Effects of Musical Stimulation on Tinnitus & Relaxation

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Where is this awful perception coming from?

History of ancient theories and treatments

- Egyptians: infused oil, frankincense, tree sap, herbs, and soil via a reed stalk inserted in the external ear.
- Mesopotamians: chanted to get rid of whispering or singing in ears.
- Early Greco-Romans: 1st suggested treatment of tinnitus based on cause. For example, if related to a cold, ear should be cleaned and the breath held until some humor froths out from it.
- Hippocrates and Aristotle: first to mention masking.
- Romans: associated it with depressive and seizure disorders

History of ancient theories and treatments

- Middle Ages: poured objects into ear, i.e. a loaf of very hot bread, divided in half, and placed in each ear
- Renaissance: introduced surgery for tinnitus. The thought was that wind was entrapped in the ear;
- 19th century: Itard “Most tinnitus is associated with hearing loss”. Described objective versus subjective tinnitus;
- 20th century: Various sources emphasized attention for contextual and emotional aspects that have become an important focus in modern management of tinnitus.

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)
- Dysfunctional gating in basal ganglia
- Other somatosensory influences (Cervical disturbances, etc.)
- Association with fear and threat (limbic system)
- Increased attention related to limbic system involvement

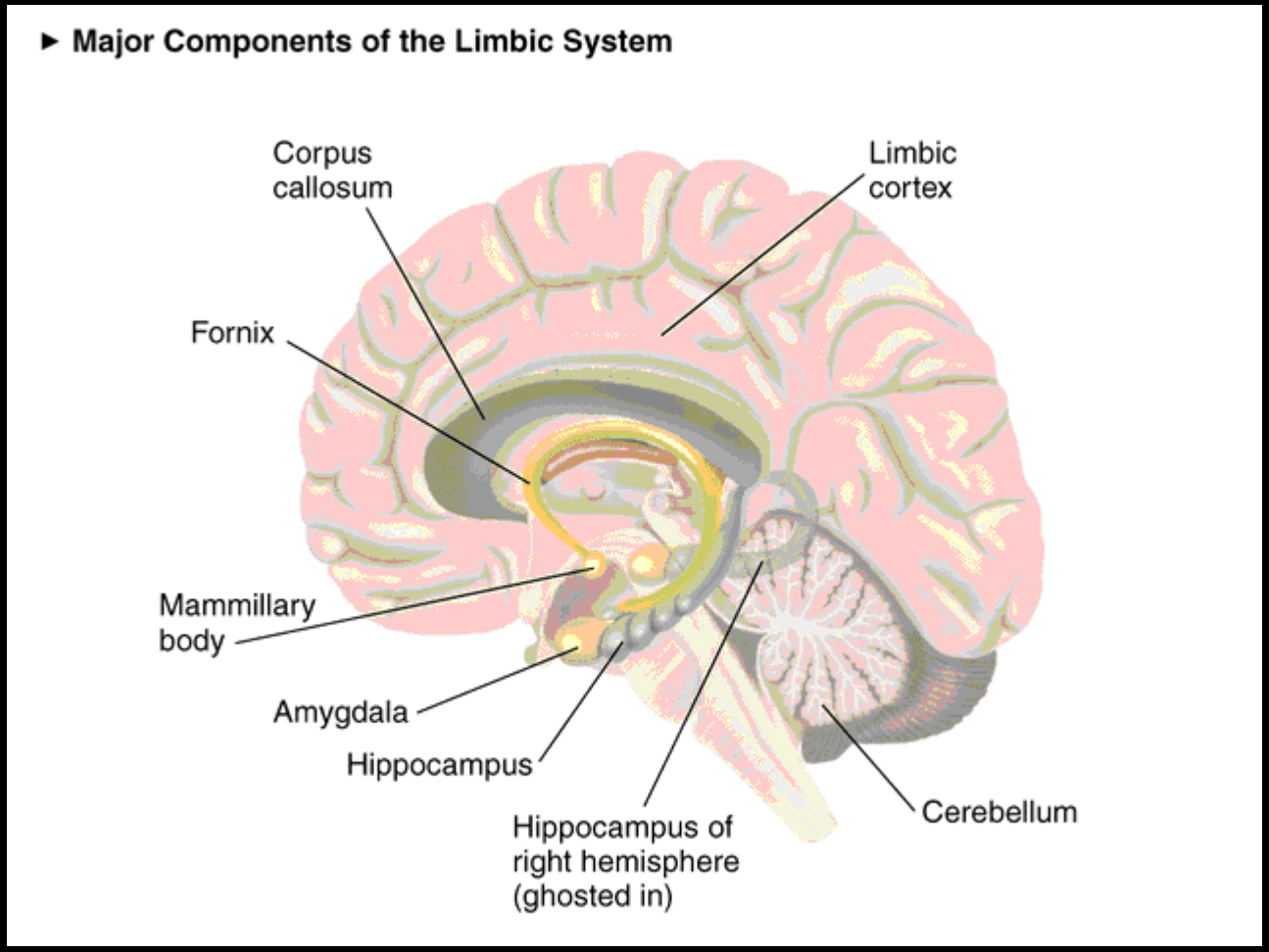
Psychological contributions

- Cognition: maladaptive cognitive strategies "The reaction is the key to whether a person with tinnitus becomes a tinnitus patient" (Sweetow, 1986; 2000)
- Habituation: intolerance results from individual's failure to adapt (Hallam et al, 1984; 2006)
- Attention: failure to shift attention away from tinnitus (Hallam and McKenna, 2006)

