Tinnitus Retraining Therapy for noise trauma induced tinnitus

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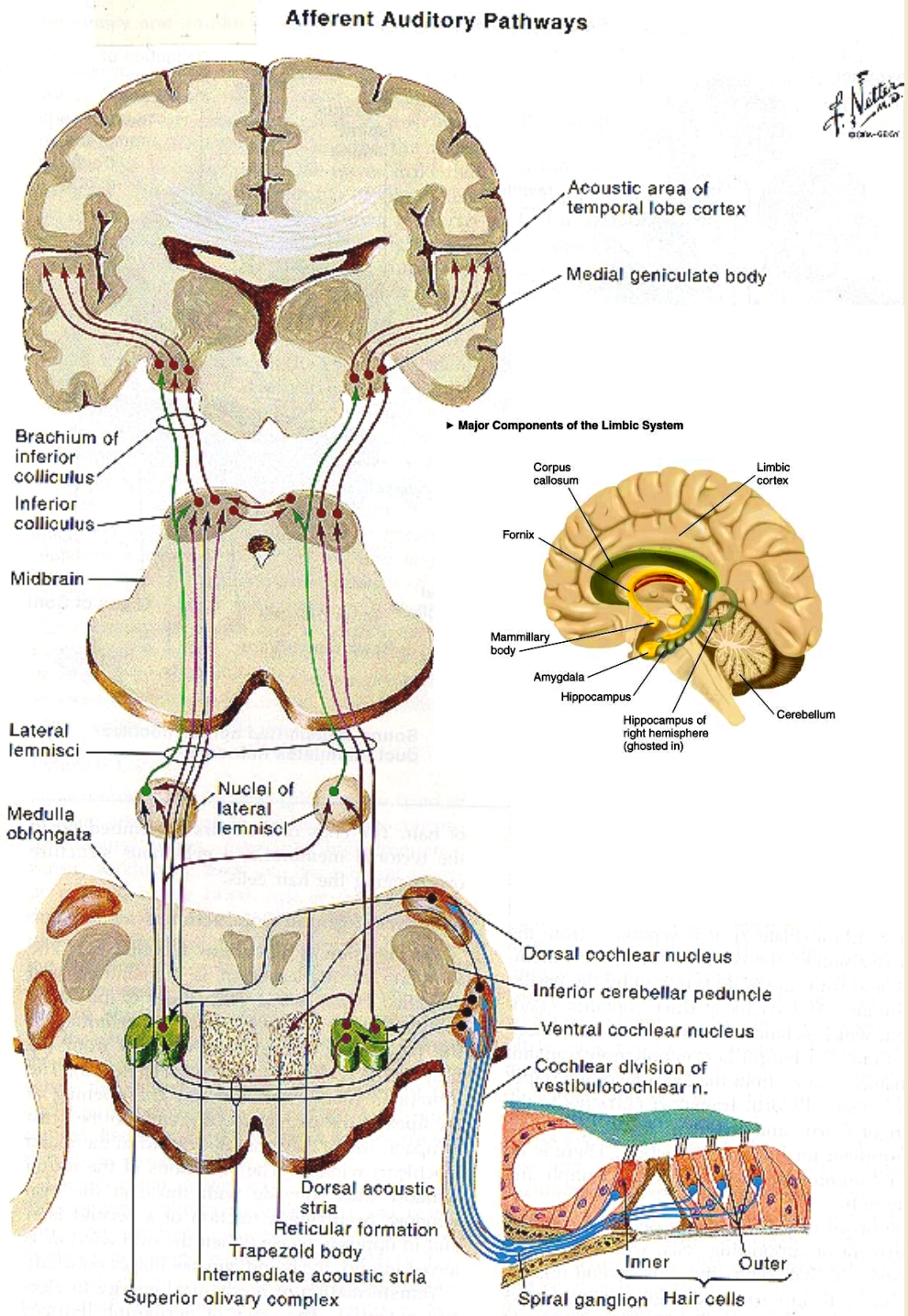
Puzzling aspect of tinnitus

- Severity of tinnitus and treatment outcome do not depend on psychoacoustical characterization of tinnitus

Conclusion

- Auditory system plays a secondary role in clinically-relevant tinnitus;
  other systems in the brain are dominant, which is the fundamental principle of

The Neurophysiological Model of Tinnitus



Auditory & Other Cortical Areas
Perception & Evaluation (Consciousness, Memory, Attention)

