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## An Integrated Approach to Tinnitus Patient Management

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**Presented by:**  
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Moderated by:  
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## An Integrated Approach to Tinnitus Patient Management

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### Tinnitus Facts

- 15% of general population
- More than 70% of hearing impaired individuals have had tinnitus
- 80-90% of tinnitus patients have some evidence of hearing loss
- 10 - 20% of tinnitus sufferers seek medical attention

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### Summary of modern theories of tinnitus origin

- **Disruption of auditory input (e.g., hearing loss) and resultant increased gain (activity) within the central auditory system (including the dorsal cochlear nucleus and auditory cortex)**
- **Decrease in inhibitory (efferent) function**
- **Over-representation of edge-frequencies (cortical plasticity)**
- **Other somatosensory influences (Cervical disturbances, TMJ, etc.); Correlated activity across nerves by phase locking - ephaptic transmission**
- **Extralemniscal neurons, particularly in dorsal cochlear nucleus and All area, receiving input from somasthetic system**
- **Association with fear and threat (limbic system) and increased attention related to limbic system involvement**
- **Widely distributed gamma network (into frontal and parietal regions)**
- **Dysfunctional gating in basal ganglia or thalamic reticular nucleus**

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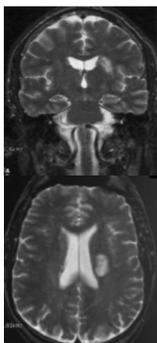
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### Case Report



63 year old otolaryngologist with 40 year history of mostly constant, high-pitched tinnitus. Tinnitus was mostly louder in the left ear, with episodic increases in loudness. Audiogram showed right moderate and left moderate-to-severe sensorineural hearing losses.

Left hemispheric stroke involving 'the more dorsal part of the corona radiata. In addition there is involvement of the neostriatum, including the body of the caudate and the caudodorsal aspect of the putamen. As such it most likely involves thalamocortical radiations and corticothalamic projection in addition to corticocortical fibers running in the superior longitudinal fasciculus.'

#### Clinical Outcomes

- Tinnitus Disappeared Completely
- Hearing Remained Unchanged

Lowry et al (2004) Otol Neurotol

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Another "gatekeeping" theory

- The linked network of brain structures involved in emotion, behavior, and long-term memory—acts as a gatekeeper to keep the tinnitus signal from reaching the auditory cortex.
- Sensory information enters both the auditory and the limbic systems through the medial geniculate nucleus (MGN)
- Before the signal is processed, it travels through the thalamic reticular nucleus (TRN), which evaluates whether or not it should be passed on.
- **There is a significant loss of volume in the medial prefrontal cortex (mPFC) in people with tinnitus. This structure projects into and activates the TRN. If the volume loss creates a loss of neurons, the mPFC and TRN will malfunction.**

Rauschecker, et al; Neuron, 2010

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Which one has a reduced medial prefrontal cortex?



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Tinnitus is associated with abnormal EEG-patterns, showing enhanced activity in the  $\delta$  band and reduced activity in the  $\alpha$  band (Weisz, Moratti, Meinzer, Dohrmann, & Elbert, 2005)

MEG data indicating that subjects with tinnitus < 4 years have gamma network predominantly in the temporal cortex; but subjects with tinnitus of a longer duration show a widely distributed gamma network into the frontal and parietal regions (deRidder, 2011)

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### Influence of noise and stress on probability of having tinnitus

- N = 12, 166 ; N with tinnitus) = 2,024 (16%)
- Each year of age increased the odds ratio of tinnitus by about 3%.
- Men generally showed a higher risk for tinnitus compared with women.
- Exposure to noise and stress were important for the probability and level of discomfort from tinnitus. However, for the transition from mild to severe tinnitus, stress turned out to be more important.
- Reduction of likelihood of tinnitus if noise is removed = 27%, if stress is removed =19%, if both removed = 42%.
- Conclusions: Stress management strategies should be included in hearing conservation programs, especially for individuals with mild tinnitus who report a high stress load.
  - Baigi, et al; Ear and Hearing 2011. 32, 6:787-789

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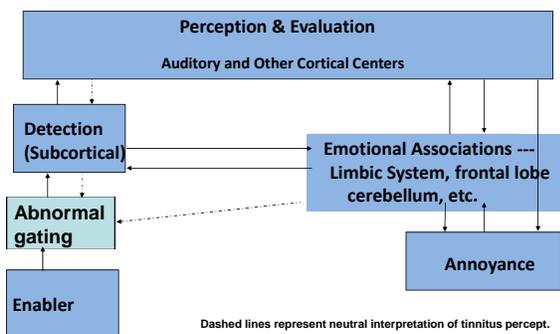
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### Revised habituation model (after Jastreboff and Hazell, 1993)



Dashed lines represent neutral interpretation of tinnitus percept.

