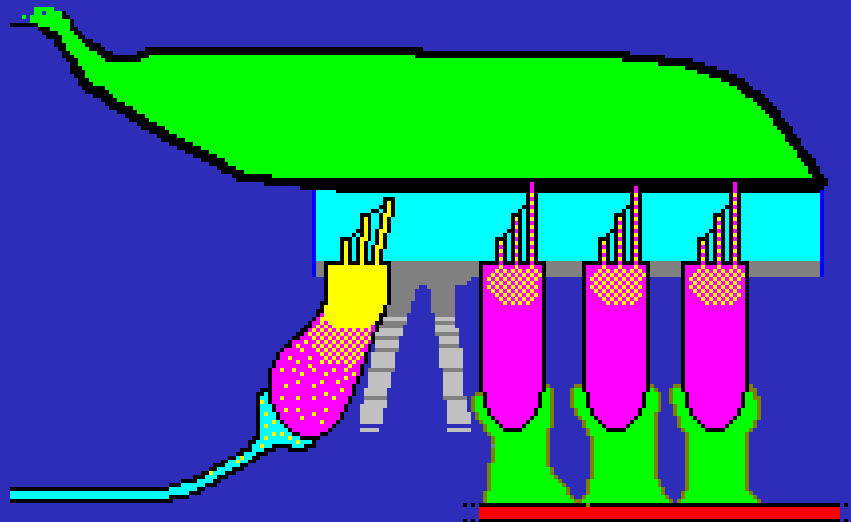
Sound Transmission to the Auditory System



So, How Does the Ear Work again?

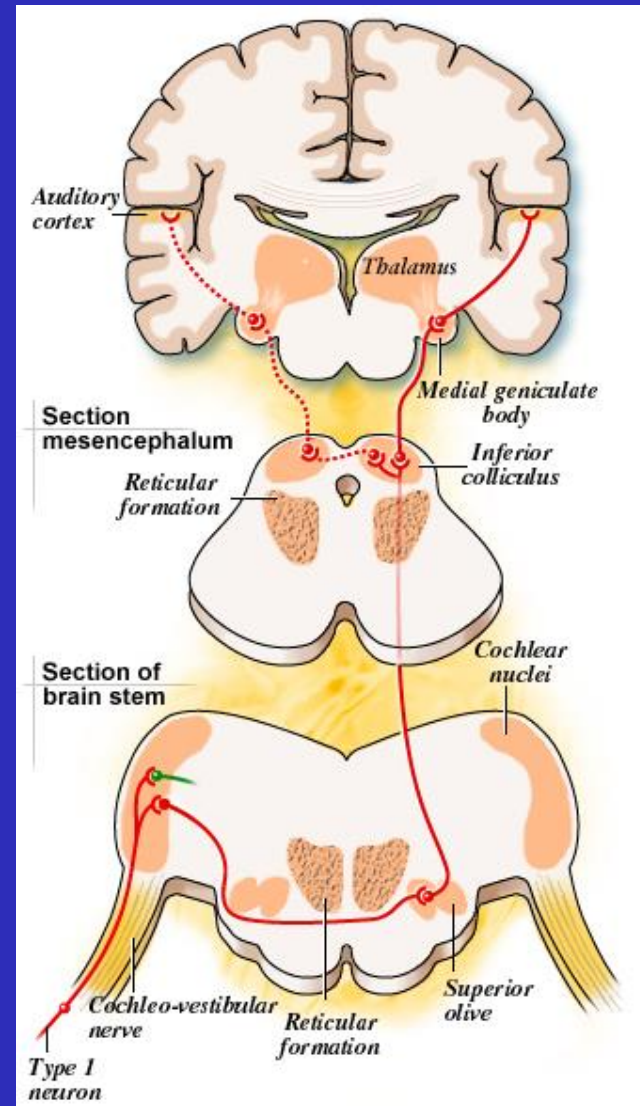


<http://www.vimm.it/cochlea/cochleapages/overview/history.htm>

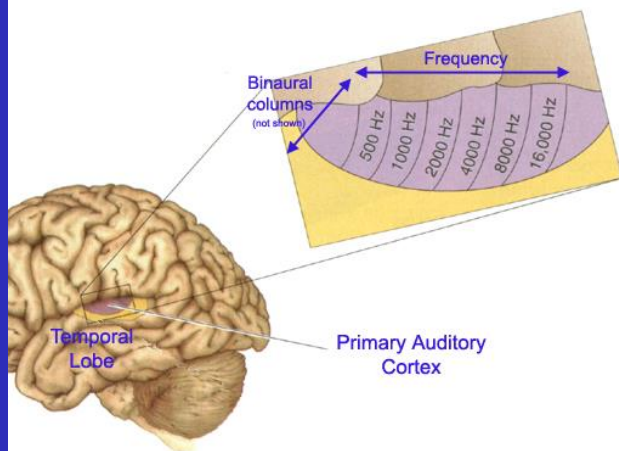


Central Auditory Pathway

- * Auditory Nerve
- * Cochlear Nucleus Complex
- * Superior Olivary Complex
- * Lateral Lemniscus
- * Inferior Colliculus
- * Medial Geniculate Body
- * Auditory Cortex (Heschl's Gyri)



Tonotopic Map Has Columnar Organization



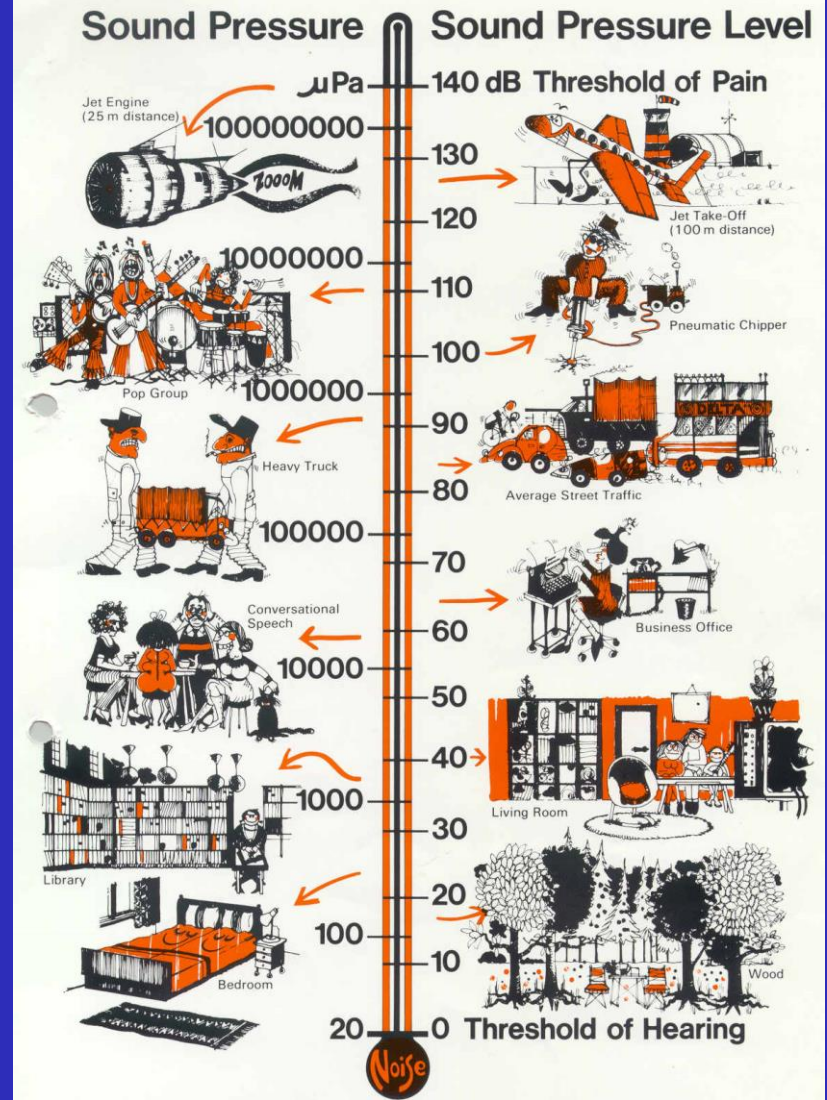
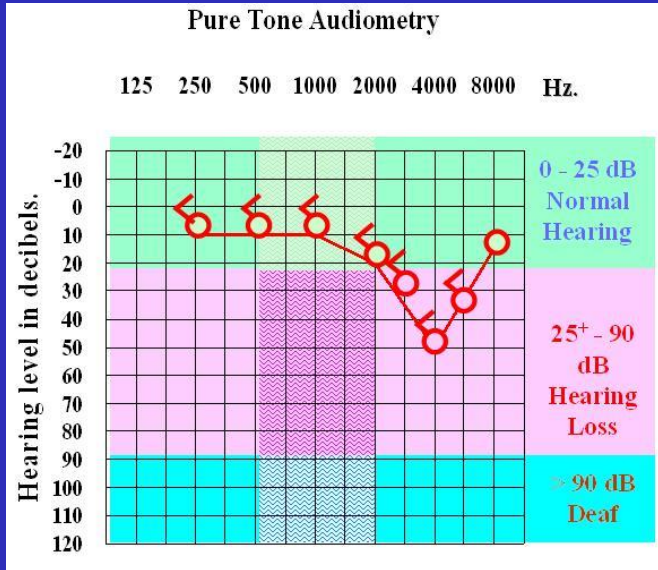
Causes of Tinnitus