Auditory Subconscious
Detection / Processing

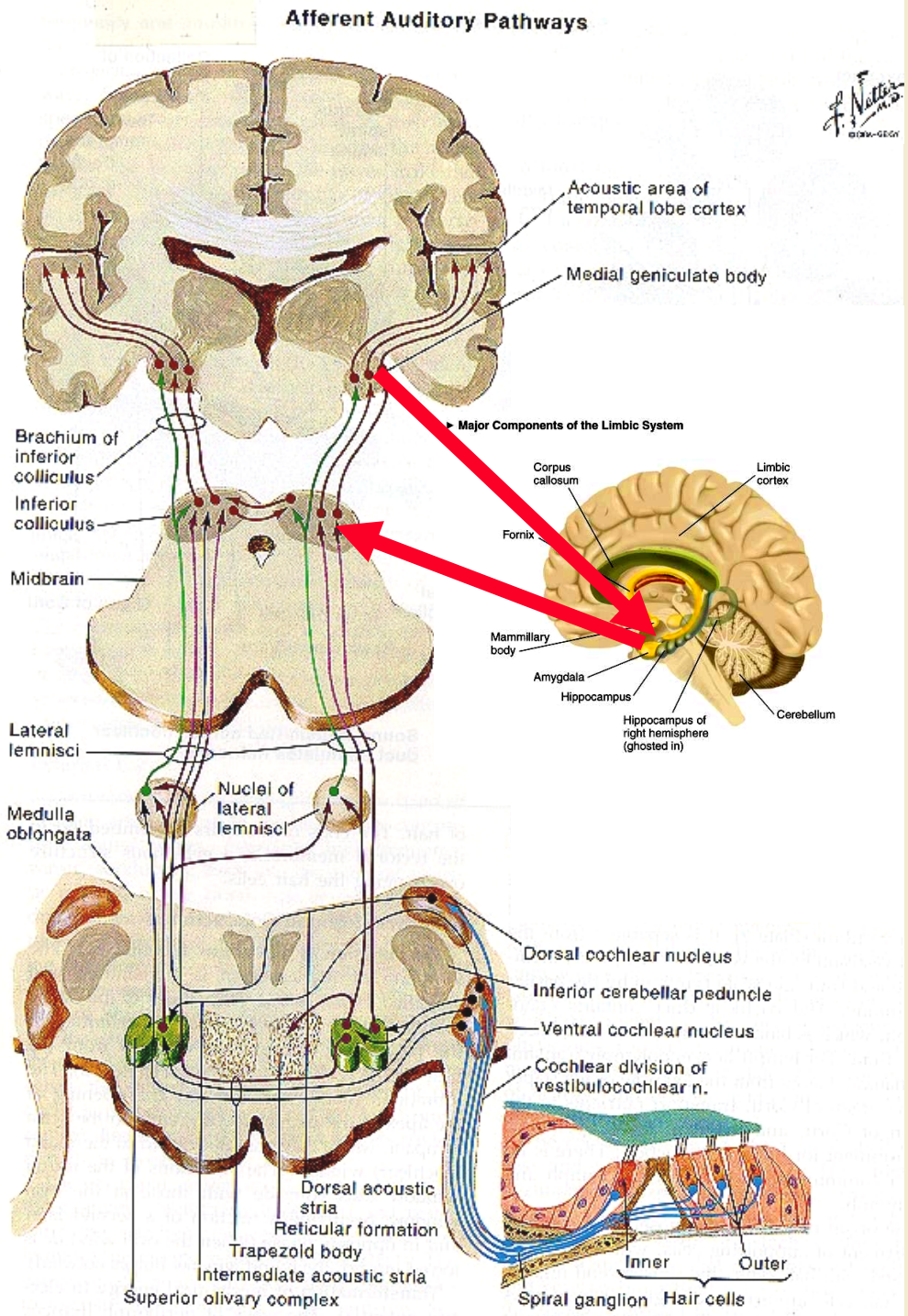
Limbic System
Emotions

Auditory Periphery
Source

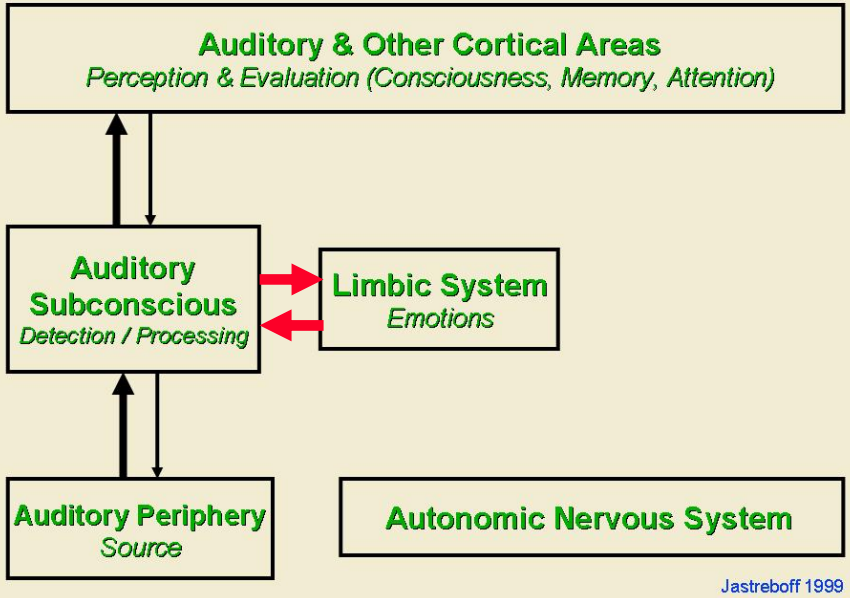
Autonomic Nervous System

Jastreboff 1999

36

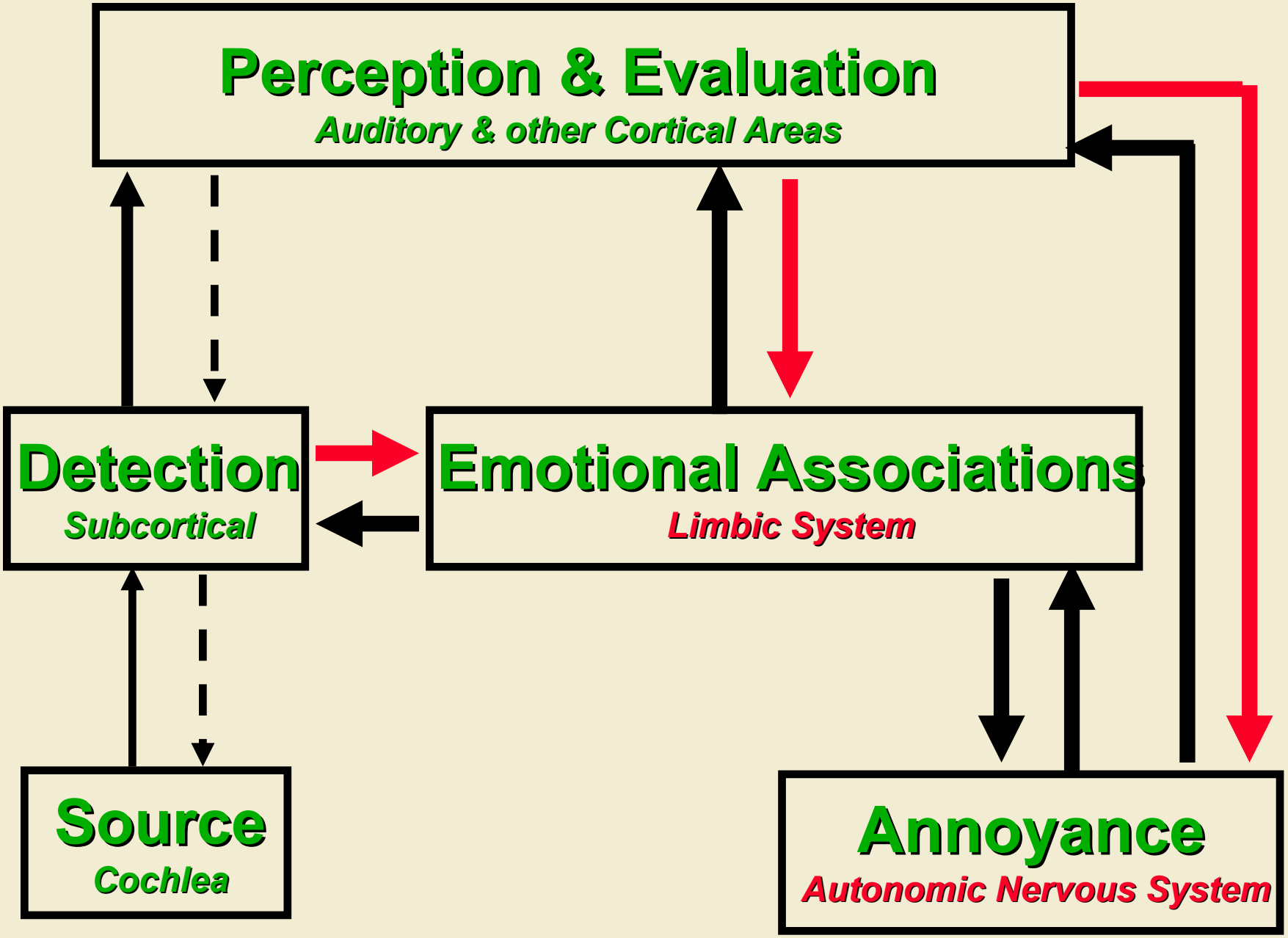


Tinnitus patient suffering because of tinnitus



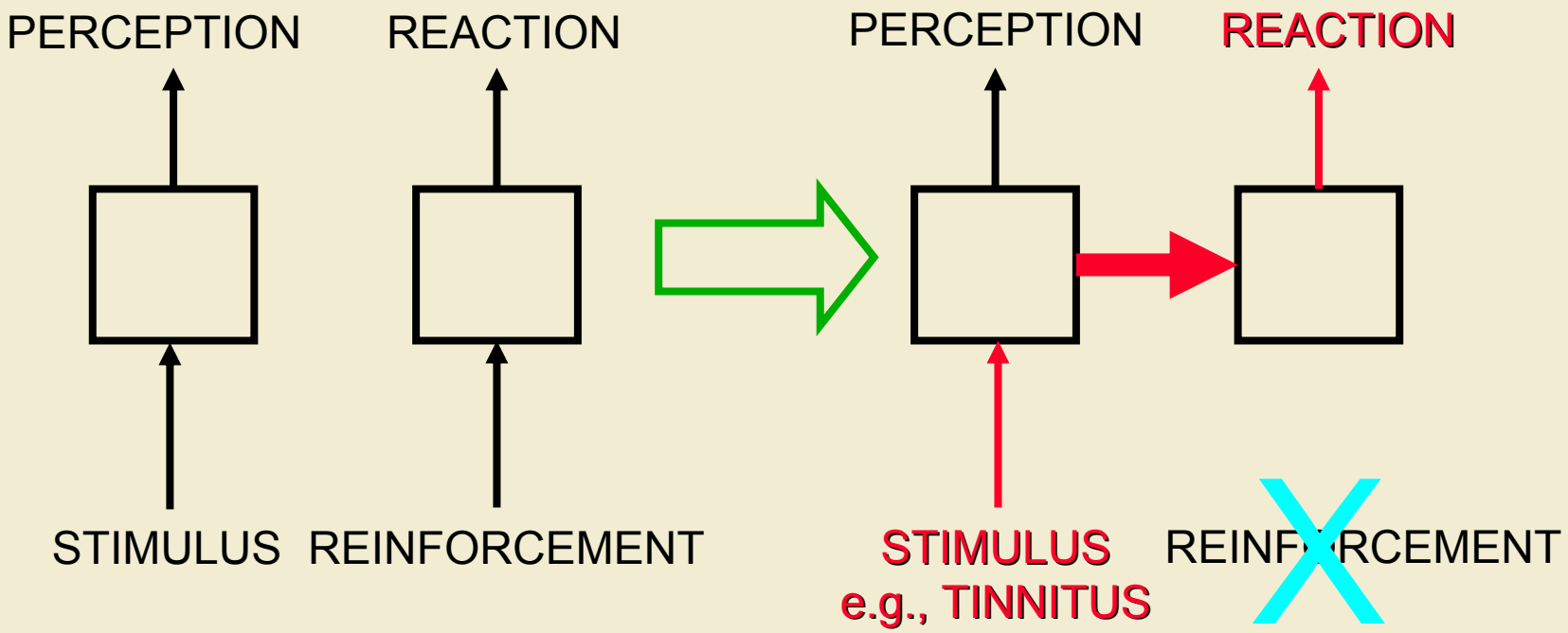
36

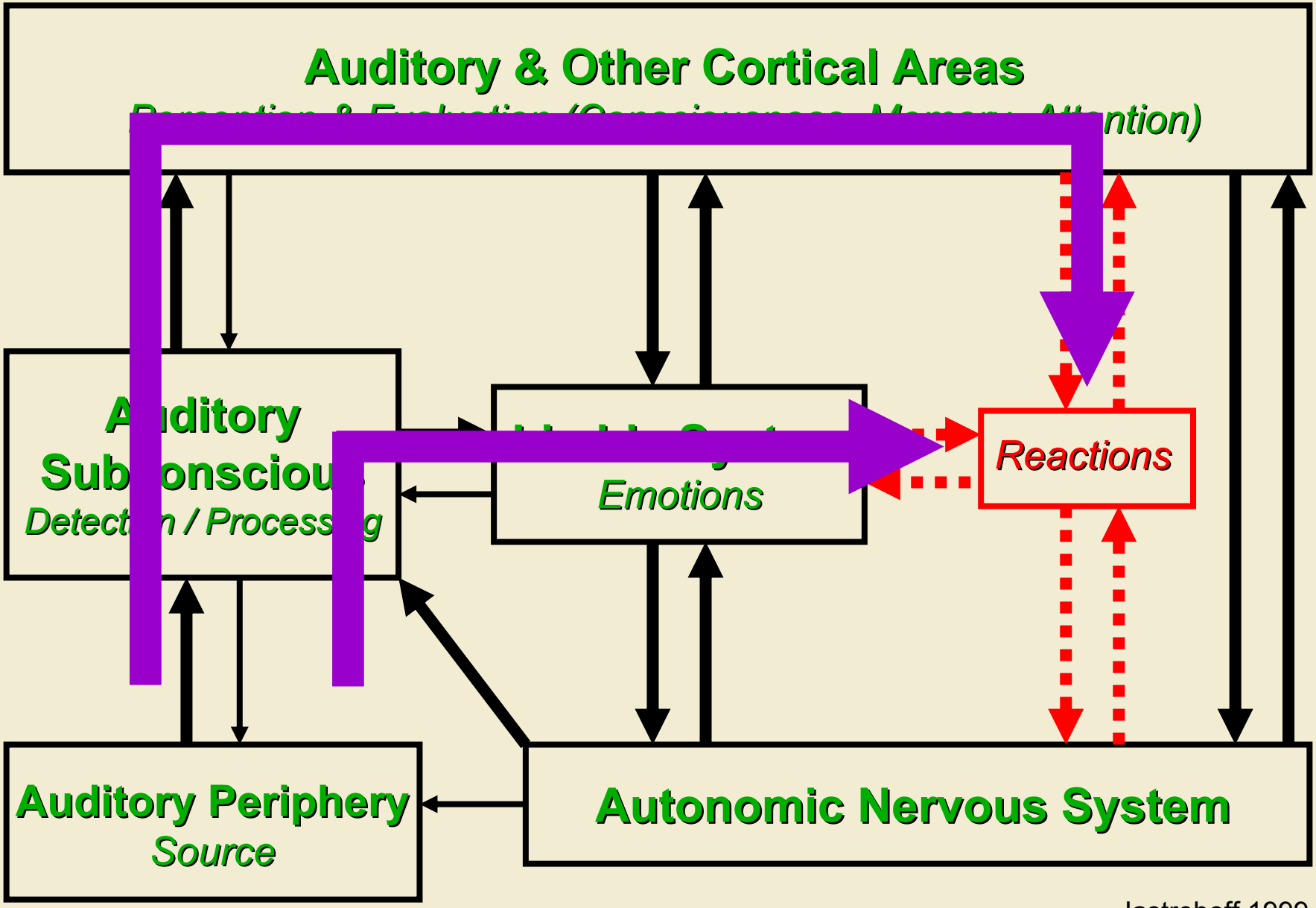
Tinnitus becomes a problem when the neuronal activity related to its perception (tinnitus signal) spreads from the auditory system and evokes activation of limbic (emotional) and autonomic nervous system. Amygdala, and its connections with medial geniculate body may play dominant role.


Perception & Evaluation
Auditory & other Cortical Areas
Detection
Subcortical
Emotional Associations
Limbic System
Source
Cochlea
Annoyance
Autonomic Nervous System

Connections between auditory, limbic and autonomic nervous systems are governed by the principles of conditioned reflexes