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### Conclusions of Kochkin, et al; 2011

- Of the nine tinnitus treatment methods assessed, none were tried by more than 7% of the subjects.
- **Treatment methods rated with substantial tinnitus amelioration were hearing aids (34%) and music (30%).**
- Subjects who had their hearing aids fit by professionals using comprehensive hearing aid fitting protocols are nearly twice as likely to experience tinnitus relief than respondents fit by hearing care professionals using minimalist hearing aid fitting protocols.
- **This study confirms that the provision of hearing aids offers substantial benefit to a significant number of people suffering from tinnitus. This fact should be more widely acknowledged in both the audiological and medical communities.**

– Kochkin S., Tyler R., Born J. MarkeTrak VIII: The Prevalence of Tinnitus in the United States and the Self-reported Efficacy of Various Treatments *Hearing Review*. 2011;18(12):10-27.

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**Why hearing aids may help tinnitus patients**

- Greater neural activity allows brain to correct for abnormal reduced inhibition
- Enriched sound environment may prevent maladaptive cortical reorganization
- Alter production peripherally and/or centrally
- Reduce contrast to quiet
- Partially mask tinnitus
- Fatigue and stress is reduced allowing more resources to be allocated to tinnitus fight
- All of the above may facilitate habituation and
- The majority of tinnitus sufferers have at least some degree of hearing loss

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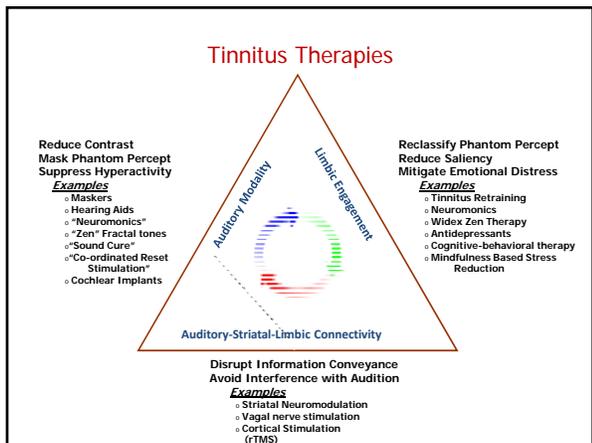
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**An analysis of tinnitus theories and treatments reveals a wide array that are often diametrically opposed.**

- Yet, evidence exists verifying effectiveness and correctness of each.
- For example, one music therapy amplifies the frequency region of hearing loss while another attenuates that region.
- Can both be correct, or are both incorrect.
- How can they both co-exist?

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Mechanism Theories	
Vagal nerve stimulation claims to work because it reverses the neural reorganization that occurs, but should not occur.	Bao et al (2011) indicate homeostatic rather than complete cortical reorganization occurs ; Tass (2011) claims tinnitus occurs because neural plasticity should, but does NOT occur.
Cheung and Larsen claim tinnitus occurs due to improper gating at the basal ganglia.	Rauschecker cites the thalamic reticular nucleus as the aberrant gateway.
Cerebellar malfunction may be related to tinnitus (Bauer )	Others site the limbic system, auditory cortex and frontal lobe.
Abnormal alpha wave ratios (Weisz)	Abnormal gamma wave activity. (DeRidder)
Increase in CNS activity (Kaltenbach, et al; Eggermont, et al)	Decrease in CNS activity (Liberman and Kiang, 1978)

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Treatments	
Neuromonics uses music filtered to stimulate hearing loss regions.	Okamoto notches music in regions where there is hearing loss to drive neural plasticity.
Zen fractal tones use unpredictable music and expound the virtues of unpredictability and relaxation via passive listening	Neuromonics uses a closed set of pre-recorded songs that may relax via active listening
Sound Cure uses signals designed to synchronize neural response	Coordinated reset (Tass) uses signals designed to desynchronize
TRT suggests avoiding silence and encourages sound enrichment 24-7.	Neuromonics suggests 2-4 hours per day
Cognitive-behavioral therapy employs distraction/avoidance techniques.	Mindfulness based stress reduction encourages the patient to embrace the sensation.