- Noise Exposure
- Aging
- Ototoxicity
- Genetics
- Metabolic Disorders
- Hearing Loss
-



Tinnitus & Noise Induced Hearing Loss

Recreational noise, iPods/MP3

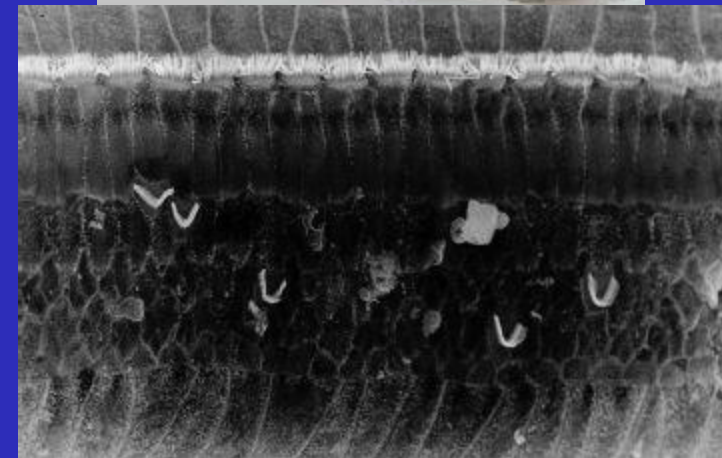
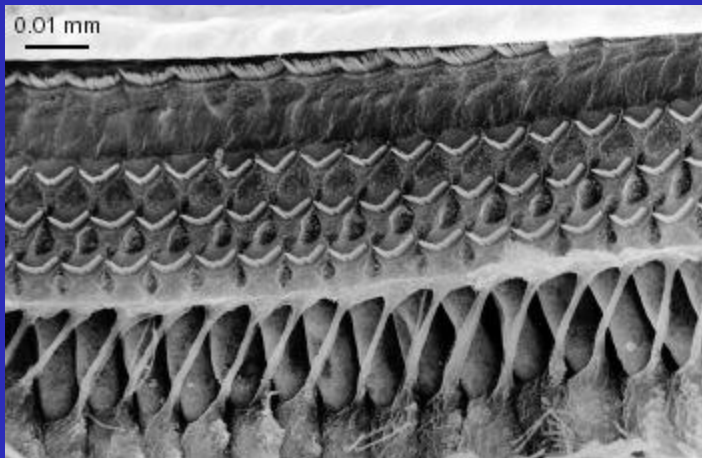


How loud is loud?

Ototoxic Medications

(initial damage to the outer hair cells, loss of otoacoustic emissions, results in sensori-neural hearing loss & tinnitus)

- Aminoglycosides
- Anti-cancer medications
- Quinine (tonic water)
- Heavy metals



Accompanying symptoms



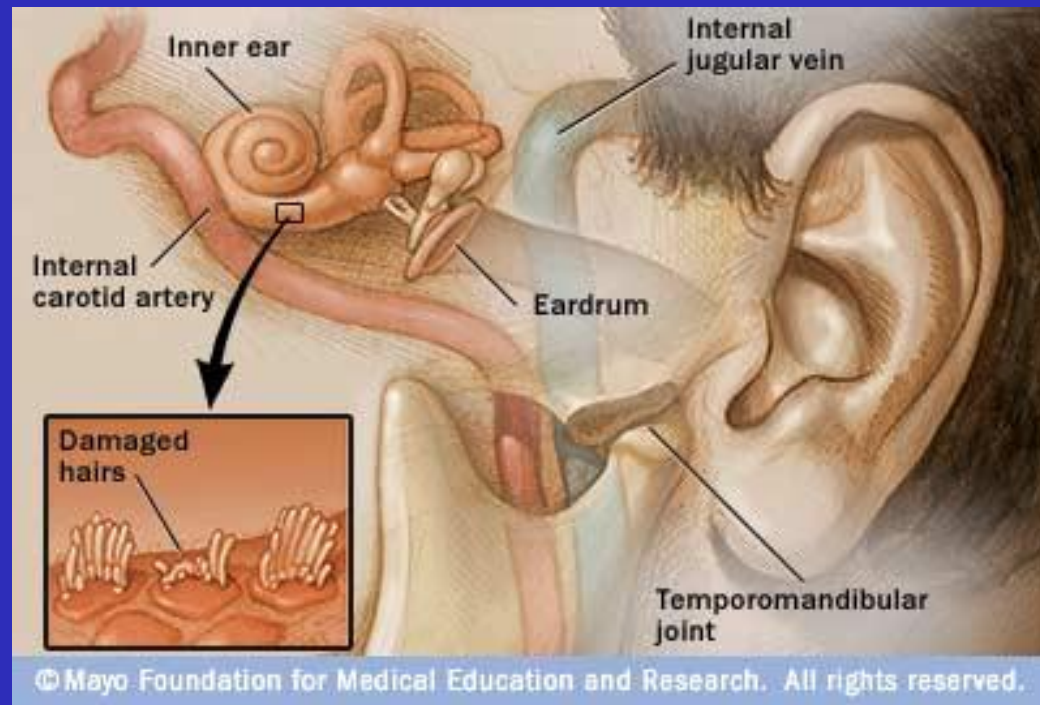
- Stress
- Anxiety
- Depression
- Fear
- Insomnia
- Fatigue
- ...