- Conditioned reflexes, linking sensory information with reactions, occur on the basis of temporal association. In the simultaneous presence of a sensory stimulus and reinforcement, there is
  no need for causal association
- Every reflex undergoes extinction when reinforcement is removed, and sensory stimulus is repeated; this process is called “passive extinction of conditioned reflexes” or “habituation of reaction” (Pavlov / Konorski)
- Habituation is used in Tinnitus Retraining Therapy and emerges in some other methods as well


PERCEPTION
REACTION
STIMULUS
REINFORCEMENT
PERCEPTION
REACTION
STIMULUS
e.g., TINNITUS
REINFORCEMENT



Jastreboff 1999

Why blast-induced tinnitus is easy to evoke and it is typically bothersome?

- Blast is an impulse noise, which has higher possibility to create damage to cochlea than continuous sound of similar level since:
  - The sound has fast rise-time preventing the acoustic reflex, which has average latency of about 100 ms, from offering a protection.
  - The spectrum of a sound has large component of high frequencies, frequently with pronounced peaks. Consequently, such a sound is causing localized damage of the basilar membrane promoting pure tone, or narrow band noise tinnitus perception. High pitch, narrow band tinnitus is typically reported by patients as particularly bothersome increasing the probability that blast-induced tinnitus becomes bothersome.

Why blast-induced tinnitus is easy to evoke and it is typically bothersome?

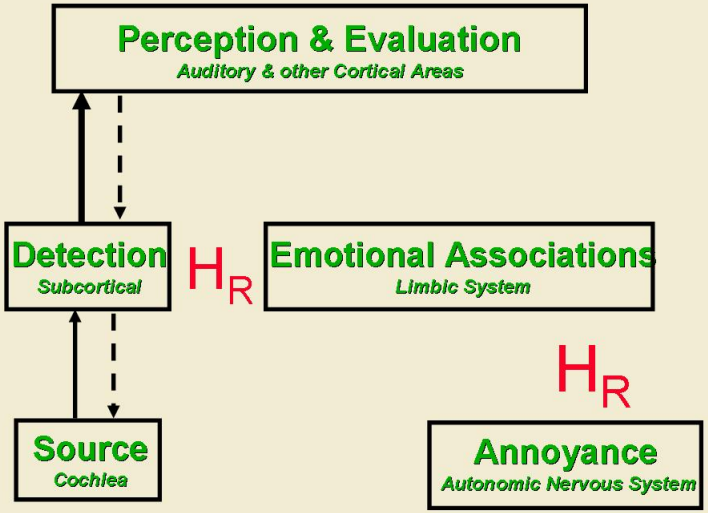
- Blast evokes startle reaction, increases arousal and evokes strong negative emotional status. This in turn creates optimal situation for development of conditioned reflexes linking tinnitus perception with negative reinforcement.
- Increased stress, arousal, panic, anxiety related to Post-Traumatic Stress Disorder (PTSD) further enhance conditioned reflexes connections and consequently facilitate the emergence of bothersome tinnitus and increase its severity.

How to treat tinnitus?