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**Integrated Tinnitus Therapy**

- **Addresses all three major components of tinnitus distress; auditory, attention, and emotion, and sleep difficulties.**
- **Many patients will be adequately served by counseling and sound therapy (hearing aids with additional acoustic options)**
- **But those patients who have increasingly significant negative reactions to their tinnitus will be best treated with a comprehensive program that integrates cognitive-behavioral concepts and relaxation exercises along with the counseling and acoustic tools.**

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### Tinnitus and Insomnia

- Severity of TRQ was shown to be a good predictor of sleep disturbance and of group association, especially the “emotional” subscore component (sensitivity 96.9% and specificity 55.3 % for identifying tinnitus patients with insomnia).
- The greater the insomnia disability, the more severe the patient’s complaints were regarding the tinnitus

Yaremchuk , et al, 2012

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### Components of Integrated Tinnitus Therapy

1. *Counseling* to educate the patient and assist the limbic system to alter its negative interpretation of the tinnitus via cognitive and behavioral intervention;
2. *Amplification* (binaurally, when appropriate) to stimulate the ears and brain in order to discourage increased in central activity (overcompensation) and maladaptive cortical reorganization;
3. *Acoustic therapy (music, fractal tones, s-tones, noise, etc.)* delivered binaurally to the patient in a discreet, inconspicuous and convenient manner, designed to both relax and provide acoustic stimulation;
4. *Relaxation strategy program* highlighted by behavioral exercises.

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### Disclosure

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## Tinnitus Questionnaire

- Otologic
- Medical
- Audiologic
- Diet
- Exercise
- Emotional Pattern
- Sleep
- Previous Treatments

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## Subjective Assessment Scales

- Tinnitus Severity Scale - Sweetow and Levy
- Tinnitus Handicap Inventory - Newman et al
- Tinnitus Handicap Questionnaire - Kuk, et al
- Tinnitus Effects Questionnaire - Hallam, et al
- Tinnitus Reaction Questionnaire - Wilson, et al
- Tinnitus Cognitive Questionnaire (TCQ) - Wilson and Henry
- **Tinnitus Functional Index (2012) Meikle, et al**

<http://www.ohsu.edu/xd/health/services/ent/services/tinnitus-clinic/tinnitus-functional-index.cfm>

WIDEX let's talk about  
TINNITUS 23xxx

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### TINNITUS FUNCTIONAL INDEX

Tinnitus Date: \_\_\_\_\_ Your Name: \_\_\_\_\_ Please Print \_\_\_\_\_

Please read each question below carefully. To answer a question, select **ONE** of the numbers that is listed for that question, and draw a **CIRCLE** around it like this: (10) or (1).

**[A] Over the PAST WEEK...**

1. What percentage of your time awake were you consciously **AWARE** of your tinnitus?  
Never aware ➤ 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% ◀ Always aware

2. How **STRONG** or **LOUD** was your tinnitus?  
Not at all strong or loud ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Extremely strong or loud

3. What percentage of your time awake were you **ANNOYED** by your tinnitus?  
None of the time ➤ 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100% ◀ All of the time

**[B] Over the PAST WEEK...**

4. Did you feel **IN CONTROL** in regard to your tinnitus?  
Very much in control ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Never in control

5. How easy was it for you to **COPE** with your tinnitus?  
Very easy to cope ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Impossible to cope

6. How easy was it for you to **IGNORE** your tinnitus?  
Very easy to ignore ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Impossible to ignore

**[C] Over the PAST WEEK how much did your tinnitus interfere with...**

7. Your ability to **CONCENTRATE**?  
Did not interfere ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Completely interfered

8. Your ability to **THINK CLEARLY**?  
Did not interfere ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Completely interfered

9. Your ability to **FOCUS ATTENTION** on other things besides your tinnitus?  
Did not interfere ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Completely interfered

**[D] Over the PAST WEEK...**

10. How often did your tinnitus make it difficult to **FALL ASLEEP** or **STAY ASLEEP**?  
Never had difficulty ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Always had difficulty