Theories of Tinnitus Generation

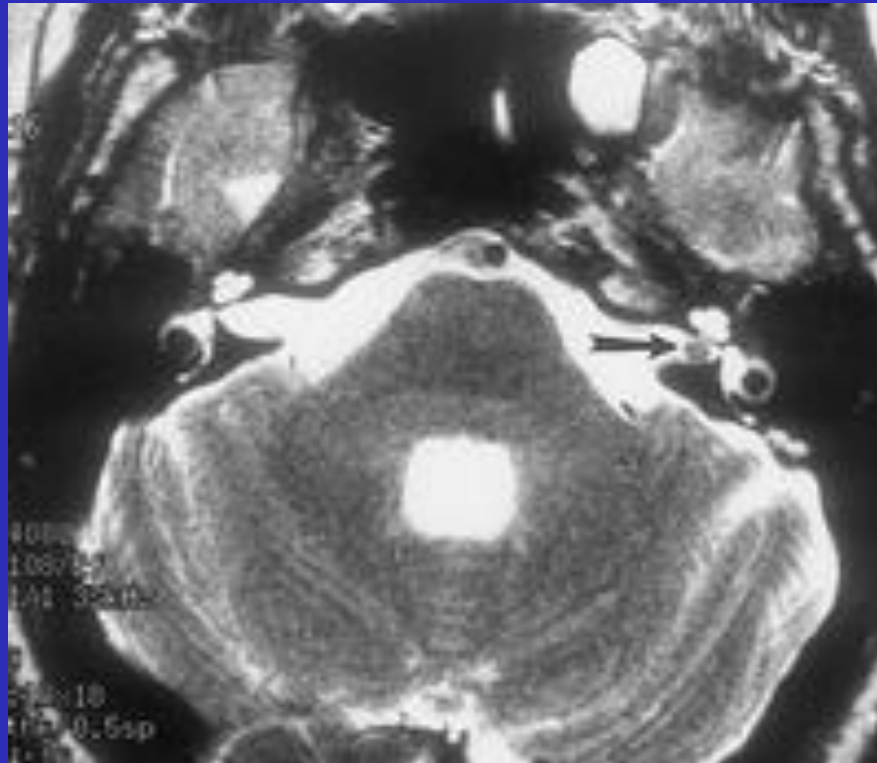


Tinnitus Classification

- Subjective Tinnitus
- Objective Tinnitus



Tinnitus due to Left Vestibular Schwannoma



Source: Weissman JL. Hearing loss. Radiology 1996; 199:593-611

Pulsatile Tinnitus

From: Alan H. Lockwood, MD, Robert F. Burkard, PhD,
Richard J. Salvi, PhD (2004)



FIGURE 18-2. Carotid stenosis with an ulcerated plaque (arrow) as a cause of pulsatile tinnitus. Turbulent blood flow at the site of the stenotic internal carotid artery generates sound waves that are transmitted to the cochlea. A loud bruit may be heard, and a thrill may be palpable. Image courtesy of Rohit Bakshi, MD.

Kaltenbach (Department of Neurosciences, Wayne State University)

Theories for Tinnitus Generation

(Cited in Sattinger, 2008, ENT Today)



- I. Increase in neural activity in the auditory system (neurons are firing at a higher rate, the same way when we hear a sound)
- II. An increase in neural synchrony in the brain leads to tinnitus. Tinnitus is a dyssynchronous signal that can arise from anywhere in the peripheral or central nervous system and expresses itself through the auditory system.

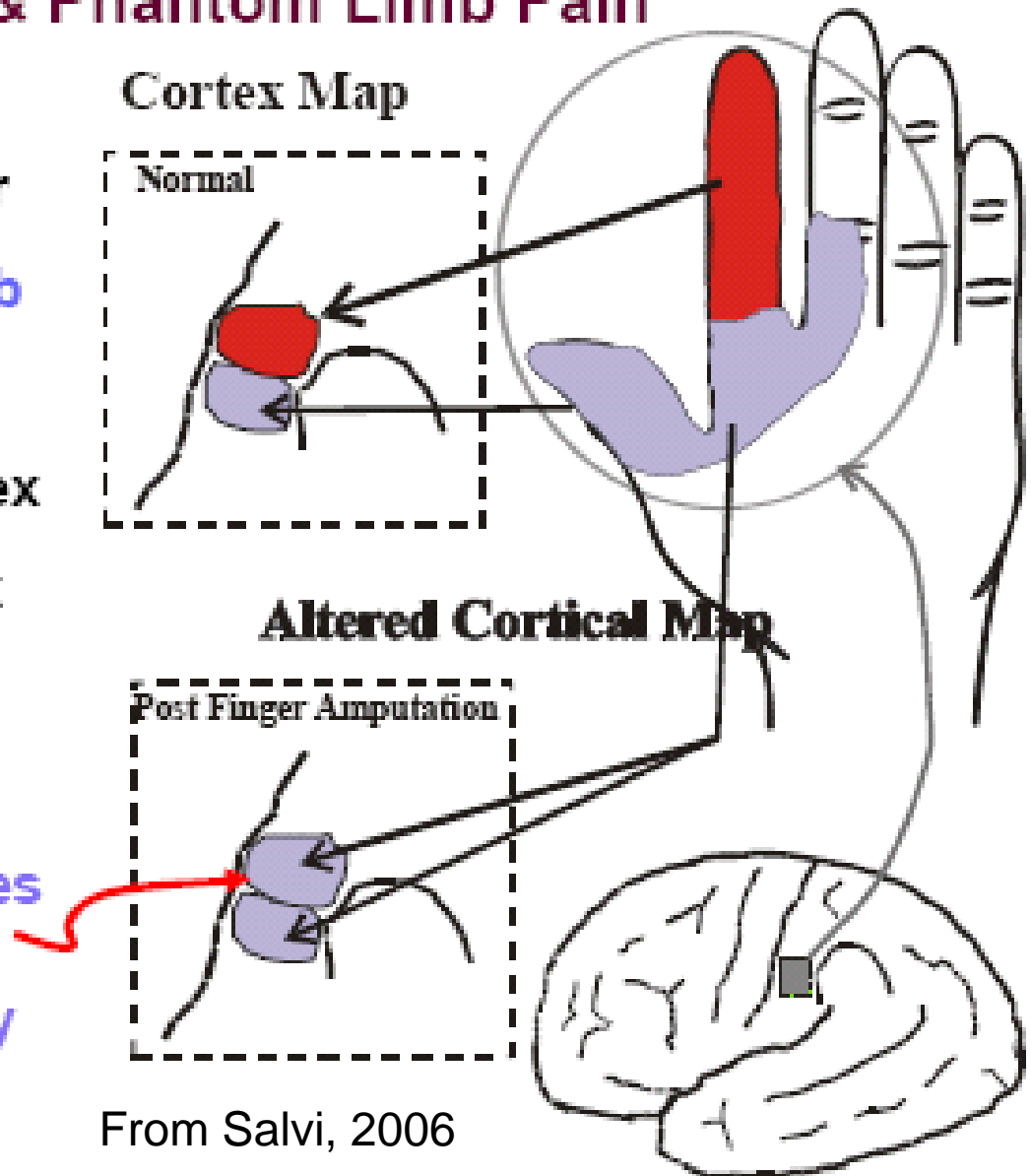
Cortical Plasticity & Phantom Limb Pain

Amputation of Finger

- **Index finger** & **thumb** normally activate restricted regions of somatosensory cortex

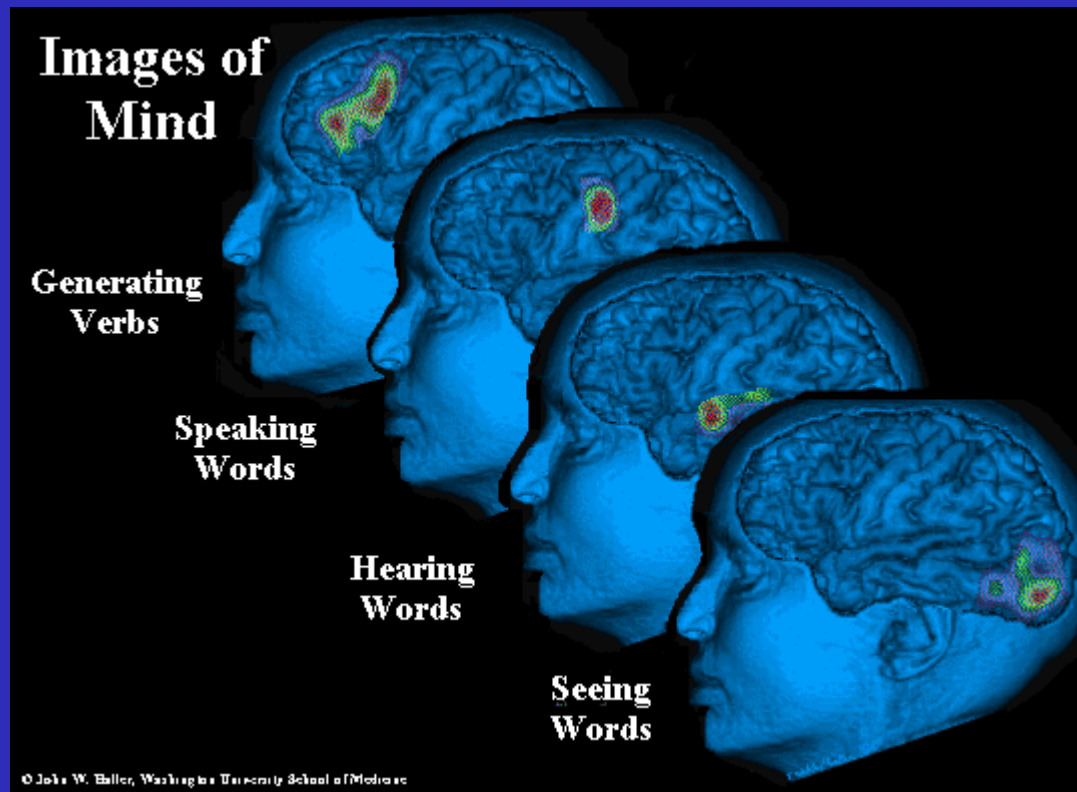
- Amputation of index finger causes expansion of **thumb** region