- Observations
  - There is no reliable method for attenuating the tinnitus source (cure for perception)
  - But the brain exhibits a high level of plasticity and it is possible to habituate to any sensory signal, if it does not have negative associations
- Conclusion
  - Interfere with tinnitus-related neuronal activity above the tinnitus source to habituate tinnitus

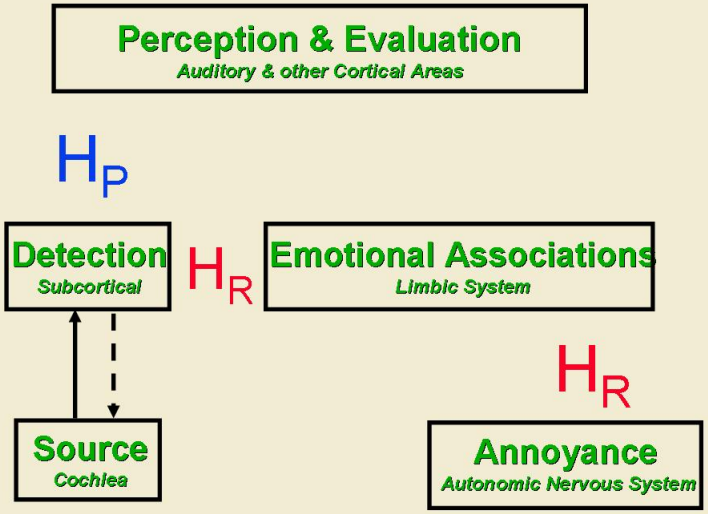
Specific goals of TRT

- Uncouple the tinnitus signal present in the auditory system from activating the limbic and autonomic nervous system **(habituate reactions induced by tinnitus)**



14

- Block tinnitus-related neuronal activity before it reaches the level of consciousness **(habituate tinnitus perception)**



15

Tinnitus retraining Therapy (TRT)

- Consists of counseling and sound therapy
- Counseling:
  to reclassify tinnitus into category of neutral stimuli
- Sound therapy:
  to decrease strength of tinnitus-related neuronal activity
- <u>Both components have to be based on the model for method to be called TRT</u>
- Effective for all types of tinnitus and levels of tinnitus severity as well as for hyperacusis and misophonia

Specific points for counseling patients with blast-induced tinnitus

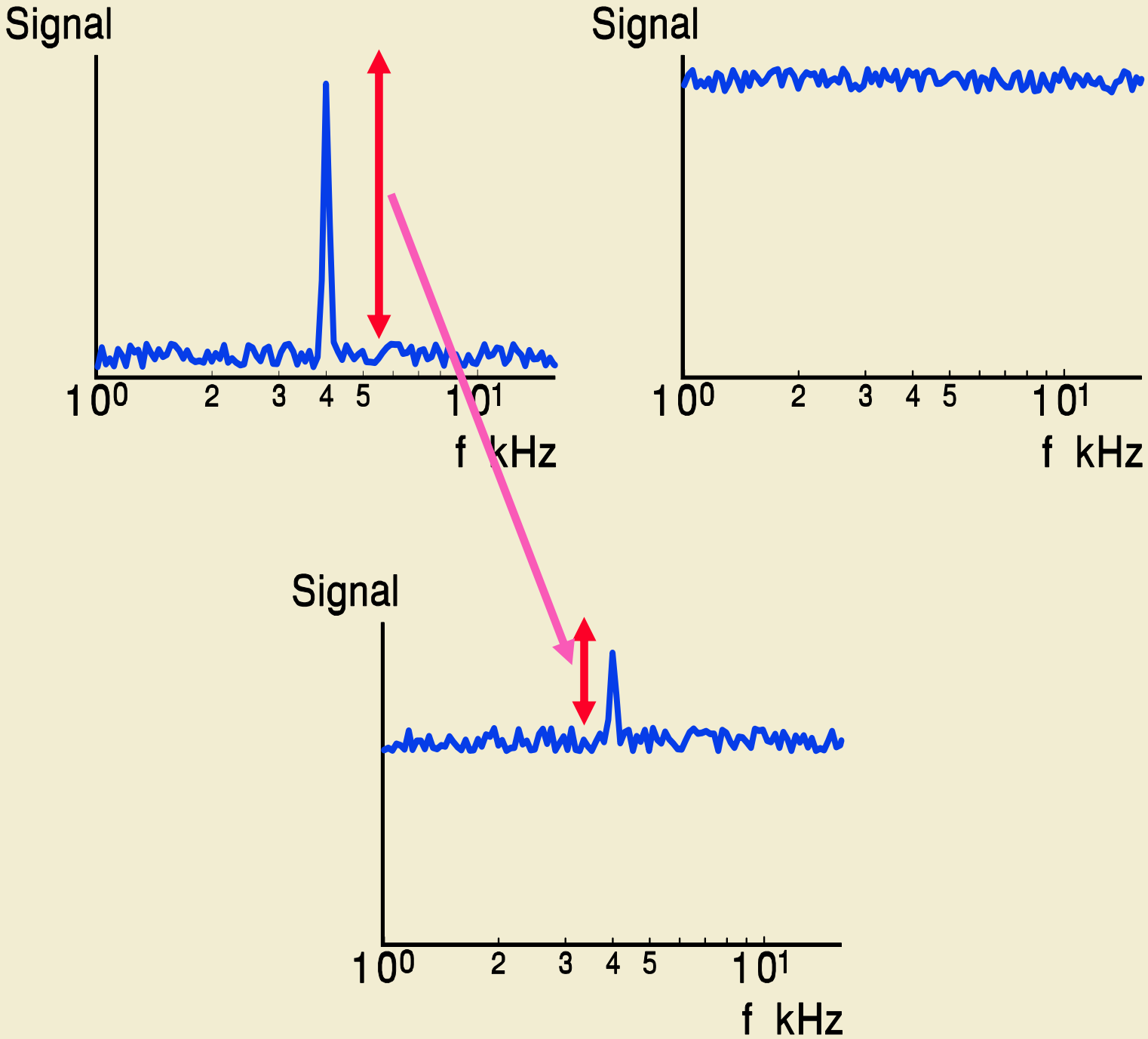
- Explanation about mechanisms of effect of impulse noise on the cochlea and the Outer Hair Cell
- Thoughtful discussion of Discordant Dysfunction Theory
- In depth explanation of the principles and role of the conditioned reflexes
- Detailed explanation of principles of modified passive extinction of the conditioned reflexes
- Discussion of effect of PTSD (if diagnosed) on tinnitus

Principles of sound therapy in TRT

- The strength of any signal in the nervous system is related to its difference from background neuronal activity
- By increasing background neuronal activity, it is possible to decrease effectively the strength of tinnitus-related neuronal activity within the auditory pathways and consequently in all systems involved
- The decrease of signal will result in a lowering of the activation in all of the systems involved, due to the dynamic balance scenario

