Research-based Tinnitus Treatments

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Audiologist, Lecturer

Journal of Neuroscience Methods

Clinical Neuroscience

Feasibility study of a game integrating assessment and therapy of tinnitus

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\textsuperscript{b} Tinnitus Research Initiative, Germany
Tinnitus & treatment realities

- Heterogeneous with regards to the underlying cause & phenotype
- Few specialized treatment centres
- Relatively low evidence for many diagnostic & therapeutic procedures
- Those treatment recommendations that do exist, are not always feasible or fulfilled in clinical practise
- Identification of sub-types suggests high relevance for treatment recommendations
- Treatment highly variable – across & within disciplines (audiology, ENT, psychology/psychiatry) but also across & within countries.

(Schecklmann, et al., 2012; Langguth, et al., 2011; Hoare, et al., 2012)
Review

Experimental, Controversial, and Futuristic Treatments for Chronic Tinnitus

DOI: 10.3766/jaaa.25.1.7

Robert L. Folmer*†
Sarah M. Theodoroff*†
William Hal Martin†
Yongbing Shi†‡

Robert L. Folmer, Ph.D., National Centre for Rehabilitative Auditory Research, Portland Veteran’s Administration (VA) Medical Centre, USA

• Acknowledged heterogeneity of studies reviewed & difficulty this poses on a precise meta-analysis

• “Not meant to be an exhaustive review; the article reflects the authors’ professional biases and prerogatives” (Folmer, et al., 2014; p. 107)

• Provides information on a wide range of approaches
Review

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**INVASIVE:** Scant support, potentially harmful & “tinnitus is a non-life threatening symptom”

**NON-INVASIVE:** Support for efficacy of hearing aids, types of environmental sound enrichment, CBT, counselling, hypnosis, biofeedback & relaxation training

**OVER-THE-COUNTER / PRESCRIPTION MEDICATION(S):** Anti-depressants, anti-anxiety, obsessive-compulsive control

**CLINICAL TRIALS:** Require “Effectiveness above & beyond the placebo effect”  

*(Folmer, et al., 2014; p. 106)*
Letter to the Editor

DOI: 10.3766/jaaa.14041

All Treatments in Tinnitus Are Experimental, Controversial, and Futuristic: A Comment on “Experimental, Controversial, and Futuristic Treatments for Chronic Tinnitus” by Folmer et al (2014)
Tinnitus treatments considered established & evidence based

Experimental, controversial (non-evidence based) & futuristic

(Folmer, et al., 2014)
Make a distinction between:

(de Ridder et al., 2015; p. 595)

• “…the authors [Folmer et al., 2014], suggest most patients can be treated with the established treatments in a satisfactory way”

• Considering the evidence base, both the distinction (between established versus experimental) & the assertion that established treatments are satisfactory – are not correct

• “…same criteria should be used to judge the scientific evidence behind the effectiveness of different treatments”

• This highlights that some therapies considered established, currently have a low, high-quality trial evidence of efficacy (e.g., hearing aids – Hoare, et al., 2014)

• Yet, “evidence for some treatments [they] consider as controversial/experimental is not that low” (e.g., rTMS – Anders, et al., 2010; Khedr, et al., 2009; Marcondes, et al., 2010)
Recommendations

• Precise description of all clinical features of tinnitus in a given individual, based on reliable & validated assessment instruments

• Good, reliable clinical characterization tinnitus as a prerequisite for arriving at a clear diagnosis, enabling appropriate treatment

• Individualised patient outcome assessments – to determine whether treatment resulted in improvement in areas most relevant for the patient/client

• Standardised assessment methods – for comparison of results across centres, clinic audits, & epidemiological studies

• Analysis of therapies, interventions (clinical trials, systematic clinical observations) using standardised assessments at defined intervals: before, during, & after intervention.