Psychological contributions

- Enhanced tinnitus perception is learned response resulting from “negative” emotional reinforcement involving limbic system and autonomic activation (Hallum;Jastreboff and Hazell, 1993; McKenna, 2004)…..de-emphasizes connection with peripheral hearing loss
- Increase in endogenous dynorphins associated with stress causes release of glutamate (Sahley and Nodar, 2001)

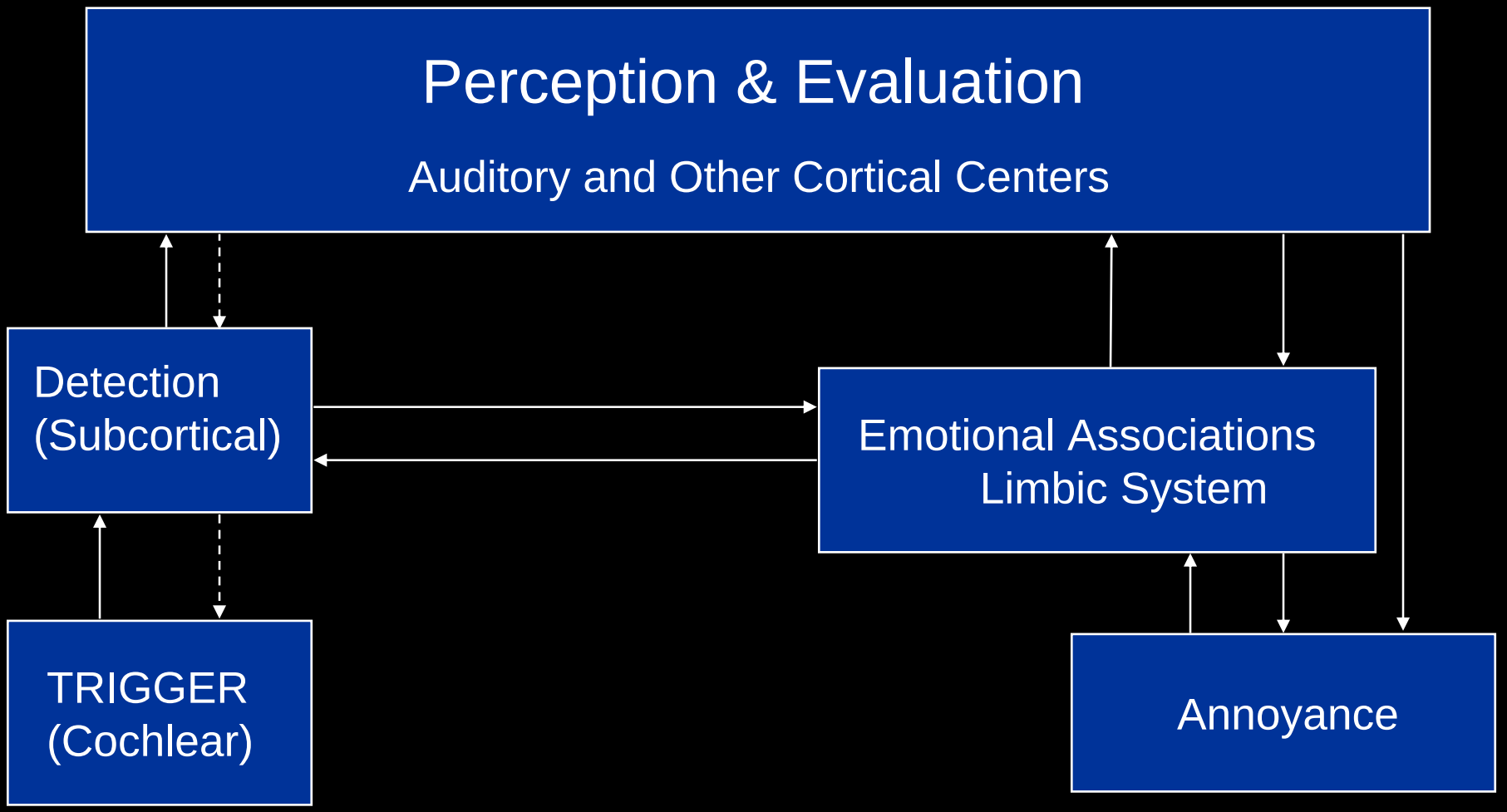
The Limbic System



Why tinnitus is bothersome

- Peripheral attenuation
- Abnormal stimulation pattern
- Cortical analysis
- Limbic system identification and instructions
  - Hippocampus
  - Amygdala
  - Autonomic (sympathetic) nervous system response

"TRT" Model (after Jastreboff and Hazell)



Dashed lines represent neutral interpretation of tinnitus percept.