Sound therapy in TRT

- Current TRT protocol is geared toward using several types of sound
  - Sounds in daily environment
  - Sounds of nature, particularly water (easy to habituate, acceptable even when used for very long time, relaxing)
  - Artificial, generated sounds, typically broadband noise
  - Music, which is used in majority of patients, mainly for misophonia
- Avoid silence
- Sound levels are controlled by requirements of not being annoying and avoiding masking
- Stress is placed on improving hearing abilities with amplifications, when needed


Signal
10^0
2
3
4
5
10^1
f kHz
Signal
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f kHz
Signal
10^0
2
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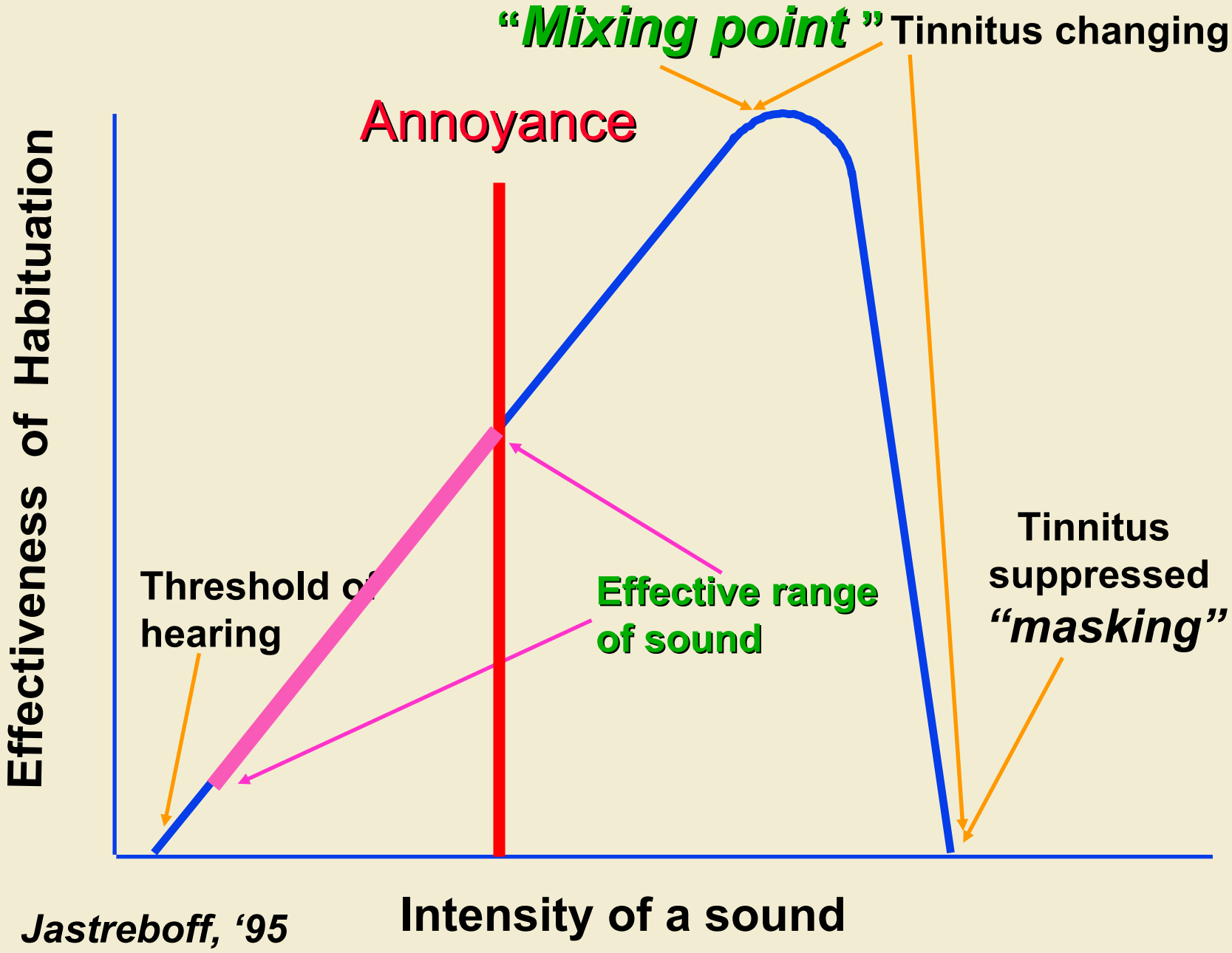
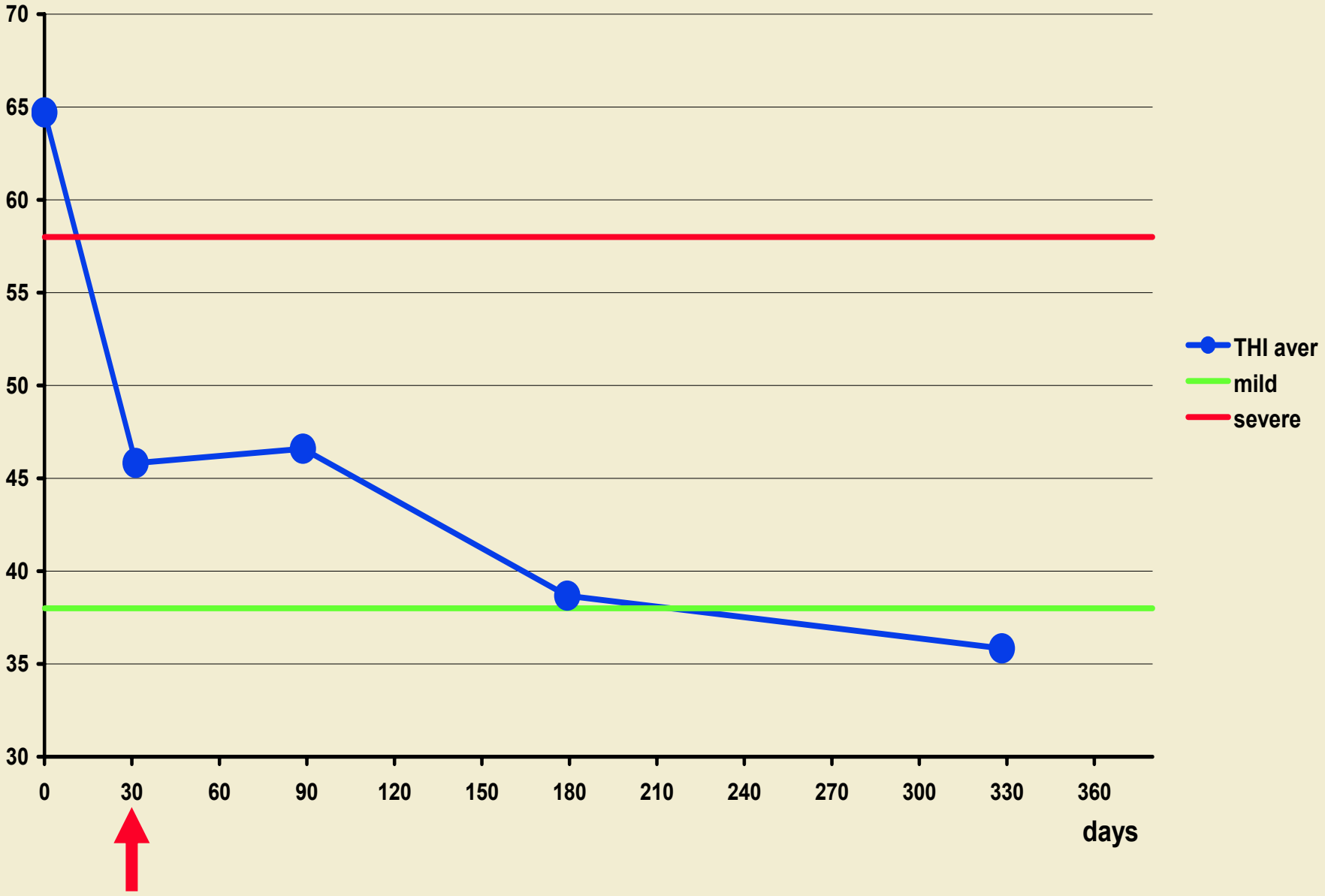

