

Making the Most of

Residual

by Larry E. Roberts, Ph.D.

Most people experience tinnitus as a constant noise. But some people can suppress their tinnitus by listening to a masking sound — an external sound that covers the tinnitus. When the external masking sound is switched off, the tinnitus may be dampened or even eliminated for 20 to 30 seconds, or for a few minutes in some cases. This temporary suppression of tinnitus is called *residual inhibition* (RI).

We decided to study RI because it just might help us understand how tinnitus is generated by the brain. Most people with tinnitus have hearing loss caused by damage to the inner ear. We've learned from animal studies that when the brain stops receiving signals from the ear because of this damage, brain cells (also called neurons) in the part of the brain that processes sound become overactive all at the same time and in the same way. This brain activity may be what is heard as tinnitus. If our theory is correct, then the frequencies of each person's tinnitus (the "tinnitus spectrum") should be the same as the frequencies of his or her hearing loss.

What masking sound works best?

Before we started our research study, we predicted that if the masking sound matches the tinnitus spectrum, it will cause residual inhibition by disrupting the abnormal brain activity caused by the hearing loss. For this disruption to occur, the masking sound has to cover the same sound frequencies in the patient's tinnitus and at a volume loud enough to be heard by ears that have some amount of hearing loss.

Fortunately, most people with tinnitus have partial, not complete, hearing loss, so it can be done.

But what does it mean to "present the sound of the tinnitus spectrum"? The idea of a single "tinnitus pitch" is a bit of a misnomer. The band-width of tinnitus is actually quite variable from person to person. Even those who describe their tinnitus as a pure tone actually hear a sound made up of several frequencies. So, when we try to induce RI with a masking sound, it is very important that the masking sound spectrum matches the tinnitus.

To evaluate our predictions, we first looked at the relationship between each patient's tinnitus spectrum and his or her "RI functions" — that is, how long the quieting lasted, and if the tinnitus was quieted fully or partially. In our study, we used masking sounds that covered the range of each person's normal and impaired hearing. Our tinnitus subjects consistently rated the masking sounds in the region of their hearing loss as the ones that most closely resembled their tinnitus. And as it turned out, these masking sounds generally produced the longest lasting and most complete residual inhibition.

In another part of our research, we wanted to determine if optimized RI is a beneficial tool to help people manage their tinnitus. (*Optimized* means finding the most effective RI-inducing masking sound.) We tested a group of 14 tinnitus patients with a CD that had sounds individually optimized to produce RI for them. We measured tinnitus sensations before and after three weeks, during which our subjects played the CD and rated their tinnitus and RI in a diary

Inhibition

several times a day. A control group of 10 people with tinnitus received an identical procedure except that RI functions were not measured and no CD was provided. All of the people in the control group rated their tinnitus using diaries, just as the people in the RI treatment group did. The diary ratings of the RI treatment group showed a small but statistically significant decrease in the loudness of tinnitus after three weeks of using the CD. The diary ratings of tinnitus loudness did not change in the control group.

While the suppression of tinnitus is more complete and longer lasting when the masking sounds and the tinnitus bandwidth were matched, the relief only lasted a few seconds longer on average. It's true that most people still report residual inhibition after hearing a masking sound that has all frequencies in it (usually called white noise). But the increased tinnitus suppression with RI, though small, is predictable, which is why it has our attention.

Why is brief residual inhibition important?

When a person first experiences significant tinnitus, it is very stressful. The fact that it is not under his or her control adds to the psychological distress of the situation — knowing that there is nothing that can be done about it. If you can demonstrate to that person that you could give him or her a sound to knock out or dampen the tinnitus — even for just 30 seconds — it can be quite reassuring and psychologically beneficial.

Another very important reason to study RI: If we can understand how

tinnitus and residual inhibition are produced, we may be able to design treatments that reduce tinnitus and even possibly prevent people from developing it.

Where does tinnitus come from?

Let me explain where we think tinnitus comes from. For people who have hearing loss (and most cases of tinnitus are associated with hearing loss), there's an increase in activity of neurons in the hearing part of the brain. It's not just that the neurons are active, or *firing*, more frequently. It is that they are also firing *synchronously* — at the same time. We think the increase in this synchronous activity is what causes the tinnitus.

We also think that when these neurons fire at the same time for a long period of time, the connections between the neurons get stronger. There are good reasons to believe that this increased firing for a long period of time — that is, listening to tinnitus for a long period of time — increases the strength of connections between neurons. We think it makes the network of neurons quite robust and resistant to interference. But we also think it may be possible to change the strength of connections between neurons by using acoustic training. When the active neurons in the hearing region of the brain all start to communicate with each other, we believe that the activity becomes fused. The acoustic training is intended to break up this synchronous, or fused, activity.

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group, and the subjects who had received the placebo were given the melatonin. This **crossover** from one treatment to the other ensures that each patient had equal exposure to the active drug and the placebo.

When evaluating the outcome of a study, researchers look for **statistical significance**. A statistically significant change means that the change caused by the treatment is greater than the change that could be expected based on chance. In the melatonin study, although the change in tinnitus pitch and volume for the group as a whole wasn't significant, those who had the greatest amount of tinnitus distress (and the least sleep) had a statistically significant amount of improvement in their tinnitus, and were most likely to benefit from melatonin treatment.

This study answered an important question about how well a specific treatment — melatonin — could remedy tinnitus. It was a very successful **clinical trial** — a research study with people! 🌟

Reference

Rosenberg S.I., Silverstein H., Rowan P.T., Olds M.J. (1998). Effect of melatonin on tinnitus. *Laryngoscope*; 108(3), 305-10.

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At present, residual inhibition of tinnitus lasts about 25 seconds for a typical person. There have been reports of extended RI, but those are rare. One of our goals is to extend RI with improved engineering of masking sounds and with acoustic training. The acoustic training method we are exploring requires the person to discriminate among sounds of different pitches in the tinnitus frequency region. This type of training may strengthen the ability of a person's brain cells to inhibit (or slow down) the cells' nearest "neighbors," which in turn could break apart the synchronous activity — the possible underlying cause of tinnitus. 🌟

Dr. Roberts is a Professor in the Department of Psychology, Neuroscience, and Behavior, at McMaster University, in Hamilton, Ontario, Canada. This research was funded by the American Tinnitus Association.

A Bridge of Hope

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his avoidance behaviors and made different choices. His depression greatly reduced, as did his levels of stress and anxiety.

By learning how to manage the psychological impact of his tinnitus, this patient created for himself a stable sense of hope. For him, and for others, this is a key to regaining mastery over one's life. With patience and practice and while still having tinnitus, it is possible to get to the other side — over a bridge of hope — and live a quality life once again. 🌟

Deborah R. Lain is a private practice psychologist, speaker, and writer in Calgary, Alberta, Canada. She can be reached through www.soulspringcounseling.com or soulspring@telus.net