# Does Tinnitus Truly Interfere With Hearing?

*Summary by John A. Coverstone, AuD*

**One of the most common** complaints of people with tinnitus is how much it affects their hearing. This is particularly true of individuals with bothersome tinnitus. However, even people with more mild conditions frequently comment about their tinnitus impacting their ability to understand others' speech.

Audiologists who specialize in tinnitus know that tinnitus typically occurs at just a few decibels above the softest sound a patient can hear — called the hearing threshold. As a result, clinicians believe that tinnitus probably does not affect hearing itself as much as it distracts patients psychologically or causes them to mistake the effects of hearing loss as tinnitus interference. (See "Distinguishing Between Hearing Loss, Tinnitus, and Hyperacusis," by James A. Henry in the Spring issue of *Tinnitus Today*.)

Fan-Gang Zeng, PhD, and his associates at the University of California, Irvine, recently sought to take this idea a step further and see whether the evidence shows tinnitus truly affecting hearing. Their research has been accepted for publication in the *Journal of Neuroscience*.

To measure the effects of tinnitus on hearing, they had 45 people with tinnitus complete a series of auditory tasks. They also had 27 people with normal hearing and no tinnitus perform the same tasks. Subjects performed an array of auditory tasks, although not all subjects completed all tasks because of time constraints. Tasks included:

- gap detection, in which an individual identifies whether one or multiple stimuli are presented,
- frequency discrimination, which is a measure of how different in pitch stimuli need to be before a subject can tell them apart,
- intensity discrimination, in which a subject identifies whether stimuli are different loudness,
- masking tasks, which involve identifying stimuli with noise present in the other ear,
- temporal modulation detection, in which a subject attempts to determine whether stimuli are steady or modulated to varying extents, and
- speech-in-noise testing, which consists of repeating words or sentences with background noise present.

One theory of tinnitus interference, developed in animal research, is that animals with no tinnitus can be conditioned to perform a task when they experience a break in an external sound. Then, if an animal develops tinnitus during the experiment, researchers presume it will not change its behavior when there is a break in the external sound because there is instead a persistent sound in the animal's environment: tinnitus. Therefore, no break in sound is experienced. Researchers often use this theory to determine whether animals develop tinnitus during experiments.

Zeng and colleagues challenged this theory for humans with the assumption that other cues are present in conversation. They proposed that humans (but possibly not animals) would have normal gap detection even with tinnitus present. Temporal cues (spacing between words and pauses in speech) are an important part of verbal communication and some believe tinnitus may affect speech understanding because it occupies the gaps in speech. The researchers wanted to be sure that hearing loss did not contribute to decreased gap detection. They therefore chose 10 control subjects and 11 subjects with tinnitus and compared gap detection at low frequency (500 Hz), mid-frequency (2,000 Hz), and high frequency (8,000 Hz). No significant difference was measured, so they then measured gap detection with stimuli set at the measured frequency of each subject's tinnitus. They found that gap detection in those with tinnitus still did not vary significantly from that of the control group.

Frequency discrimination was measured at 30 dB (soft sound for those with normal hearing) and 70 dB (loud-ish sound for those with normal hearing) above the person's lower threshold of hearing. Stimuli were presented slightly above and below 500 Hz, 2,000 Hz, and 8,000 Hz, as well as at the pitch of the person's tinnitus. Again, no significant differences were found between the control group and the people with tinnitus when pitches different from a person's tinnitus were used. There were some effects of hearing loss on frequency discrimination at 8,000 Hz, which is the pitch most likely to be affected by decreased hearing. However, there were no significant differences in frequency discrimination between the normal-hearing control group and the people with tinnitus when stimuli were matched to people's tinnitus.

Intensity discrimination was also measured at the same loudness and pitches as frequency discrimination, with loudness varied slightly above and below the target levels. The 30 dB and 70 dB targets were also relative to each participant's hearing threshold. For most presentations, there were no significant differences between those with tinnitus and the control group. Interestingly, those with tinnitus had significantly better intensity discrimination than the control group at 30 dB. Zeng thought this might be a result of the more rapid increase in loudness often people with hearing loss experience. He studied this effect further and was able to rule out hearing loss as the underlying factor. Instead, he stated that tinnitus might be the reason people performed better on intensity discrimination tasks than did those in the control group.

Another task involved presentation of a tone with a broadband noise playing. The participant was tasked with detecting the tone each time. A threshold was established at the softest point the tone could be detected. For this task, there was likewise no significant difference in how people with tinnitus detected a short tone in the presence of noise compared with those in the control group. However, a small but significant difference was found when comparing how much louder that stimulus needed to be compared to the noise. This is called *overshoot* and was compared for all subjects. It was noted for some conditions that the overshoot was greater for those with tinnitus.

When the participants were asked to detect whether a stimulus was modulated (think of a musician using vibrato), there was also no significant difference between those with tinnitus and the control group.

Lastly, people were asked to repeat words presented in a noisy background. This is a common test used in an audiology examination and has been shown to be an effective way to determine if someone has hearing loss. For this task, people repeated phrases the best they could and the score was calculated based on the number of correct responses. Words were presented with three different background sounds present: a noise sound, a competing male speaker, and a competing female speaker. An age effect was discovered when analyzing subjects' ability to understand speech in noise, indicating that the aging process may contribute to difficulty understanding speech in the presence of noise. However, tinnitus did not contribute to any significant differences between the groups.

Dr. Zeng has proposed an *attention-normalization model* to describe people's perception of the effect of tinnitus on hearing. Essentially, the ear hears external sounds and they are relayed up through the auditory nervous system to the brain. This is called a *bottom-up* processing strategy because sound begins at a lower level (the nerves connected to the ear) and is carried upward to the brain. Tinnitus, on the other hand, originates in the brain and is processed from the *top down*. Zeng proposes that these processing pathways may be separate and each may be independently modulated by attention.

The data in this study shows that tinnitus affects only a few of the parameters studied, and only one of those was a negative effect. The other differences noted between people with tinnitus and the control group were an improvement in hearing function. As a result, Zeng concludes that tinnitus does not affect hearing and understanding of speech.

Zeng, F.G., Richardson, M. & Turner, K. (2020). Tinnitus does not interfere with auditory and speech perception. *Journal of Neuroscience.* 2020(10): 1523.