"Mixing point"
Tinnitus changing
Annoyance
Effectiveness of Habituation
Threshold of hearing
Effective range of sound
Tinnitus suppressed "masking"
Intensity of a sound
Jastreboff, '95

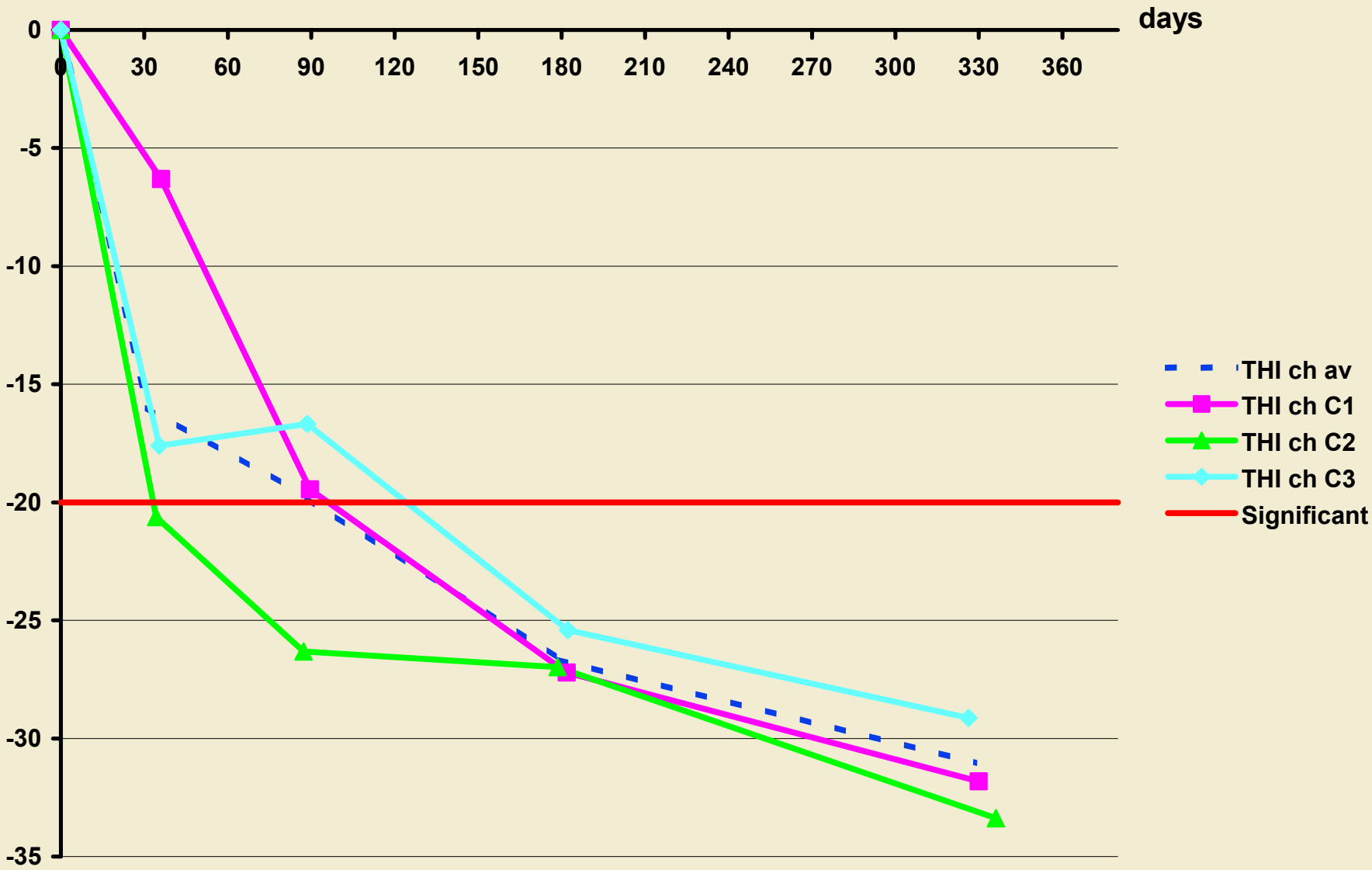
Modification of sound therapy for patients with blast-induced tinnitus

