



Washington University in St. Louis

Tinnitus

Tinnitus is an abnormal reaction to a perceived sound. While tinnitus may not have a definitive cure, with the right management techniques, support, and a positive mindset, individuals can lead fulfilling lives and minimize the impact of tinnitus on their overall well-being.



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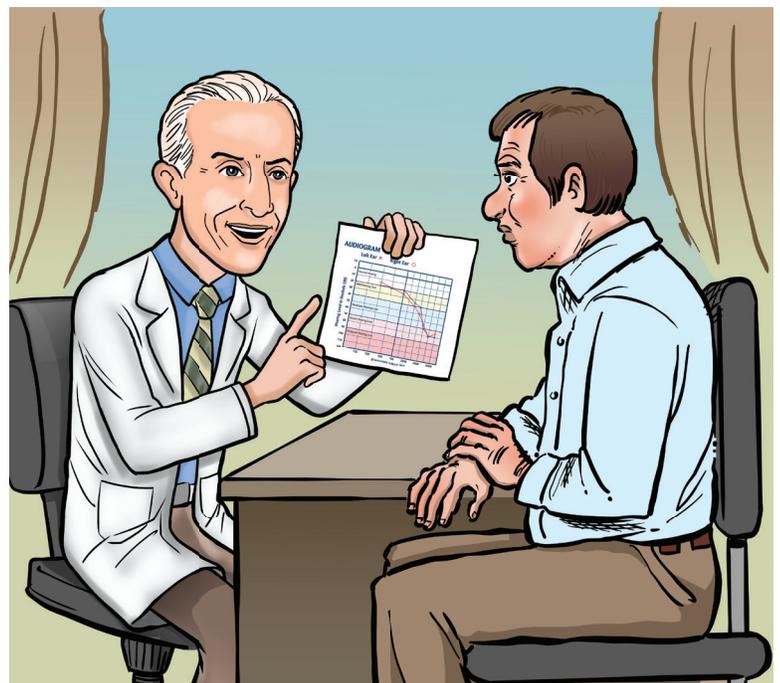
DEFINITION

Tinnitus is a condition characterized by the perception of sounds, such as clicking, buzzing, or humming, in the absence of external sound stimuli. Tinnitus affects a significant number of people, with estimates suggesting that around 80 million Americans experience some form of tinnitus. For most individuals, tinnitus is a symptom rather than a dangerous disease, but it can be burdensome and bothersome for some. National health surveys estimate that perhaps as many as 80 million Americans experience some form of tinnitus. Among US military veterans, tinnitus is the most common service-connected disability, accounting for disability payments to nearly one in nine new veterans. Of 100 people with tinnitus, approximately 80 are not bothered by it and do not pay much attention to it. For the remaining 20, tinnitus is burdensome and bothersome. For these tinnitus patients, the perceived sound becomes a focus of attention and may interfere with sleep, concentration, and the cognition (thinking) required for day-to-day functioning. For 1 out of 100 patients, these sound perceptions are extreme and debilitating; the patient's psychological reaction becomes an enormous source of distress and disability.

DIAGNOSIS

The first step in the diagnostic process for the person with tinnitus that persists for more than 3 months is a thorough medical evaluation. The objective of this medical examination is to determine if there are any underlying conditions that may have caused the tinnitus, such as loud noise exposure or ear trauma. The health care professional will take a detailed medical history and perform a physical examination, including a complete head and neck examination and a neurological examination.

The next step is to conduct a hearing test to assess the patient's hearing abilities. This may include an audiogram, which measures the patient's ability to hear different sounds and pitches, and other tests to evaluate the function of the ear and the auditory nerve.



Patients with pulsatile tinnitus (which may be a symptom of increased blood pressure in the brain or vascular lesions), dizziness, abnormalities on physical examination (for example, a draining ear),

or abnormal hearing tests may be referred to an otolaryngologist (also known as an ear, nose, and throat [ENT] physician) for further evaluation.