(Langguth, et al., 2011; Hoare, et al., 2014)
Case history

- **Information, self-help materials**
- **Manual** *(Konzag, et al., 2006)*
- **Scope of practise**
- **Consider specialist practitioner networks of those accommodating tinnitus (multidisciplinary)**
  - ENT *(Langguth, et al., 2011)*
  - Counselling/psychological *(Searchfield, et al., 2010)*
  - Musculoskeletal *(Sanchez & Rocha, 2011)*
  - Jaw *(Sanchez & Rocha, 2011)*
  - Sleep *(Kentish, Crocker & McKenna, 2000; Hébert & Carrier, 2007)*
  - Relaxation *(Öst, 1987; Weber, et al., 2002)*

*(Langguth, et al., 2011)*
Themes

• Internet strategies
• Medical Management
• Non-invasive Neurological Methods
• Psychological & Counselling Therapies
• Sound Provision
• Self-help & Pervasive Healthcare Approaches
• Neuroplasticity & Training Models
Internet strategies

• Uppsala (Sweden)
  Treatment Programme

Internet-Based Cognitive Behavioral Therapy
for Tinnitus

Gerhard Andersson and Viktor Kaldo
Uppsala University

(Andersson & Kaldo, 2004)

Professor of Psychology Linköping
University & CBT-trained
Psychotherapist

AWARDS:
Outstanding Swedish psychologist (2014)
Nordic prize in medicine (2014)
Swedish Assoc. of Behaviour Therapy,
Lifetime achievement award (2015)
Table 1
*Overview of Self-Help Treatment for Tinnitus Presented via the Internet*

<table>
<thead>
<tr>
<th>Case Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structured clinical interview (in clinic)</td>
</tr>
<tr>
<td>Internet-based questionnaire assessment</td>
</tr>
<tr>
<td>Treatment rationale and information (in session and on the Web)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Presented in Six Separate Modules*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied relaxation (1. progressive relaxation, 2. short progressive relaxation, 3. cue-controlled relaxation, and 4. rapid relaxation)</td>
</tr>
<tr>
<td>Positive imagery</td>
</tr>
<tr>
<td>Sound enrichment by means of external sounds</td>
</tr>
<tr>
<td>Hearing tactics and advice regarding noise sensitivity</td>
</tr>
<tr>
<td>Modification of negative thoughts and beliefs</td>
</tr>
<tr>
<td>Behavioral sleep management</td>
</tr>
<tr>
<td>Advice regarding concentration difficulties, exercises of concentration (mindfulness)</td>
</tr>
<tr>
<td>Exposure to tinnitus</td>
</tr>
<tr>
<td>Advice regarding physical activity</td>
</tr>
<tr>
<td>Relapse prevention</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet-based questionnaire assessment</td>
</tr>
</tbody>
</table>

*Treatment also includes continuous interaction with the therapist and training diaries.*

(Andersson & Kaldo, 2004)
Pros & Cons

- Promotes regular interaction, assessment – works with individual lifestyle; remote access
- Supports monitored group approaches
- Fosters programme adherence
- Single case-based study
- Case formulation & pathway may need to be changed & this is readily facilitated in a 1:1 setting, but not as straightforward with internet
- Not appropriate for all
- Should follow (not replace) professional/specialist consultation & receive appropriate review

(Andersson & Kaldo, 2004)
A Randomized Controlled Trial of Internet-Delivered Cognitive Behavior Therapy and Acceptance and Commitment Therapy in the Treatment of Tinnitus

(Hesser, et al., 2012)

METHODS:
- \( n = 99 \), (mean age 48.5 years; 43% female)
- CBT \( (n = 32) \)
- Acceptance & Committment Therapy \( (n = 35) \)
- Control (monitored Internet discussion forum; \( n = 32 \))

RESULTS:
Mixed-effects linear regression analysis of all randomized participants showed significant effects on the primary outcome (Tinnitus Handicap Inventory) for CBT & for ACT compared with controls at post-treatment

Within-group effects were substantial from pre-treatment through 1-year-follow-up for both treatments; no significant difference between treatments

CONCLUSIONS:
ACT procedures may be a viable alternative to traditional CBT techniques in the management of tinnitus. The Internet can improve access to psychological interventions for tinnitus.
Other studies