- **thumb region invades** cortical region normally activated by **index finger**

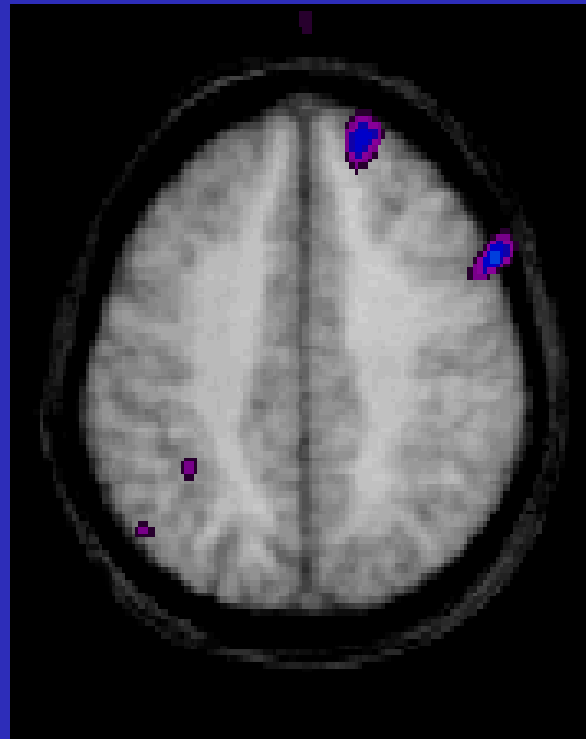


From Salvi, 2006

Neuroimaging Studies of Tinnitus

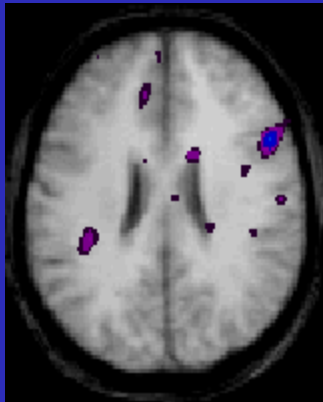


How are the functional neuroimaging techniques used in Tinnitus studies?

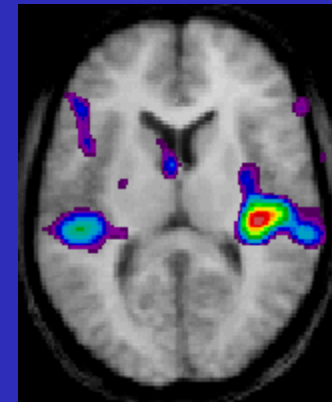


Dr. Frank Mirz Tinnitus Lab, Copenhagen-Denmark

Normal State
(No Tinnitus)



Evoked Tinnitus!
Altered Tinnitus



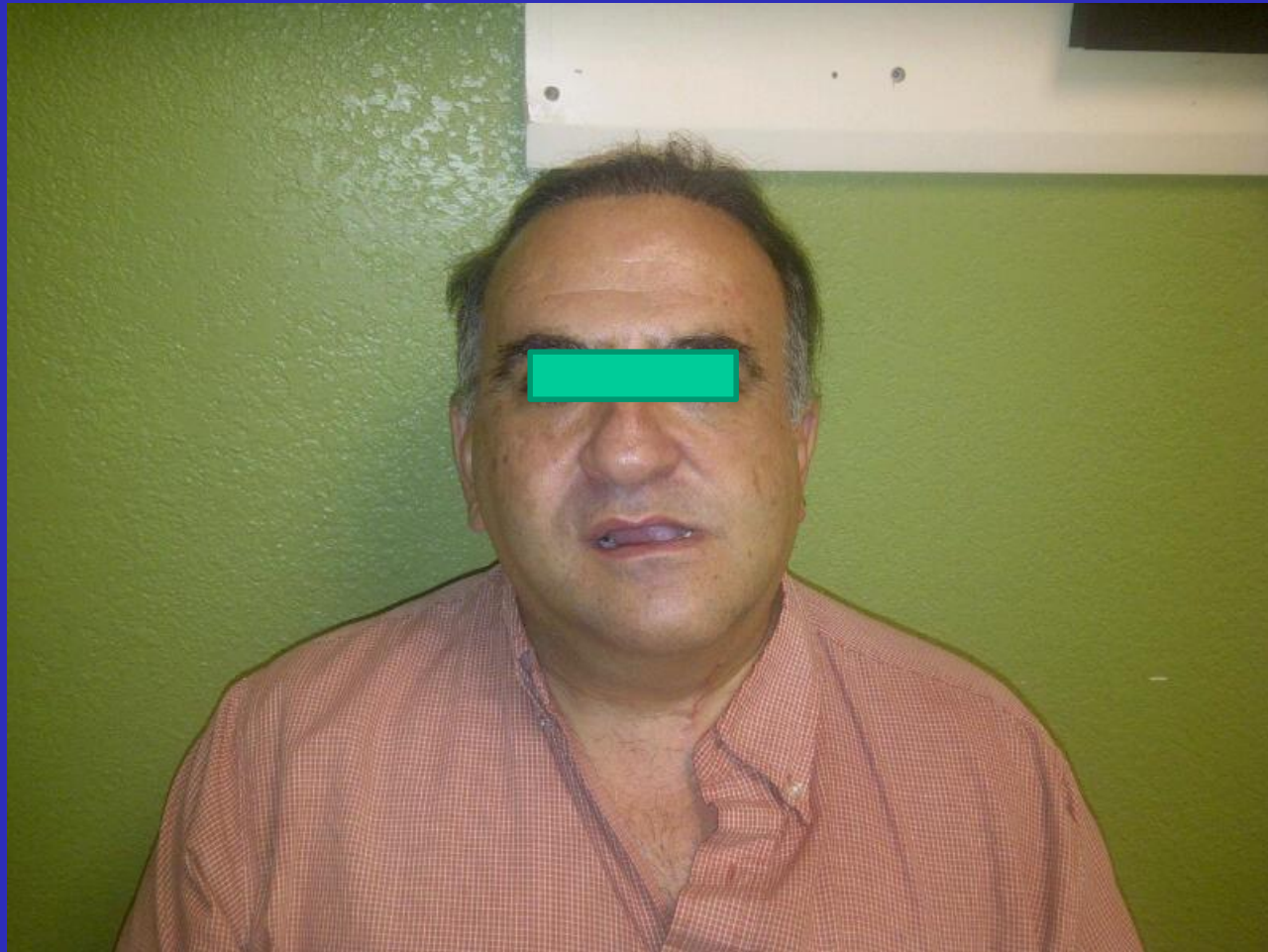
Evoked-Tinnitus Classification

- **Visual-motor evoked (e.g., Gaze-evoked tinnitus)**
- **Somatosensory-evoked tinnitus/Cutaneous-evoked (fingers or external ear) tinnitus**
- **Finger-movement-evoked tinnitus
Somatomotor-evoked tinnitus**
- **Orofacial/Jaw movement evoked tinnitus**
- **Cranio-cervical manipulations of head and neck**
- **Applying electrical stimulation to the median nerve and hand region**