Additional diagnostic testing may be recommended (for example, magnetic resonance imaging) to rule out structural or vascular abnormalities that may be causing the tinnitus.

In summary, diagnosing tinnitus involves a thorough medical evaluation that includes a detailed medical history, a physical examination, and a hearing test to identify any underlying conditions that may have caused the tinnitus. Further



testing or referral to a specialist may be recommended depending on the specific characteristics of the tinnitus and its associated symptoms. For most patients with tinnitus, the only abnormality discovered during the medical evaluation is hearing loss.

EXPLANATION

Tinnitus may follow long-standing or sudden exposure to loud noise, hearing loss, other injuries to the hearing nerve (for example, blast or pressure changes), vascular abnormalities, certain medications, or emotional stressors. For people experiencing tinnitus, exposure to loud noise or ear injury may reduce the amount of sensory input from the ear to the brain. This reduction in sensory information from the ear to the brain leads to reorganization of the brain in a way that is similar to how the brain reorganizes when someone loses a limb. Some patients who have lost a limb still feel pain in the missing limb, and this is called phantom limb pain. The neurons of the brain that are responsible for feeling in the missing limb are still present in the brain, and they create the sensation of limb pain or feeling. Scientists think that tinnitus may be similar and that it can be thought of as "phantom sound." In affected patients, tinnitus is the perception of sound when there is no sound present in the environment.

For many people, no specific cause or event can be identified. For these people, attention and focus on the "phantom sound" seems to be very important to the cause and maintenance of tinnitus. To understand the importance of attention to the perception of tinnitus, consider what happens when you walk into a room with a loud air conditioner. At first, you hear the sound that it makes, but then it seems to fade into the background, and you become less aware of it. This "fade into the background" is the experience for people who are not bothered by their tinnitus. The perceived sound becomes less noticeable, and these patients are only aware of their tinnitus when they concentrate on "finding" it. However, some people focus on the sound or give the sound extra importance, so they are constantly aware of the sound or "checking for it." This creates a connection between the part of the brain that registers sound and the part of the brain that controls attention.

Regardless of the source or cause of the tinnitus, we believe that tinnitus is not an auditory or hearing sensation. Rather, tinnitus is an abnormal psychological reaction to a perceived auditory stimulus. Stress, anxiety, paying too much attention to the "sound," and lack of sleep can make the patient's reaction worse.

TINNITUS AND STRESS

Tinnitus tends to worsen with stress. Stress is known to increase the activity of the "attention" part of the brain, which can strengthen all of the connections associated with it. This means that, when an individual is stressed, their brain may be more likely to focus on the sounds of their tinnitus, which leads to increased perception of these sounds and increased distress associated with them.

In addition, stress can trigger physical changes in the body, such as increased muscle tension, changes in breathing patterns, and changes in heart rate and blood pressure, which can contribute to tinnitus symptoms. These physical changes may affect the auditory system and make tinnitus more noticeable and bothersome.

Stress can also affect sleep quality, which can further exacerbate tinnitus symptoms. Poor sleep can lead to increased fatigue,

difficulty concentrating, and heightened emotional distress, all of which can contribute to the perception of tinnitus. Thus, good sleep quality and quantity is very important. To paraphrase the famous American executive E. Joseph Cossman, "The shortest distance between hope and despair is a good night's sleep."

In summary, stress can worsen tinnitus symptoms by increasing the activity of the attention part of the brain, triggering physical changes in the body that affect the auditory system and sleep quality. Managing stress through relaxation techniques, exercise, and other stress-reducing activities may help to improve tinnitus symptoms.

BRAIN IMAGING

The brain is responsible for processing and perceiving sound, and this process involves a network of neurons that work together to create the perception of sound. Abnormal connectivity between different areas of the brain that are involved in sound perception and attention can disrupt this process, leading to tinnitus.