11. How often did your tinnitus cause you difficulty in getting **AS MUCH SLEEP** as you needed?  
Never had difficulty ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ Always had difficulty

12. How much of the time did your tinnitus keep you from **SLEEPING** as **DEEPLY** or as **PEACEFULLY** as you would have liked?  
None of the time ➤ 0 1 2 3 4 5 6 7 8 9 10 ◀ All of the time

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### Counseling

- Instructional counseling helps educate the patient about aspects of the tinnitus itself. For example, it addresses.....
  - the basic anatomy and physiology of the auditory (and central nervous) system,
  - *why* the tinnitus is present (particularly when it is a normal consequence of having a hearing loss),
  - *what* the logical course of the tinnitus might be,
  - *how* the limbic system affects the tinnitus perception and *how* the patient's reaction impacts the ability to cope with or habituate to the tinnitus.

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### Habituation

- the process of "ignoring" (or becoming accustomed to) a stimulus without exerting any conscious effort.
- from a psychological perspective, it is defined as the adaptation, or decline of a conditioned response, to a stimulus following repeated exposure to that stimulus.

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### Examples of normal habituation

- Ring on your finger
- Clothing
- Refrigerator humming
- and my personal favorite.....

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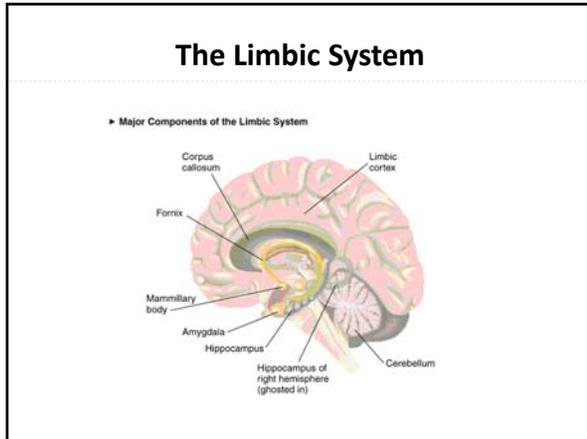
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### How sensory systems suppress stimuli

- Somatosensory
- Auditory
  
- **How brain (limbic system) determines importance of external stimuli**
  - Thunder versus soft, unexpected sound

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### A simple structure for remembering the sequence of the brain's analysis of the tinnitus

1. The auditory cortex analyzes
2. The hippocampus identifies
3. The amygdala determines salience

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### Adjustment based counseling...

- Helps the patient recognize aspects about how the tinnitus is affecting him or her, and the cognitive and behavioral implications. It is designed to :
- *address* the emotional sequelae of tinnitus, including fear, anxiety and depression;
- *identify* and correct maladaptive thoughts and behaviors;
- *understand* the relationship between tinnitus, stress, fear, behaviors, thoughts, and quality of life.

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Awareness of tinnitus

Cognitions (Automatic thoughts)

Emotional state  
(anger, depression, anxiety)

Emotional response is the result of the thoughts, not the event (awareness of the tinnitus) itself.

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### Cognitive behavioral intervention....

- is designed to identify the unwanted thoughts and behaviors hindering natural habituation, challenge their validity, and replace them with alternative and logical thoughts and behaviors.
- the objective is to remove inappropriate beliefs, anxieties and fears and to help the patient recognize that it is not the tinnitus itself that is producing these beliefs, it is the patient's reaction (and all reactions are subject to modification).

The basic processes in cognitive-behavioral intervention are :

- identify behaviors and thoughts affected by the tinnitus;
- list maladaptive strategies and cognitive distortions currently employed;
- challenge the patient to identify negative thoughts;
- identify alternate thoughts, behaviors, and strategies.

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### Challenging your thoughts

- What is the evidence that my thinking is true?
- What facts am I forgetting or ignoring?
- What are some alternative ways of thinking about this situation?
- What is the worst thing that could happen?
- How likely is it that the worst thing will happen?
- What is probably or most likely to happen?

