**Tinnitus: Current neuroscience research and theories**

**What is tinnitus?**

- Tinnitus is a common hearing disorder, in which a person hears a “phantom sensation” of ringing or buzzing in the ear, even though no external sound is present. Tinnitus can be present for long periods of time, or, in many cases, is present constantly.

**How does tinnitus impact the patient? society?**

- The impact that tinnitus has on daily life varies from person to person. Tinnitus can be associated with difficulty sleeping and fatigue, stress, anxiety and depression, difficulty concentrating, and other factors. For some, the impact of tinnitus is severe, and maintaining “normal” daily function can be a struggle.

- As many as 15% of people in the U.S. are affected— that’s over 46 million people. People most at risk are those who are exposed to loud noise, like construction workers, musicians, and military personnel. In fact, more military veterans receive compensation for tinnitus and hearing loss than for any other medical issue. Tinnitus is also becomes more prevalent with age.

**What do we know about the causes of tinnitus?**

- The exact cause of tinnitus is unknown; however, tinnitus can be initially triggered in several ways. The most common trigger is exposure to loud noise and resulting hearing loss. Head or neck injury, temporomandibular joint (TMJ, or jaw) dysfunction, and certain drugs can also trigger tinnitus.

- However, not everyone with hearing loss or head injury develops chronic tinnitus. *Why?*

- This is the question that neuroscience research is attempting to answer. It is possible that all these different triggers for tinnitus cause the same changes in the brains of people with tinnitus. *To understand what causes tinnitus, we need to understand how the brains of people with tinnitus are different from those without tinnitus.*

**What does neuroscience research tell us about how tinnitus affects the brain?**

- Current neuroscience research and theories identify changes in two parts of tinnitus patients’ brains: the auditory system and the limbic system.

- Tinnitus and the Auditory System:
  - The auditory system begins in the ear, where sound is converted to neural impulses. These impulses travel through several processing stations before arriving at the final destination of auditory sensory processing, the auditory cortex.
  - In people with tinnitus, the auditory cortex is hyper-responsive to sound, especially sounds like their tinnitus sensation.
  - In all people, auditory cortex contains tissue organized by what frequency (or pitch) it responds best to, like a keyboard on the brain. This is called tonotopy. In people with hearing loss, these “brain keyboards” are missing “keys” corresponding to the hearing
loss and have extra “keys” corresponding to frequencies (or pitches) close to their hearing loss. In people with tinnitus, these extra keys often match the tinnitus sensation.

- These imbalances in hyper-activity and tonotopy (or, brain keyboards) are thought to produce the tinnitus sensation.
- However, it is currently unclear whether these changes are due to hearing damage, or to tinnitus. Therefore, changes to the auditory system alone may not be enough to cause tinnitus.

• Tinnitus and the Limbic System:
  - The limbic system is typically thought of as the emotional part of the brain, but recent research shows that it is also involved in deciding the value of our thoughts, perceptions, and behaviors.
  - In people with tinnitus, the limbic system seems to be different. For example, a part of the limbic system called the ventromedial prefrontal cortex is structurally different than in people without tinnitus. This difference might be due to a slightly smaller number of brain cells in this area. Similar differences in this part of the brain are found in people with depression and chronic pain.
  - My colleagues and I propose that this part of the limbic system works like a noise-cancellation system. When this system doesn't work well, people are not able to suppress unimportant thoughts, behaviors, and perceptions—including phantom perceptions like tinnitus. In people with tinnitus, the limbic system is unable to regulate hyper-activity in the auditory system originally triggered by, for example, hearing damage or head injury.

How can this research impact the development of treatments for tinnitus?

• There is currently no cure for tinnitus. There are several treatments available, but there is no “fail safe” treatment that is completely effective, or that works for everyone.

• Identifying the brain basis of tinnitus will be crucial in developing effective treatments for tinnitus. For example:
  - If the brain basis of tinnitus is mostly auditory, then treatments that target the auditory system would work best. This could include sound therapy or, in more severe cases, electrical stimulation of the auditory cortex.
  - If the brain basis of tinnitus is mostly limbic, then treatments targeting the limbic system would work best. This could include drug therapies targeting chemicals in the limbic system, or, in severe cases, electrical stimulation of the limbic system.

• Despite its increasing public awareness and scientific research, tinnitus is still a little understood disorder. Future research will further our understanding of this common disorder, help develop effective treatments, and ultimately a cure, for tinnitus.

For more information, the American Tinnitus Association is an excellent resource (www.ata.org).