Orofacial/Jaw-Evoked Tinnitus



Orofacial/Jaw-Evoked Tinnitus



Gaze-Evoked Tinnitus



Gaze-Evoked Tinnitus



Underlying factors of evoked tinnitus

- **Peripheral deafferentation**
- **Crossmodal reactive sprouting of neurons to denervated synaptic sites (Wall et al.,1987) (Hypotheses)**
- **Non-classical auditory pathways become reactivated as an expression of neuroplasticity (Moller and Rolins, 2002) (Speculation)**

Recent Research: The effects of Parental Mental Health in childhood in coping with tinnitus and hyperacusis in adulthood

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Director of Tinnitus and Hyperacusis
Specialist Clinic, Surrey Hospital, Guildford,
UK



Brian C. J. Moore, PhD, Professor, Department
of Psychology, University of Cambridge,
Cambridge, UK



Topics that were investigated:



1. Exploring the connection between parental separation and parental mental health on tinnitus and hyperacusis disability

2. Exploring the effects of parental mental health as a risk factor for anxiety and depression in tinnitus and hyperacusis patients

- **Parental separation and parental mental health are two key factors that may influence coping with tinnitus and hyperacusis in adulthood.**
- **It is not clear if there is a relationship between parental separation and its impact on perceived disability from tinnitus and hyperacusis in adulthood.**



Parental separation and parental mental health in childhood and tinnitus and hyperacusis disability in adulthood: a retrospective exploratory analysis

Hashir Aazh, Berthold Langguth & Ali A. Danesh

To cite this article: Hashir Aazh, Berthold Langguth & Ali A. Danesh (2018) Parental separation and parental mental health in childhood and tinnitus and hyperacusis disability in adulthood: a retrospective exploratory analysis, *International Journal of Audiology*, 57:12, 941-946, DOI: [10.1080/14992027.2018.1514470](https://doi.org/10.1080/14992027.2018.1514470)

- **The risk of parental mental health on factors such as anxiety and depression and its effect on tinnitus and hyperacusis has not thoroughly been investigated.**

Parental Mental Health in Childhood as a Risk Factor for Anxiety and Depression among People Seeking Help for Tinnitus and Hyperacusis

DOI: 10.3766/jaaa.18001

Hashir Aazh*
Ali A. Danesh†
Brian C. J. Moore‡



Material & Method:

- **Employing a retrospective cross-sectional study with a correlational design, the effects of parental mental health on tinnitus and hyperacusis of a group of sequential patients who attended a clinic in UK were investigated (N=287, Mean Age=52.5 years).**



Material & Method:

- The association between mental health and tinnitus/hyperacusis perception was explored by measuring the associated anxiety and depression via the Generalized Anxiety Disorder questionnaire (GAD-7) and the Patient Health questionnaire (PHQ-9).

GAD-7

Over the last 2 weeks, how often have you been bothered by the following problems?	Not at all	Several days	More than half the days	Nearly every day
1. Feeling nervous, anxious or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3

Total Score _____ = Add Columns _____ + _____ + _____

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all	Somewhat difficult	Very difficult	Extremely difficult
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Study Conclusion:

- There were no significant differences in the scores for THI and HQ between patients with and without history of parental separation but there were significant differences in THI and HQ scores between patients with and without history of parental mental health illness.
- **Clinicians offering tinnitus and hyperacusis rehabilitation should screen patients for parental mental illness in childhood, especially for those with comorbid depression.**

History
Self-performed questionnaires

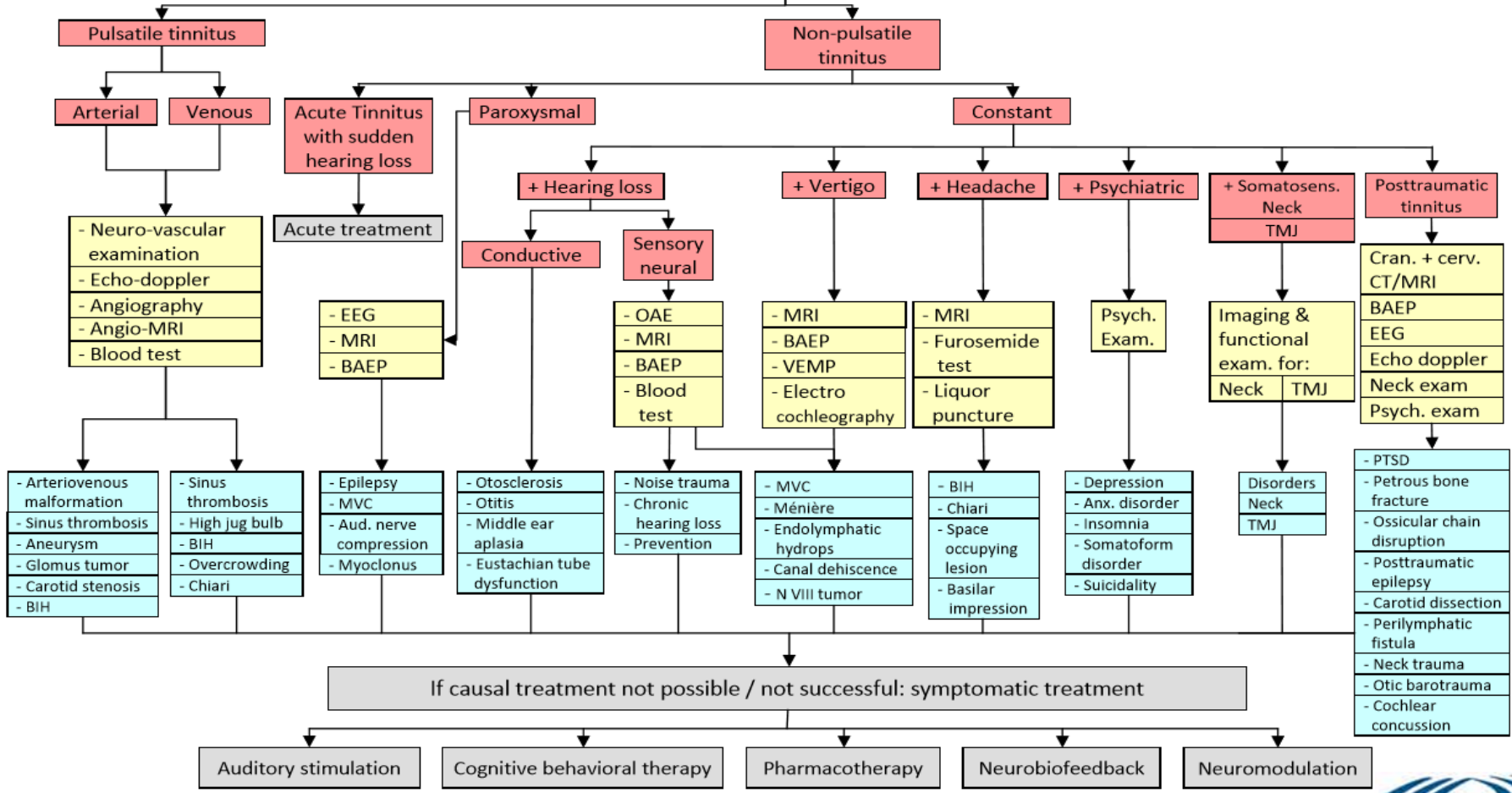
- Tinnitus Handicap Inventory
- Tinnitus Questionnaire
- Case History Questionnaire
- Tinnitus Severity Grading (E.Biesinger)

Clinical examination

- Otoscopy
- Cranio-mandibular & neck examination
- Auscultations

Audiological measurements

- Audiometry
- Psychophysical measurements
- Tympanometry
- Tubal impedance-manometry
- Distortion product OAE



COUNSELLING

Abbreviations: BAEP = Brainstem auditory evoked potential, BIH = Benign intracranial hypertension, MVC = Microvascular compression, OAE = Otoacoustic emissions, PTSD = Posttraumatic stress disorder, SOL = Space occupying lesion, TMJ = Temporomandibular joint, VEMP = Vestibular evoked myogenic potential



© Tinnitus Research Initiative

Tinnitus Treatments!