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### Testing validity of NATs: common distortions in NATs



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### Sound therapy considerations

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**Conclusions**

- Subjects who experienced suppression reported louder tinnitus (db SL) at baseline
- Best stimuli were amplitude modulated pure tones with carrier frequencies between 6K and 9K
- White noise is ineffective as a suppressor
- For subjects with any suppression, AM and FM pure tones were more likely to yield total suppression compared to un-modulated pure tones

– Vanessa S. Rothholtz, Qing Tang, Kelly M. Reavis, Jeff Carroll, Edward C. Wu, Esther Fine, Hamid R. Djalilian, Fan-Gang Zeng

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- If tinnitus is related to a disorder either in synchrony or asynchrony, the use of a dynamic signal as opposed to a steady state signal could alter synchronous response
- Given the unclear, but widespread effect of tinnitus on the brain, doesn't it make sense to use acoustic stimuli that activate widespread regions?

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- Music has been shown to activate the limbic system and other brain structures (including the frontal lobe and cerebellum) and has been shown to produce physiologic changes associated with relaxation and stress relief.

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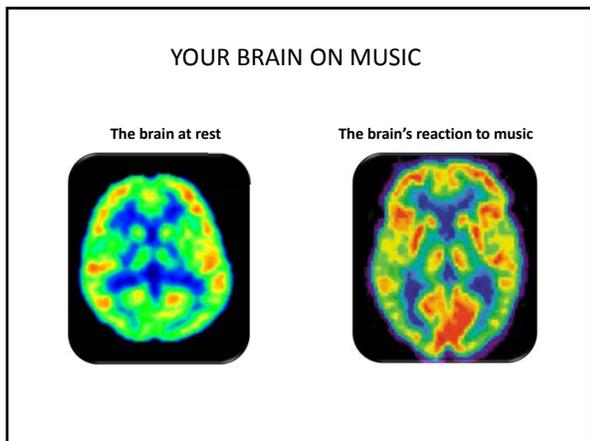
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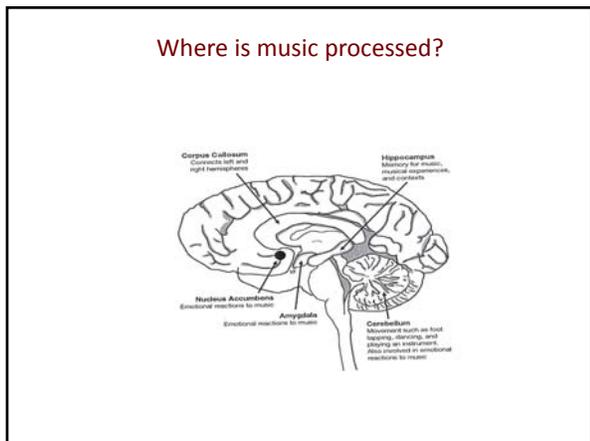
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- ### “Rules” of music and emotions
- Slow onset, long, quiet sounds – calming
  - Music with a slow tempo (i.e. near natural heart rate (60 – 72 beats per minute) - relaxing
  - Repetition - emotionally satisfying

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### Selecting the right sound

- Sounds affect people in different ways, due to inherent, learned, and cultural preferences (Iversen et al, 2000).
- It is thus important to use relaxing background sounds (that activate the parasympathetic division of the autonomic nervous system) and avoid exposure to negative or annoying sounds (that activate the sympathetic division)
- Earworms?

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### Earworms

- Nearly 98% of people have had songs stuck in their head, Kellaris reported at the recent meeting of the Society for Consumer Psychology. The 559 students -- at an average age of 23 -- had lots of trouble with the Chili's "Baby Back Ribs" jingle and with the Baha Men song "Who Let the Dogs Out." But Kellaris found that most often, each person tends to be haunted by their own demon tunes.
- "Songs with lyrics are reported as most frequently stuck (74%), followed by commercial jingles (15%) and instrumental tunes without words (11%)." Kellaris writes in his study abstract. "On average, the episodes last over a few hours and occur 'frequently' or 'very frequently' among 61.5% of the sample."
- Top 10 earworm list:
  - Chili's "Baby Back Ribs" jingle.
  - "Who Let the Dogs Out"
  - "We Will Rock You"
  - Kit-Kat candy-bar jingle ("Gimme a Break ...")
  - "Mission Impossible" theme
  - "YMCA"
  - "Whoomp, There It Is"
  - "The Lion Sleeps Tonight"
  - "It's a Small World After All"

• Kellaris, 2003

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### Music suggestions

- evokes positive feelings
- without vocals
- no pronounced bass beat
- pleasant, but not too interesting or compelling (though for short term relief attention capturing music can be beneficial)
- induces relaxation while reducing tinnitus audibility (best for long term relief)
- Play at low levels where music blends with tinnitus
  - Hann D, Searchfield G, Sanders M, Wise K (2008) Strategies for the selection of music in the short-term management of mild tinnitus.