Studies using magnetic resonance imaging have identified abnormal connections between areas of the brain involved in sound perception and attention in individuals with tinnitus. These abnormal connections can cause a breakdown in communication between different areas of



the brain, leading to an over activation of certain regions and a lack of inhibition in others.

Neuroimaging studies have also identified multiple neural systems associated with bothersome tinnitus, including the attention, emotion, auditory, body sensation, and visual brain networks. Researchers believe that these abnormal brain network connections may be the reason why patients focus on the sound and are bothered by it.

Thus, abnormal brain connectivity in areas involved in sound perception and attention can disrupt the processing of sound and lead to tinnitus.

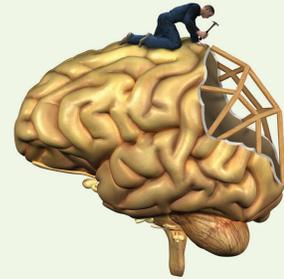
THE HUMAN BRAIN AND NEUROPLASTICITY

The human brain is a complex organ responsible for controlling and coordinating all of the body's functions. It consists of more than 100 billion nerve cells called neurons, which communicate with each other through specialized connections called synapses. These connections are the basis for the brain's incredible capacity to process information, learn, and adapt to new experiences.

Neuroplasticity (or brain plasticity) is the brain's ability to change and adapt in response to experiences, learning, and injury. This means that the brain is not fixed and unchangeable; rather, it can continually reorganize and form new connections throughout a person's life.

Neuroplasticity is thought to act on the brain in several ways. One of the main mechanisms of action is through the strengthening or weakening of the synapses between neurons. When a particular neural pathway is used repeatedly, the synapses within that pathway become stronger, making it easier for information to flow through that pathway. Conversely, when a neural pathway is not used, the synapses within that pathway become weaker, making it harder for information to flow through that pathway.

Neuroplasticity is critical for learning and memory as well as for recovery from injury. When someone learns a new skill (for example, playing an instrument or learning a new language), the brain forms new connections between neurons to support that skill. Similarly, when someone experiences brain damage (for example, due to a stroke or traumatic brain injury), the brain can reorganize and form new connections to compensate for the damaged areas. Sometimes, for unknown reasons, the brain will make the wrong connections. In the case of tinnitus, we think the brain makes the wrong connections between attention, emotion,



- **Neuroplasticity**, also called brain plasticity, means that the brain can change and adapt because of experiences, learning, and injuries.
- The brain is not fixed and can keep organizing and making new connections as we grow up.
- Neuroplasticity helps the brain by making the connections between brain cells stronger or weaker, which affects how information moves in our brain.
- This is important for learning, remembering things, and getting better after a brain injury.
- When someone has tinnitus, their brain can make wrong connections between attention, feelings, and the sound they hear, which can make them upset.
- Treatments for tinnitus use the ideas of neuroplasticity to help the brain create new, healthy connections and make tinnitus less bothersome.
- In conclusion, the brain is very complex and can change a lot because of neuroplasticity. This helps us adapt and do well in a world that keeps changing.

and the "sound" that we call tinnitus. The problem is that the brain focuses on the "sound," and this creates the "bother" or emotional disturbance associated with tinnitus.

Overall, the brain's incredible complexity and capacity for change through neuroplasticity makes it a remarkable organ that allows us to adapt and thrive in an ever-changing world. The most successful treatments for tinnitus are based on the principles of neuroplasticity. The goal of these treatments is to help the brain reorganize and form new and healthy connections to reduce the attention and bother of tinnitus.

TINNITUS TREATMENTS

Unfortunately, there is no magic pill or device to take away tinnitus, despite what one may read on the internet or see advertised on cable TV. Most successful treatments for tinnitus are based on relieving the functional effects of tinnitus, such as sleep disturbance, difficulty concentrating, problems with hearing, and difficulty relaxing.

Tinnitus Maskers and Hearing Aids. Tinnitus maskers and hearing aids are two common treatments used to help manage tinnitus.