Turn off my tinnitus! (Where is that “magic pill”?)



"Hell's Bell's, Hell's Bells."

Comments made by some clinicians to their
tinnitus patients about tinnitus treatment
(Danesh, 2002 Tinnitus study)

- “Go and live with it”!
- “Nothing can be done”!
- “If I knew how to cure it, I will be a rich person”!
- “It is in your head”!

Tragedies: “Man murders doctor who prescribed him ***, claimed it ruined his life (caused tinnitus)” (David Cornbleet, MD in Chicago, 2008)
&
John Kemink, MD, in Michigan (1992)**



Tinnitus Treatment Categories

- Medications
 - Psychological Approaches (e.g., Cognitive Behavioral Therapy)
 - Sound Therapy
 - Physical Manipulation
 - Electrical Stimulation
 - Surgical Approaches
 - ...
- * **Amplification (Hearing Aids)**
 - * **Biofeedback**
 - * **Cochlear Implants/Electrical Stimulation**
 - * **Cognitive Behavioral Therapy**
 - * **Tinnitus Reaction Modification**
 - * **Drug Therapy**
 - * **Masking/Habituation Therapy**
 - * **Tinnitus Retraining Therapy**
 - * **TMJ Treatment**
 - * **Alternative Treatments**
 - * **Surgery**

Source: www.ata.org

Electrical Stimulation of the Cortex in Rats

Mouse is the human's best friend!



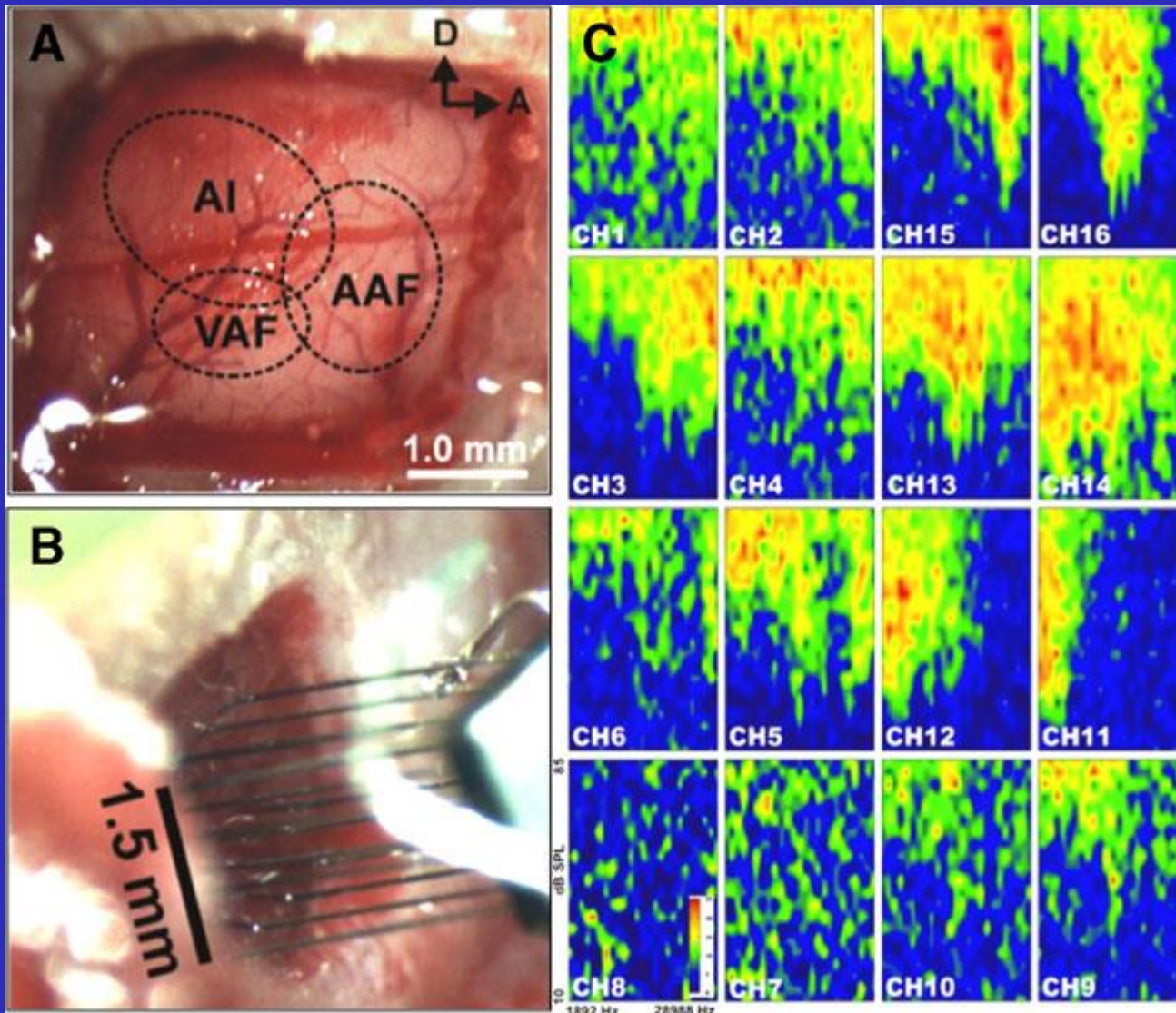
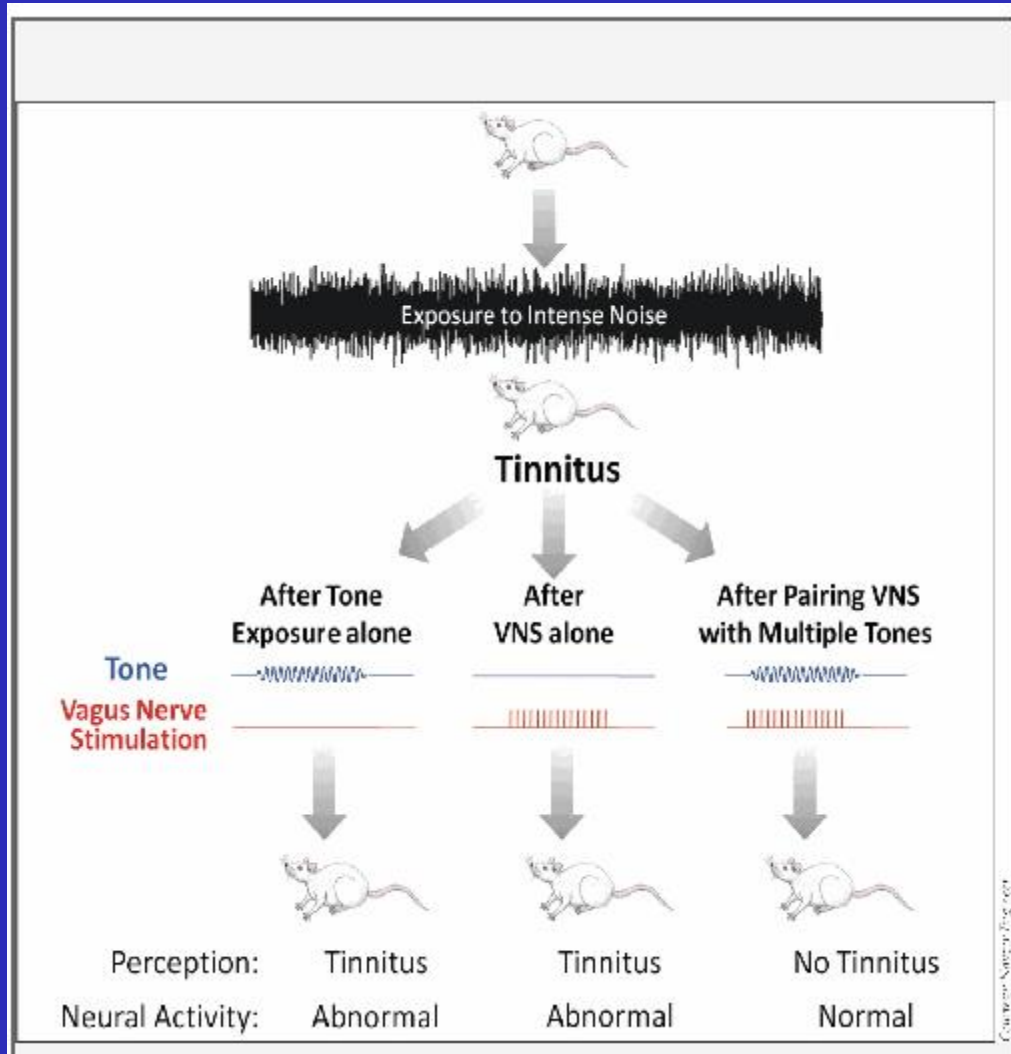