Newly proposed mechanisms

- Rauschecker et al, 2010 (June 24 issue of *Neuron*)
- Cheung and Larsen, 2010 (June, 2010 issue of Neuroscience)

- Both based on concept of an inhibitory gating system (in the thalamic reticular nucleus or in the basal ganglia caudate nucleus)

Current behavioral concepts

- Fear of threat alters limbic system emotional response, leading to increased attention (hypervigilence)

or does…….

- Abnormal gating drive limbic related behavioral and emotional reactions (addiction?) and form perceptual habits?

- Impact on counseling

Tinnitus patient management procedures

- Counseling
  - Reassurance (including placebo)
  - Education
  - Cognitive-Behavioral Therapy
- Sound enrichment
  - Masking or mixing
  - Amplification
- Combination
  - Desensitization / Habituation (TRT)
  - Neuromonics acoustic desensitization protocol
  - Zen

Current sound treatments

- Maskers
- Hearing aids
- Combination instruments
- Noise generators
- Home based
- CDs (e.g. Personal Growth Tinnitus Relief, Petroff DTM)
- Music
  - iPod
  - Neuromonics
  - Fractal tones

- NOTE: Counseling is required with any of these treatment approaches

Sound enrichment for desensitization / habituation

- low level noise interferes with pattern recognition by increasing neuronal activity
- this makes tinnitus more difficult to detect
- gradually increasing input could decrease gain over an extended time
- Some (Jastreboff) suggests 24 hours a day, 7 days a week
- Others (Neuromonics) claim 2-4 hours adequate

Goals

- Active listening (distraction)
- Masking (covering up)
- Passive listening (habituation, desensitization))

Tinnitus exacerbating factors

- caffeine
- alcohol
- nicotine
- sodium
- high cholesterol, hyperlipidemia, hyper and hypothryroidism
- noise exposure
- **stress**

Non-auditory effects of hearing loss may include…..

- Social isolation
- Paranoia
- Emotional turmoil
- Depression
- Anxiety (increased stress)

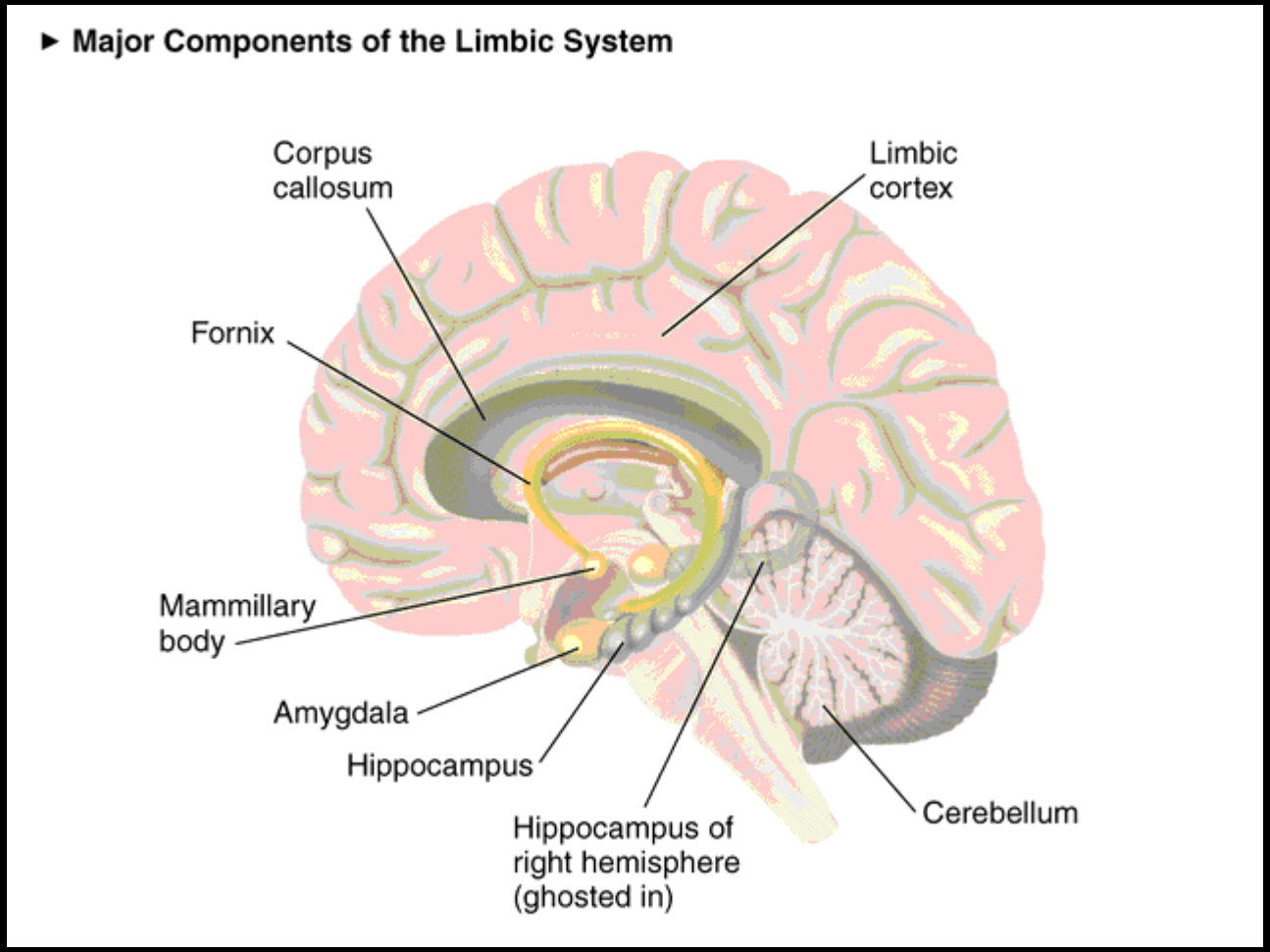
A perfect example of an auditory disorder closely related to stress:

Tinnitus

What is Stress?