Tinnitus maskers are electronic devices that generate and emit sounds (usually white noise) that are designed to mask the sound of tinnitus. The idea is that the masking sound helps to distract the brain from the sound of the tinnitus, making it less noticeable and bothersome. Tinnitus maskers can be worn



as standalone devices or integrated into hearing aids.

Hearing aids can also be used to help manage tinnitus, especially in patients who have both hearing loss and tinnitus. Hearing aids amplify external sounds, making them easier to hear, which can help to reduce the perceived loudness of tinnitus. Some hearing aids also include built-in tinnitus maskers, which can help to further reduce the perception of tinnitus.

It is important to note that, while tinnitus maskers and hearing aids can be effective for managing tinnitus, they do not cure the underlying condition that causes tinnitus. They are simply tools that can

help to make the tinnitus less noticeable and bothersome.

Behavioral Therapy. The most successful treatments for tinnitus are Cognitive Behavioral Therapy (CBT), Mindfulness-Based Stress Reduction (MBSR), and Acceptance and Commitment Therapy (ACT).

Cognitive Behavioral Therapy. CBT for tinnitus bother is consistently found to be a useful

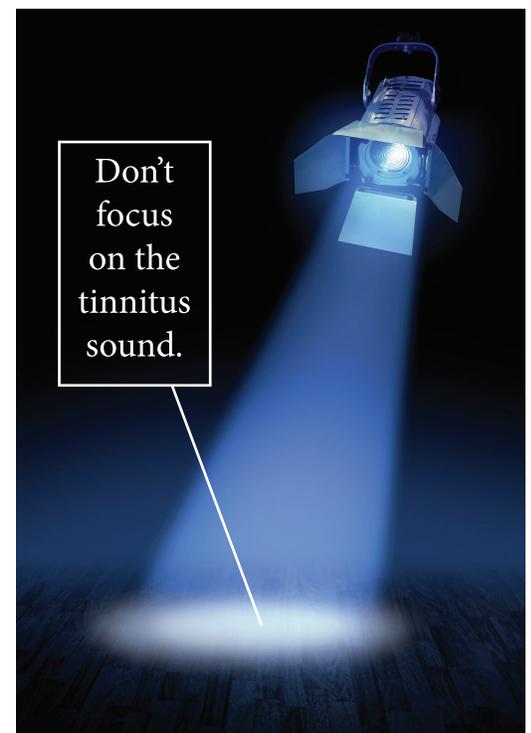
treatment. CBT is based on the idea that how well we cope with difficult things in our lives depends on two major things. The first is cognition, or how we think about situations. This is where the C comes from. The second is behavior, or how we behave when facing a difficult situation, which is where the B of CBT comes from. CBT teaches us how to change the way we think and the things we do to make life with tinnitus easier to manage. There are two basic goals of CBT. The first goal is to address and help with other things that can contribute to the tinnitus being more bothersome at certain times. For example, it is possible that tinnitus may bother a person more during times when they are more stressed or having more negative thoughts about their tinnitus. CBT is designed to help with the triggers that make life more difficult, like stress and negative thoughts. The other basic goal of CBT is to help a person manage the distress when it does come up. What can someone do when their tinnitus is bothering them in the moment? CBT provides helpful tools for this situation.



Mindfulness-Based Stress Reduction. MBSR is a psychological intervention that emphasizes the focused, non-judgmental awareness of present-moment experiences without efforts being made to alter or avoid them. It is a practice that is embedded in mind/body and integrative medicine, and it helps people to cultivate psychological and emotional resilience. MBSR improves anxiety, depression, insomnia, and other psychological outcomes. In a recent study of meditation programs, researchers concluded that meditation may be equal to medications and other well-established interventions for

improving stress-related outcomes related to a wide range of chronic conditions, including tinnitus.