FIG. 2. An example showing chronic implantation of a 4×4 microwire electrode array in the rat AC and electrophysiological responses to acoustic stimulation. **A** AC areas before implantation. **B** Placement of a chronic microwire electrode array. **C** Frequency tuning curves were recorded and used to determine the frequency representations of the implanted electrodes in the AC. Responses in channels such as 1, 2, 3, 4, 5, 9, 11, 12, 13, 14, 15, and 16 were well or sharply tuned to tones, suggesting that these neurons are located in the core area of the AC. Responses in channels such as 6, 7, 8, and 10 were less sensitive or broadly tuned to tones, suggesting that these neurons are probably near or located in the belt region. Scale bar for activity rate is on CH8.

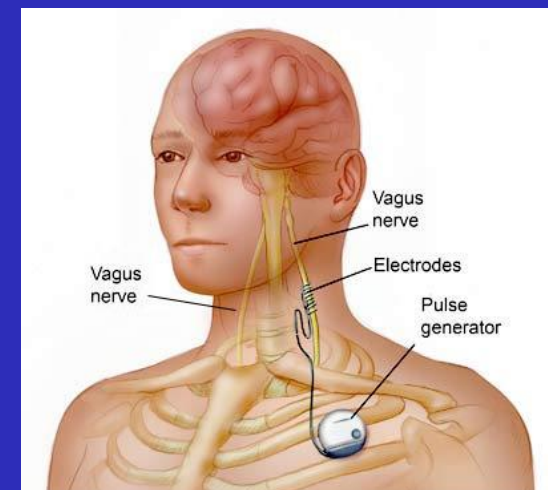
**Ref: Auditory Cortex Electrical Stimulation Suppresses Tinnitus in Rats
 JINSHENG ZHANG , YUPENG ZHANG, AND XUEGUO ZHANG , JARO (2010) DOI:
 10.1007/s10162-010-0246-z D 2010 Association for Research in Otolaryngology**

Vagus Nerve Stimulation in Rats

Targeted nerve stimulation

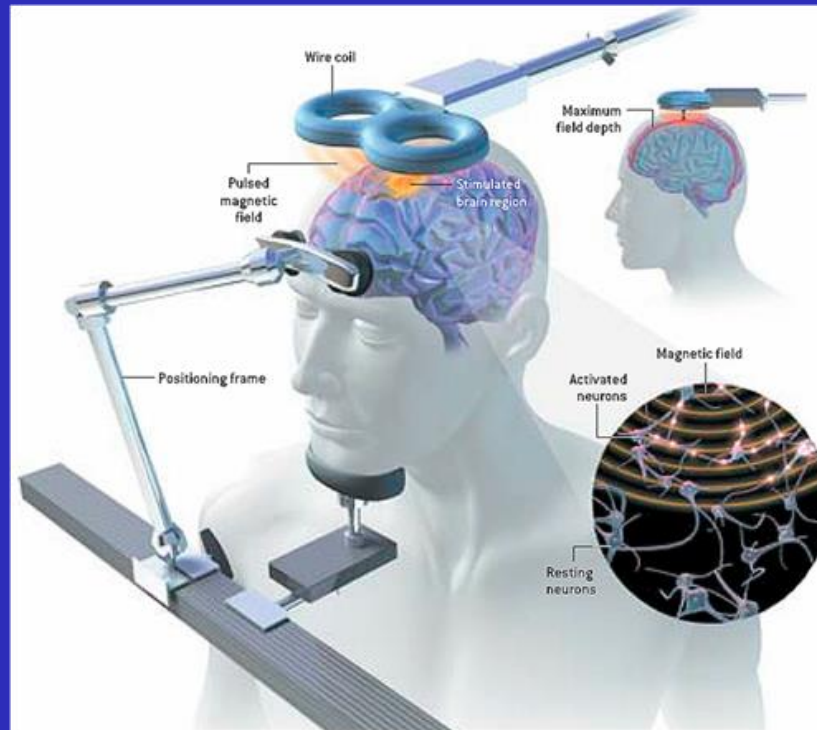


Engineer et al. (2010). **Reversing pathological neural activity using targeted plasticity.** Nature, 470, 101–104

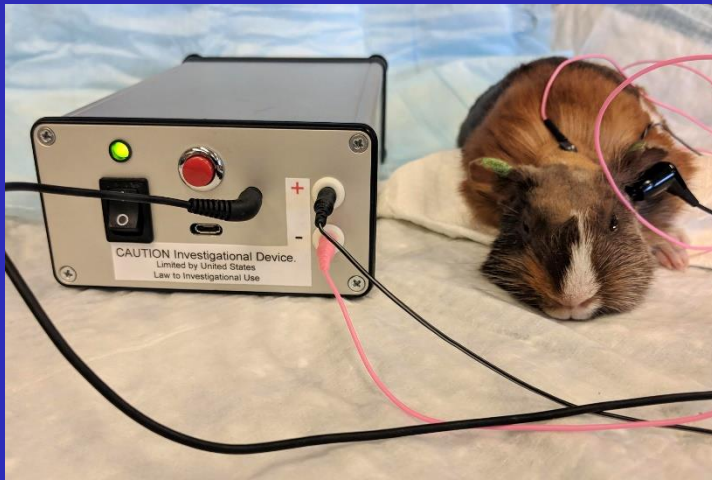


rTMS

- Repetitive transcranial magnetic stimulation (rTMS) is an innovative method for locally modulating brain activity including Tinnitus.



Susan Shore, PhD



Neuromod Lenire



Medication Therapy for Tinnitus



Medication Therapy for Tinnitus!

Where is the magic pill?

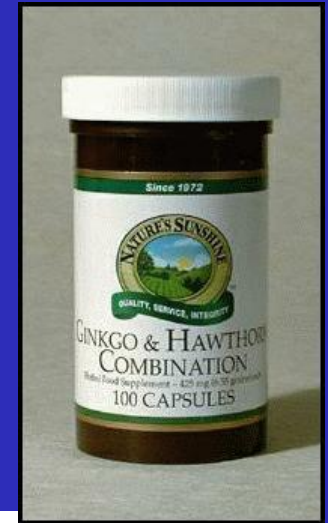
In October of 2014, the American Academy of Otolaryngology—Head and Neck Surgery Foundation (AAO-HNSF) published its clinical practice guideline (CPG) for clinical management of primary (neurophysiologic/sensorineural) tinnitus (Tunkel et al, 2014, Otolaryngol Head Neck Surg. 2014 Oct;151(2 Suppl):S1-S40).