- Effects due to increased sympathetic nervous system activity
  - Outpouring of adrenaline, cortisol and other stress-related hormones
- Stress is fight-or-flight response
  - Present-day psychological stress has same effects
- Chronic psychological stress can have damaging effects to the body

The Limbic System

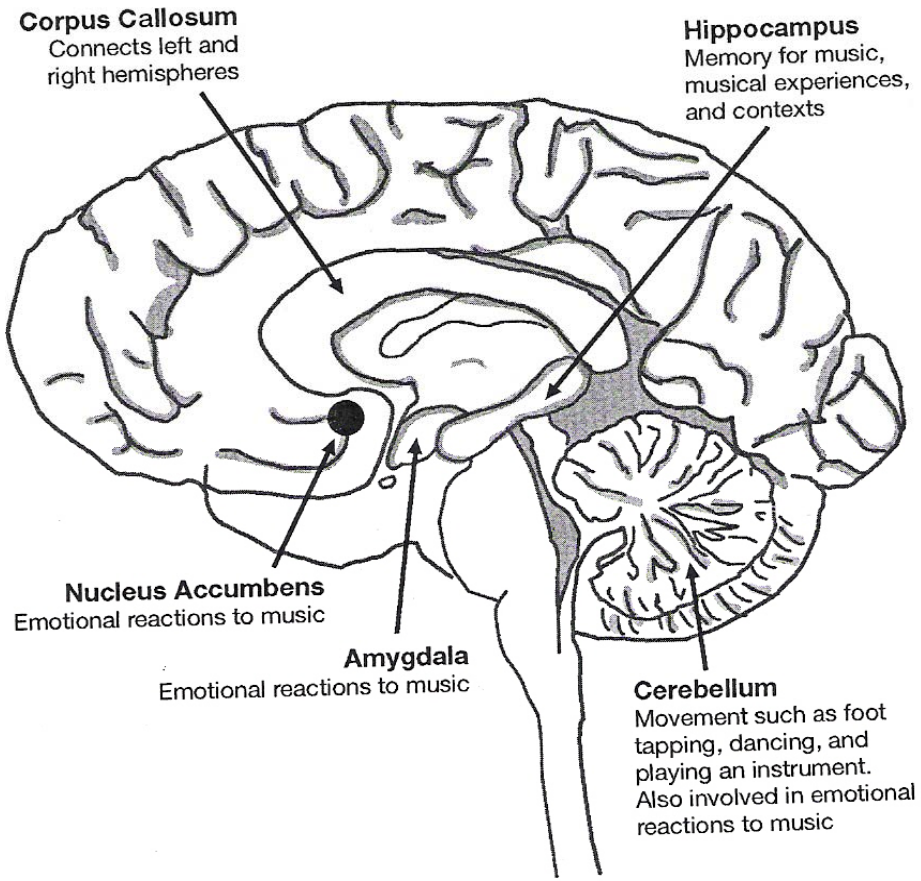


When the deep limbic system is less active there is generally a positive, more hopeful state of mind. When it is heated up, or overactive, negativity occurs

How is music used?

- Home
- Work
- Celebrations
- Advertising
- Romance
- Movies
- Athletic locker rooms
- Shopping malls
- Hospitals
- Therapies
- Relaxation

Where is music processed?



- Parallel (versus sequential) processing
- Bottom up (feature extraction) and Top down (feature integration) processing

- Cascade of activation…..
  - initial processing in the cochlea and auditory cortex;
  - processing of musical structure and expectations in the frontal lobe and hippocampus;
  - analysis of rhythm and meter in the cerebellum and basal ganglia and emotions through connections to the amygdala and frontal lobe
  - arousal in the limbic system
    - nucleus accumbens produces and transmits opioids and dopamine inducing pleasure

“Rules” of music and emotions

- Sadness – quiet, slow, and large deviations from metrical timing

- Slow onset, long, quiet sounds – calming
- Abrupt, short, loud sounds – alerting

- Music with a rhythm slower than your natural heart rate (72 – 80 beats per minute) is useful to many people

- Repetition is emotionally satisfying

Categorical Expectations

- We don’t like the unexpected
- But certain rules have to be followed
- Active listening arouses, passive listening soothes
- Active listening distracts, passive listening may allow for increased cognitive function
- For tinnitus patients, active listening draws attention to the tinnitus, passive listening may facilitate habituation

Neuromonics

- a bit of cognitive therapy
- A bit of TRT
- Music therapy (for affect and relaxation) and wide band stimulation using a iPod-like processor with Bang and Olufsen earphones
- Hearing instrument algorithm (equal sensation level) for hearing loss compensation
- Rhythm
- 2 stage program
- Expensive

Why can’t we just use an iPod?