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## Fractals

- "a rough or fragmented geometric shape that can be split into parts, each of which is (at least approximately) a reduced-size copy of the whole,
- Properties include self-similarity and a simple and recursive definition
- Fractal tones create a melodic chain of tones that repeat enough to sound familiar and follow appropriate rules, but vary enough to not be predictable.
- Fractal technology ensures that no sudden changes appear in tonality or tempo

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Fractal styles	Default pitch				Tonality		Dynamic Range		Default tempo		
	Low	Medium low	Medium high	High & reverberant	Major	Minor	Restricted	Broad	Slow	Medium	Fast
Aqua	■				■		■		■		
Coral			■			■		■	■		
Lavender			■		■			■			■
Green				■	■		■			■	
Sand			■		■			■			■

Frequency response and amplitude settings are based on in-situ audiogram.  
 A filtered broad band noise can be used as a separate program or in combination with the fractal tones.  
 Signals are dichotic

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## Evidence of effectiveness

- Sweetow & Henderson-Sabes, The use of acoustic stimuli in tinnitus management. *JAAA* 21,7, 461-473, 2010
- Kuk F, Peeters H, Lau CL. The efficacy of fractal music employed in hearing aids for tinnitus management. *Hearing Review*. 2010;17(10):32-42.
- Herzfeld and Kuk, *Hearing Review*, 2011; 18,(11), 50-55.

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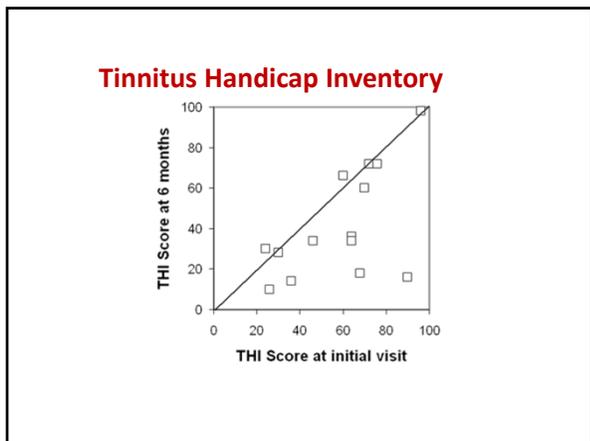
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- ### Summary of findings
- Fractal tones were effective as a tool in promoting relaxation and reducing annoyance from tinnitus
  - Both fractal tones and noise reduced tinnitus annoyance, but the fractal tones were preferred by subjects for longer term use

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- ### Caveats for interpreting tinnitus therapy data
- Subject population
  - Drop out stats
  - Group versus individual statistics
  - Benefit / cost analysis

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### Relaxation Exercises

- Progressive Muscle Relaxation
- Deep breathing
- Guided imagery
  
- Sleep suggestions

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### Sleep suggestions (partial list)

- Maintain a standard bedtime for each day.
- Set your alarm for the same time each day.
- Walk or exercise for ten minutes a day, but not right before going to sleep.
- Set thermostat for a comfortable bedroom temperature.
- Use a fan or white noise machine to interfere with your tinnitus.
- Close your curtains/drapes and maintain a bedroom dark enough to sleep.
- Change the number of pillows you use. This also may impact somatic contributors to tinnitus.
- Don't watch TV, eat or read in bed. Use your bed for sleep and sex.
- Sleep on your back or on your side, try to avoid sleeping on your stomach.
- Take prescription medicines as directed, but only if required.

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### The manual.....

.....helps establish realistic, time-based expectations, provides methods of assessing progress, and creates a follow up schedule.

In addition, the information is demonstrated with the use of case examples.

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### Conclusions

- Tinnitus patients with hearing loss may best be served by amplification that incorporates low compression thresholds, a broad frequency response, and flexible options for acoustic stimuli
- Tailor the therapy to the patient's functional and financial needs
- Sound therapy without counseling is not likely to work

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Thanks for listening

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