Acceptance and Commitment Therapy. ACT is a form of psychotherapy that focuses on accepting difficult thoughts and feelings rather than trying to avoid or control them. It encourages individuals to identify their values and take actions (i.e., commitment) toward living a meaningful life despite the presence of challenging experiences. ACT can help individuals learn to accept the presence of the tinnitus sound and focus on their values and actions rather than their symptoms. ACT may also help individuals develop psychological flexibility, which can enable them to be more adaptive in the face of challenging experiences.





Each treatment provides patients with multiple ways to cope with the tinnitus sound in a more neutral or relaxed way. Thus, instead of tinnitus being a source of distress, it can recede into the background and allow patients to go about their lives normally. By rethinking things, patients can reduce stress, and the connection between their attention and the tinnitus is weakened. Behavioral therapy helps the attention centers of the brain reduce paying attention to the phantom sound. This reduction in attention reduces

the associated bother. CBT, MBSR, and ACT each offer multiple, specific skills and practices that help patients learn how to reduce the bother from tinnitus. Although these modalities are helpful for individuals with tinnitus, it is important to note that none of the behavioral therapies are a cure for the condition. **The treatment goal is to turn the "attentional spotlight" away from the sound.**

Treatment directed at the tinnitus sound (for example, sound maskers or hearing aids) may not be as effective as behavioral therapies for some people because the problems associated with tinnitus are based on the patient's reaction to the sound rather than the nature of the sound itself. With this perspective, it is easier to understand why behavioral therapies are so successful for patients with tinnitus.

PROFESSIONAL ORGANIZATIONS AND PATIENT SUPPORT GROUPS

There are several professional organizations and patient support groups for tinnitus that provide valuable resources, support, and information for people with tinnitus, their families, and their caregivers.

1) American Tinnitus Association (ATA): The ATA is a nonprofit organization dedicated to improving the lives of people with tinnitus. It provides resources and support for people with tinnitus, and it funds research into new treatments. <https://www.ata.org>

2) British Tinnitus Association (BTA): The BTA is a UK-based charity that provides support and information to people with tinnitus. The BTA also promotes research into the condition. <https://tinnitus.org.uk/>

3) Tinnitus Research Initiative (TRI): TRI is an international organization that aims to promote research into tinnitus and find new treatments for the condition. <https://www.tinnitusresearch.net/>



4) Tinnitus Hub: Tinnitus Hub is an online support community for people with tinnitus. It provides forums for discussion as well as resources and information about the latest treatments for tinnitus. <https://www.tinnitushub.com/>

5) Tinnitus Talk: Tinnitus Talk is another online support community for people with tinnitus. It provides forums for discussion as well as resources and information about the latest research and treatments for tinnitus. <https://www.tinnitustalk.com/International>

6) American Academy of Audiology: The American Academy of Audiology is a professional organization that includes audiologists and other health care professionals who work with patients with tinnitus. It provides resources and support for both patients and professionals, and it promotes research into the condition. <https://www.audiology.org/>

TINNITUS RESEARCH

There is a lot of exciting research in the field of tinnitus. The ongoing research is aimed at better understanding the underlying causes of the condition and developing new treatments. Some of the exciting research includes the following:

Neurostimulation: There are several forms of neurostimulation being researched as potential treatments for tinnitus, including transcranial magnetic stimulation (TMS), transcranial direct current stimulation (tDCS), and vagus nerve stimulation (VNS).

Genetics: Recent studies have identified specific genes that may be associated with tinnitus, suggesting that genetics may play a role in the development of the condition.

Brain imaging: Advances in brain imaging technology are allowing researchers to better understand the brain activity associated with tinnitus, which could lead to new treatments targeting specific areas of the brain.

Drug therapies: Researchers are investigating the use of drugs that target specific neurotransmitters in the brain that are thought to be involved in tinnitus, such as glutamate and GABA.

Sound therapy: There is ongoing research into the use of sound therapy to treat tinnitus, including the use of specific types of sound that can help to "retrain the brain" to ignore the tinnitus sound.

Overall, the research in the field of tinnitus is promising, and there is hope that new treatments will be developed that can provide relief for people living with this condition.