- Frequency shaping
- Loudness balance
- Compression

Selecting the right sound for stress reduction

Sounds affect people in different ways, due to inherent and learned preferences

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)

Cultural differences

Why hearing aids help tinnitus patients

- Mask tinnitus
- Reduce contrast
- Alter production peripherally and/or centrally
- Greater neural activity allows brain to correct for abnormal reduced inhibition
- Structured pattern is created
- Fatigue and stress is reduced allowing more resources to be allocated to tinnitus fight
- Facilitate habituation

Disclaimer

Zen

- A listening program (or option) in all the Passion, Min, and Clear hearing aids that plays continuous, chime-like tone complexes using fractal algorithms.
- The chimes are generated based on an understanding of the properties of music that would be most relaxing (Robb et al., 1995):
    - Ability to self select music.
    - Tempo at or near resting heart rate (60-72 bpm).
    - Fluidic melodic movement.
    - Variety of pitches
    - Element of uncertainty (Beauvous 2007).
    - No rapid amplitude changes
    - Passive listening.

Selecting the right sounds for stress reduction

Sounds (including music) affects people in different ways, due to inherent, learned (and cultural) preferences

Thus it is appropriate to use relaxing background sounds (that activate the parasympathetic division of the autonomic nervous system) and minimize exposure to alerting, negative, or annoying sounds (that activate the sympathetic division)

Need to avoid earworms?

- 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

Zen

- An optional listening program in certain (Passion, Mind, and Clear) Widex hearing aids that plays adjustable, continuous, chime-like tone complexes using fractal algorithms.
- The chimes are generated based on an understanding of the properties of music that would be most relaxing (Robb et al., 1995):
    - Ability to self select music.
    - Tempo near or below resting heart rate (60-72 bpm).
    - Fluid melodic movement.
    - Variety of pitches
    - No rapid amplitude changes
    - Element of uncertainty (Beauvous 2007)
    - Passive listening

	Default Pitch				Tonality		Dynamic Range		Default Tempo		
Fractal Styles	Low	Medium Low	Medium High	High & Reverberant	Major	Minor	Restricted	Broad	Slow	Medium	Fast
Aqua	■				■		■		■		
Coral			■			■		■	■		
Lavender			■		■			■			■
Green				■	■		■			■	

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.

- Each Zen program can be individually adjusted to loudness, pitch and tempo preferences
- The fractal tones (or the noise) should be audible , but relatively soft
- It should never interfere with conversational speech
- The annoyance level of the tinnitus should just begin to decrease (i.e., tinnitus can still be audible)

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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.

Study Questions

- Does a fractal tone background reduce tinnitus annoyance and stress?
- Do hearing aid wearers (overall) find fractal tones relaxing and/or stress relieving?

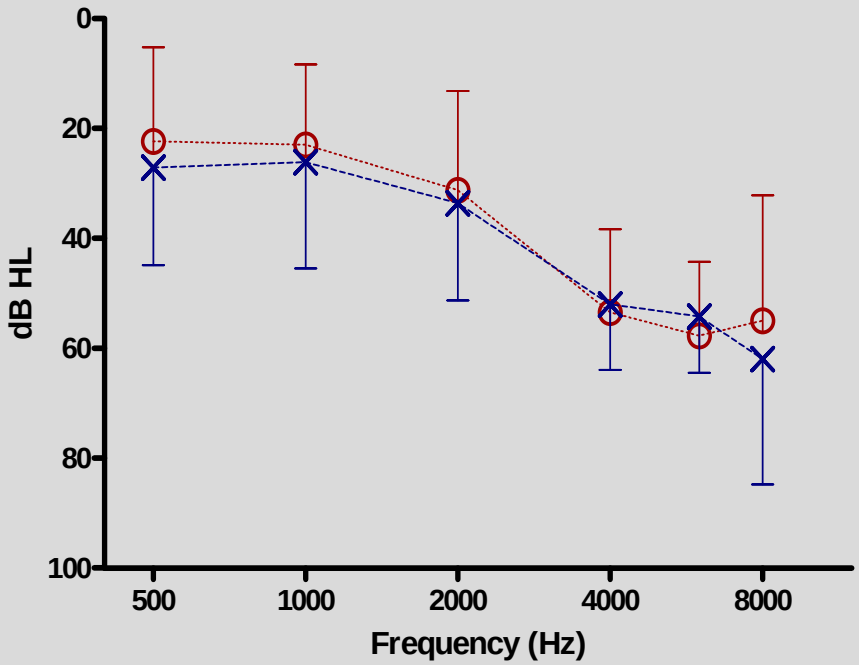
(Sweetow & Henderson-Sabes, The Use of Acoustic Stimuli in Tinnitus Management. JAAA 7, 2010

•14 subjects with severe, uncompensated tinnitus, 6 non-tinnitus subjects. 2 subjects dropped out.