The CPG recommends against the following treatments:

- 1) pharmaceutical medications
- 2) dietary supplements
- 3) transcranial magnetic stimulation



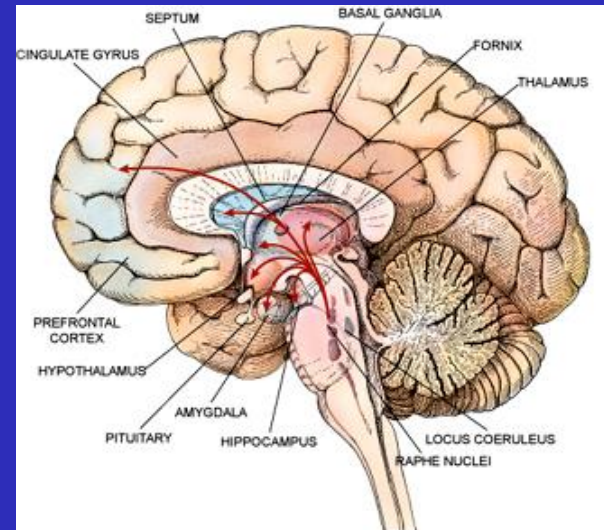
http://www.audiology.org/sites/default/files/publications/R2R_Tinnitus_ClinicalResearch_EvidenceBasedPractice.pdf



N acetyl cysteine for tinnitus
Antioxidants, herbs, vitamins.

Cyclobenzaprine (Flexeril) and Tinnitus

- *Cyclobenzaprine* is a skeletal muscle relaxant (fibromyalgia)
- Activates Locus Coeruleus in the brainstem (stress and panic)



Supplements and CBD

- Supplements such as micronutrients, antioxidants, cannabinoids (CBD), etc.
- No direct effect discovered yet!



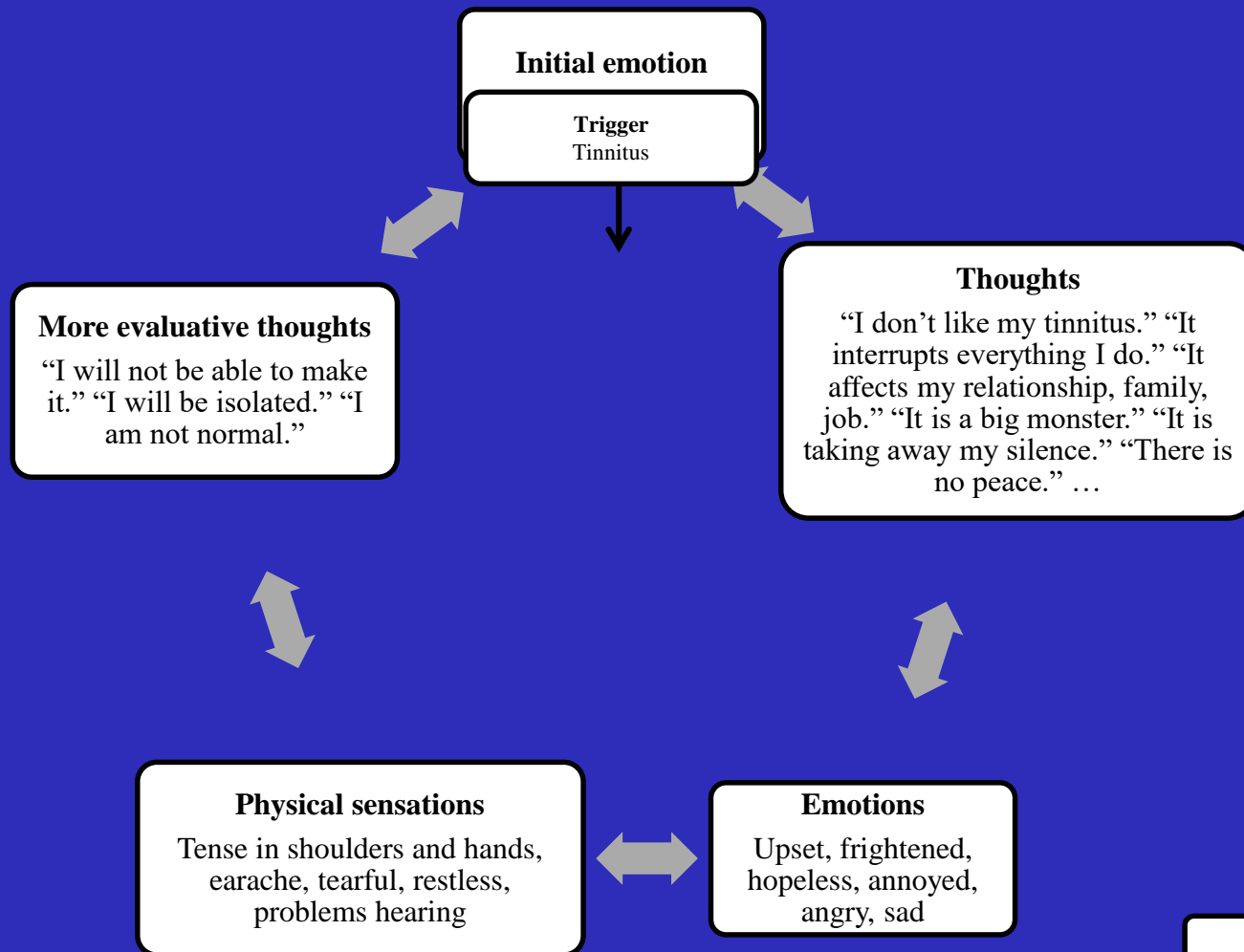
Cognitive Behavioral Therapy (CBT)

CBT is a psychological intervention that aims to alleviate anxiety by helping the patient to modify their dysfunctional cognitions, ruminations and safety-seeking behaviors.

Aazh et al, 2019

CBT for:

Tinnitus, Hyperacusis, Misophonia



Aazh et al, 2019

Hearing Loss and Tinnitus

- Listening hard or straining yourself to hear better will make your tinnitus awareness more common.
- Hearing Aids have helped many people to reduce the anxiety associated with social interactions and have improved tinnitus control and management.

The hidden effects of untreated hearing loss in addition to contributions to tinnitus generation.

The Consequences of Untreated Hearing Loss

Depression

Those with untreated hearing loss have **significantly higher** incidence of feelings of isolation and depression.



Lifespan

Studies show **adults with untreated impaired hearing have a shorter lifespan** than peers with hearing aids.

Cognitive Decline

Adults with untreated hearing loss experience a **30-40% faster decline in cognitive abilities**.



Balance

People with a mild hearing loss (less than 25 decibels) are three times more likely to have a history of falling. Furthermore, each additional 10 decibels of hearing loss will increase the **falling risk by 1.4 times**.

Dementia

Adults with untreated hearing loss **are up to 5 times more likely to develop dementia**.

5x

Hear better. Live better.

Sound Therapy and Habituation Therapy

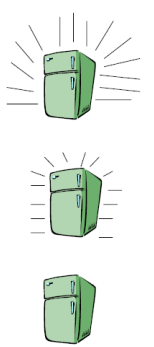
Very promising and noninvasive



Habituation

- “Habituation” is defined as the disappearance of a reaction to a stimulus.

Habituation to Sound



New refrigerator is loud at first

After a while it is less noticeable

Not even aware it is present

© Copyright R.S. Tyler 2006,
The University of Iowa



What is the Goal of Habituation?

- Habituation therapy is a process in which tinnitus becomes an unimportant signal even though it is still there.

Jastreboff suggests two things that are important in the control of the tinnitus:

- 1- The patient must habituate to the tinnitus itself, and
- 2- The patient must habituate to the emotional consequences of the tinnitus.

Take Home Message

There are many methods which can help tinnitus patients. Incorporating a healthy and informative approach for tinnitus patients in your practice is essential.

Thank You

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