- Detailed explanation of the necessity to avoid ear overprotection
- Explanation of the auditory toughening
- Higher need for sound generators or combination instruments
- Higher need for fitting with utilization of Real Ear Measurements

THI, Emory University, 303 patients



THI changes, individual categories



Case

- Special forces, NATO
- Exposed to explosion in a Middle East country
- Normal hearing, except 30 dB HL in RE at 2 kHz
- Highly bothersome tinnitus with initial THI = 44
- Tinnitus matched at 16 kHz, 4 dB SL
- Treated unsuccessfully in his country for over a year including 23 session of hyperbaric oxygen therapy, medications, so called “TRT”
- 40 audiograms, ABR, CT
- Diagnosed with PTSD
- On antidepressants (no depression before tinnitus)
- Decreased Sound Tolerance (misophonia)
- Moderate English, patient came with his own ENT who acted as translator
- TRT initiated with modification for blast induced tinnitus; sound generators fitted with use of Real Ear Measurement

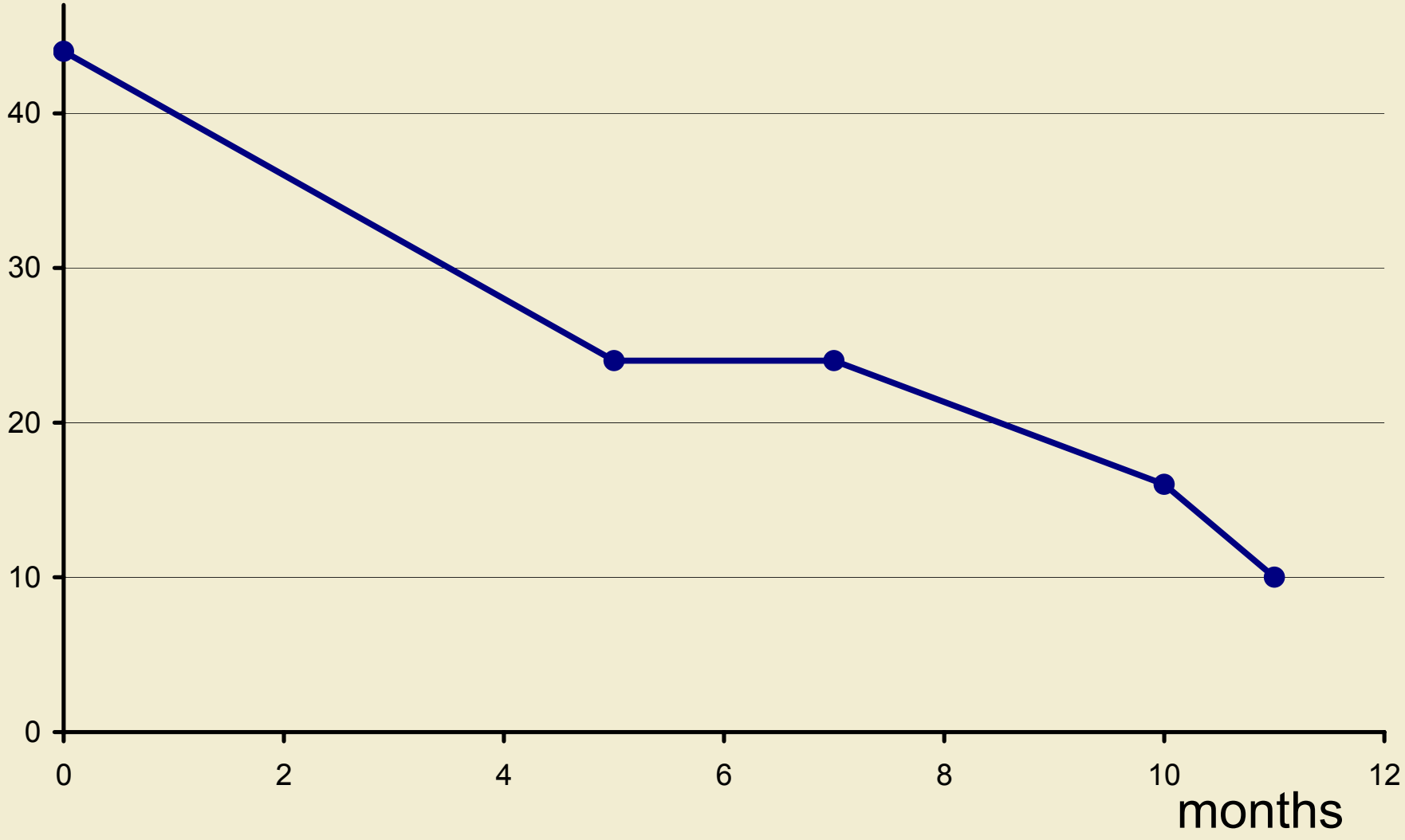
Changes during treatment

- Initial status
  - Aware 30% of time; annoyed 20% of time
  - Severity 7.5
  - Unable to work and significant deterioration of social interaction
- 2 m FU
  - Awareness 10% and only when takes SG off; annoyance 5%
  - Reports significant improvement in interaction with family
- 5 m FU
  - % of time of awareness and annoyance the same
  - Severity 3
  - No problem with Decreased Sound Tolerance

Changes during treatment

- 7 m FU
  - Reports that while using SG he is not bothered by tinnitus at all
  - Severity 2
  - Perceives significant emotional improvement
  - No depression but still PTSD
- 10 m FU
  - He is working in an office
  - Still depends on using sound generators, but while using them tinnitus is not a problem
- 11 m FU
  - 5% of time of being aware and annoyed by tinnitus
  - Severity 2
  - He plans to return to full duty

THI



Interesting points of the case

- Typical case of blast induced tinnitus with minimal hearing loss and highly bothersome tinnitus
- Problem with English
- Problem with office visits – some follow-up visits performed on Skype
- Fully restored working ability in the military environment

Conclusions

- Blast induced tinnitus can be successfully treated with TRT within time scale as for other patients
- Modification of counseling and the use of instrumentation are needed
  - Additional stress on the role of conditioned reflexes
  - Detailed explanation of discordant dysfunction theory
  - Investigation for presence of decreased sound tolerance, particularly misophonia
  - Fitting with utilization of Real Ear Measurements
  - Frequent follow-ups