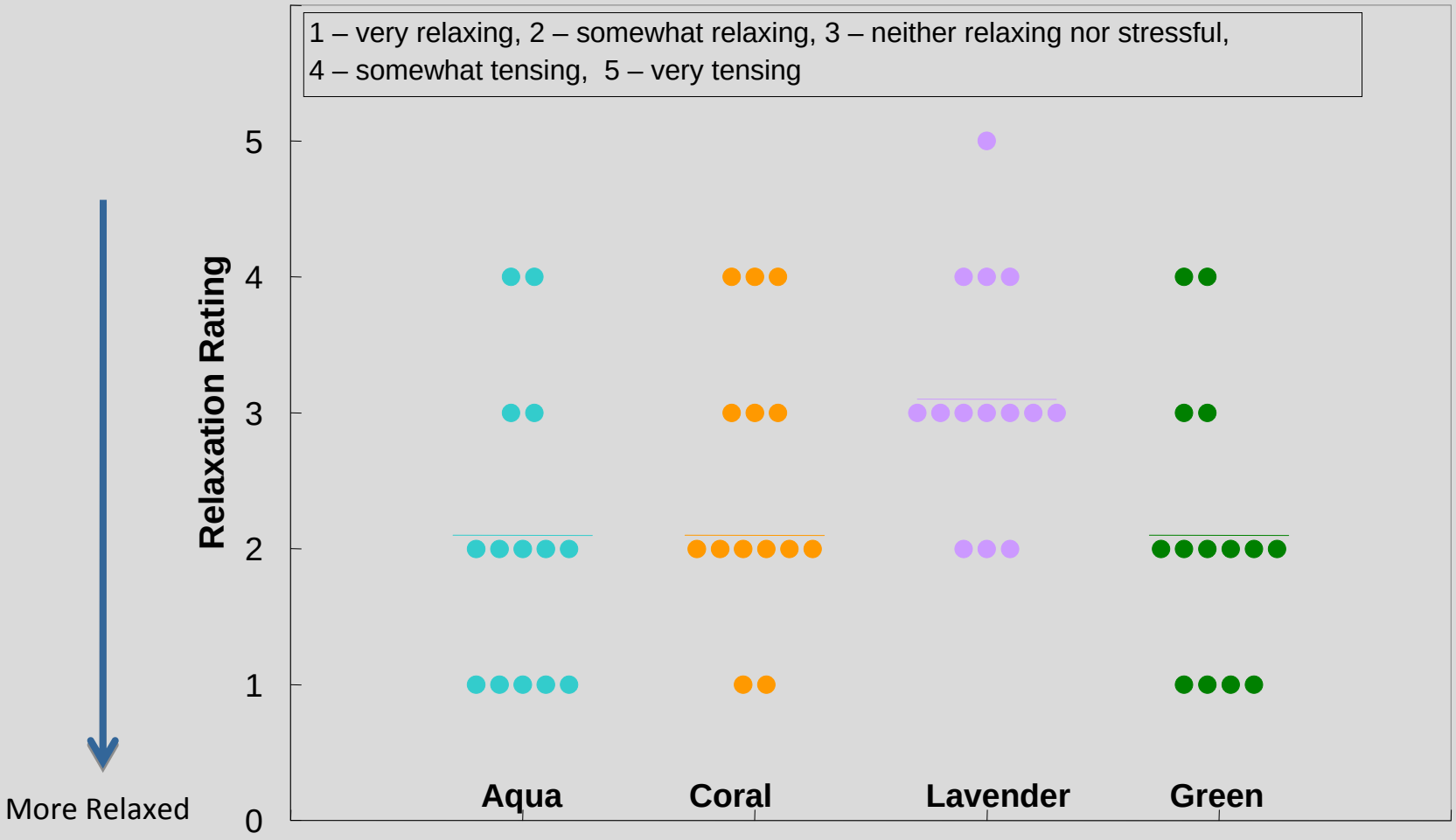
• All tinnitus subjects had been seen at UCSF for tinnitus treatment at least 3 mos. prior to the study – completed tinnitus counseling and other therapies but were still significantly bothered (average THI entering study = 58.7).

• All subjects had tinnitus for at least one year and had received no active treatments (including counseling) for at least three months prior to the start of the experiment.

• Battery of questionnaires = THI, TRQ, stress, annoyance, and relaxation measures.



Relaxation ratings



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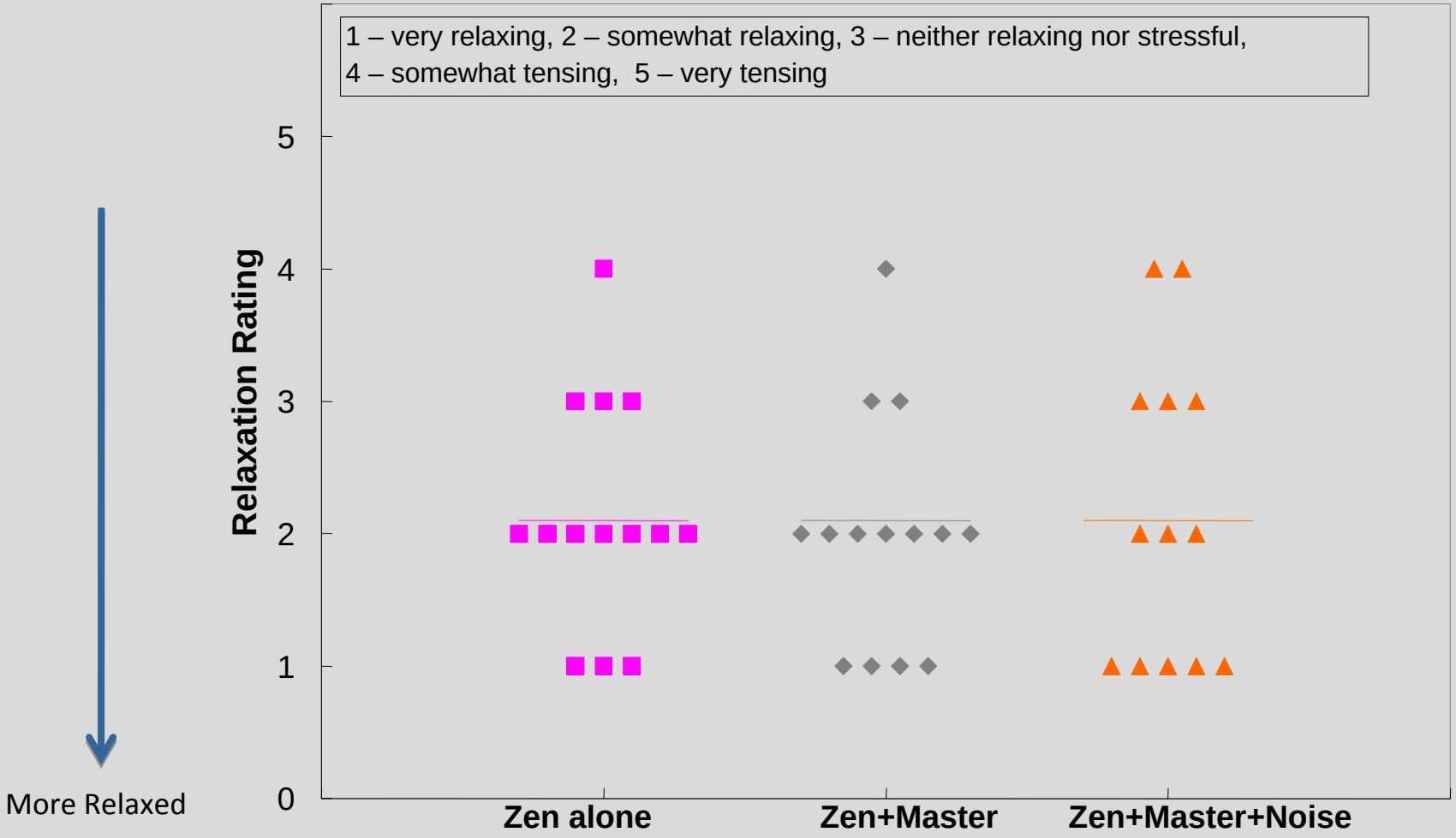
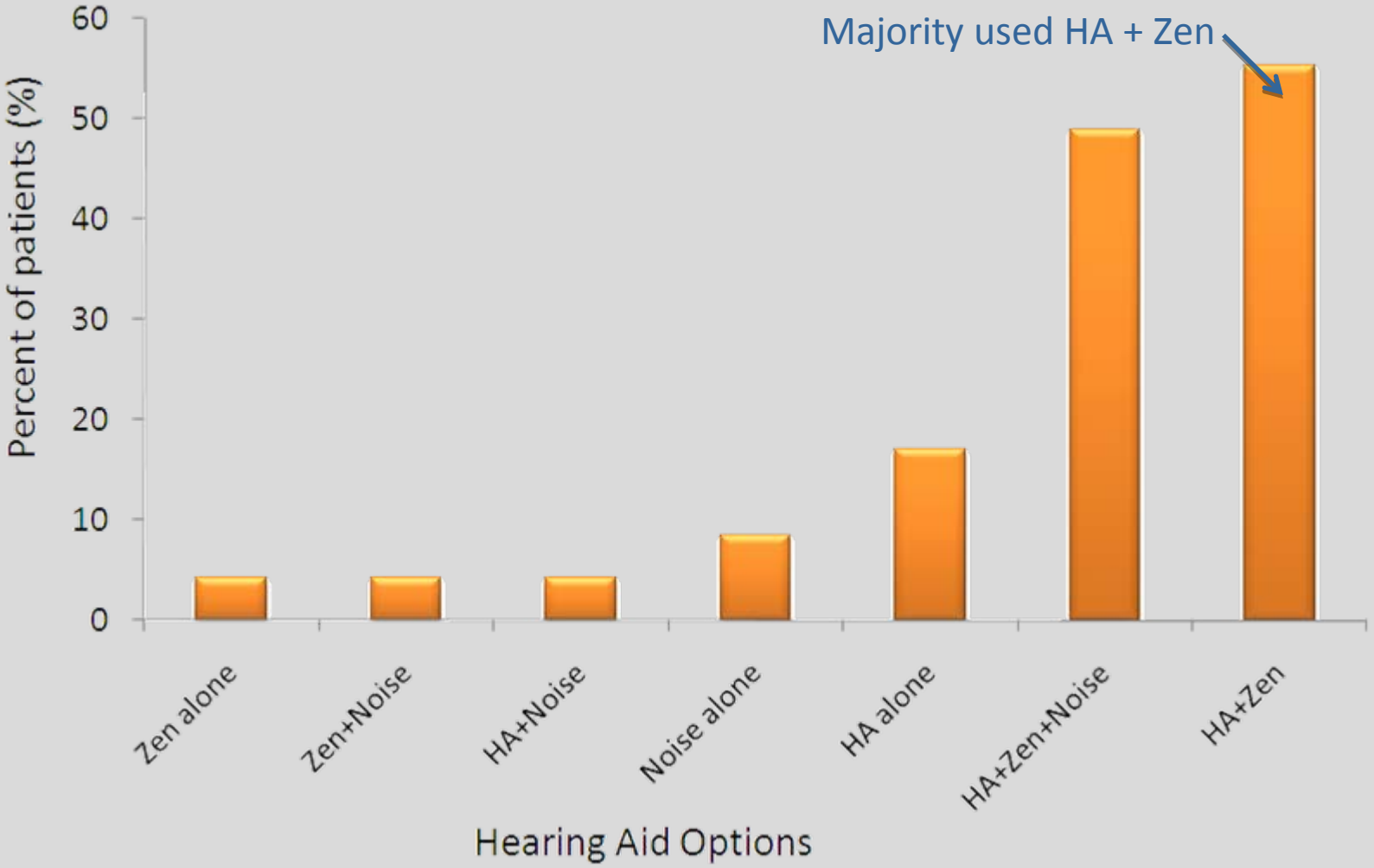
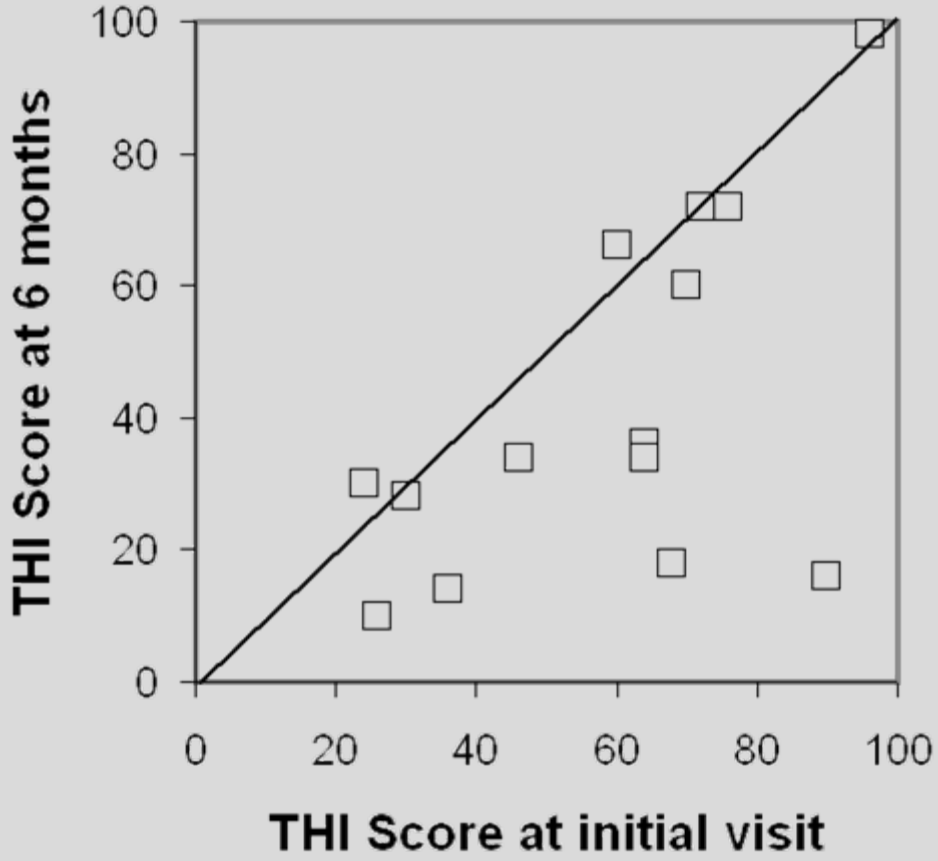


Tinnitus annoyance

Zen options used for tinnitus



Tinnitus Handicap Inventory



Summary of findings

- Zen was effective as a tool in promoting relaxation and reducing annoyance from tinnitus
- Both Zen and noise can reduce tinnitus annoyance, but Zen was preferred by subjects for longer term use

Establish realistic, time-based expectations

- Effect may NOT be immediate

- Criteria for success:
  - Quality of life; not loudness, is the issue
  - Tinnitus awareness
  - Disturbance
  - Sleep
  - Reduction of negative thinking about tinnitus

Conclusions

- Tinnitus patients with hearing loss may best be served by amplification that incorporates the broadest high frequency response and flexible options to sound stimuli
- Sound therapy without counseling is not likely to work

Tinnitus research issues

- selection and number of subjects
- group mean data
- research design
- measurement scales
- interpreting the findings
- follow-up data

Thanks for listening

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