(Kaldo, et al., 2008)

– ‘Randomized controlled trial’ comparing internet-based, self-help ($n = 26$) with group-based CBT ($n = 25$)
– Significant improvements for both groups, little difference between the groups, results stable after 1-year follow-up
– Consumed less time & 1.7 times more cost-effective
– However, intake rating that internet-approach less credible

(Abbott, et al., 2009)

– Industrial, ‘cluster randomized trial’ comparing internet-based, CBT program ($n = 28$) for tinnitus distress compared to information-only controls ($n = 23$)
– Internet CBT was not significantly better than controls, but high attrition & resultant low sample size, precluded generalising findings
– Internet programme needs to be engaging to ensure compliance
Medical Management

- Glomus Tumour;
- Otosclerosis
- Superior Semi-circular Canal Dehiscence
- Sudden Unilateral SNHL
- Vascular Compression
- Vestibular Schwannoma
- Ménière’s

3rd Window Lesions, (BC) THEORY: 3rd Window causes ↓ impedance on SV side, improving cochlear response to BC. For patients with healthy cochleae as in SSCD, supra-normal BC thresholds may be seen.
Medical Management

• Medical model – formal medical-based specialist assessment as initial step in diagnosis & treatment

• “...to standardize & improve clinical management of tinnitus patients, development of an algorithm for diagnostic & therapeutic tinnitus management (as a living, changing document)”

• Generated by a multidisciplinary team: otolaryngologists, neuro-otologists, audiologists, neurologists, psychiatrists & a neurosurgeon.

(Langguth, et al., 2011; Tinnitus Research Initiative, 2006)
Medications – treat or cause?

<table>
<thead>
<tr>
<th>Type of Medication</th>
<th>Examples</th>
<th>Tinnitus-Related Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analgesics</td>
<td>Salicylates, nonsteroidal anti-inflammatory agents</td>
<td>Cause subjective and high-frequency tinnitus; may be reversible when the drug is stopped</td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Aminoglycosides, e.g., gentamicin, streptomycin, neomycin. Other antibiotics such as erythromycin, azithromycin, vancomycin, tetracycline, and chloramphenicol.</td>
<td>Cause subjective and high-frequency tinnitus; not usually reversible</td>
</tr>
<tr>
<td>Antineoplastic agents</td>
<td>Bleomycin, cisplatinum, methotrexate, vincristine</td>
<td>Cause subjective and high-frequency tinnitus; not usually reversible</td>
</tr>
<tr>
<td>Loop diuretics</td>
<td>Bumetanide, ethacrynic acid, and furosemide</td>
<td>Cause subjective and high-frequency tinnitus; usually reversible when the drug is stopped</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td>Cause subjective and high-frequency tinnitus; transient and usually reversible</td>
</tr>
<tr>
<td>Quinine/chloroquine</td>
<td></td>
<td>Cause subjective and high-frequency tinnitus; usually reversible when the drug is stopped</td>
</tr>
<tr>
<td>Tricyclic antidepressants</td>
<td>Amitryptiline, imipramine, doxepin</td>
<td>Cause subjective and high-frequency tinnitus; usually reversible when the drug is stopped</td>
</tr>
</tbody>
</table>

Anti-depressants, Anti-convulsants, Anxiolytics, Hypnotics, Tranquilizers

Interactions? Ability to metabolise?

(Holmes & Padgham, 2011; p. 99)
SNPs & Medication

- Single Nucleotide Polymorphism,
- Simple Nucleotide Polymorphism,
- SNP, “snip” or “snips” (plural)

Genetic anomaly – DNA sequence variation occurring commonly within a population (e.g. 1%)

CYP2D6 is a gene polymorphism that encodes how people metabolise

People respond differentially to medications/drugs and can be high or low responders

(Kleim, 2015)
Non-invasive Neurological Methods

- **Brain Stimulation**
  - TMS
  - rTMS
  - tDCS

**Neuromodulation:**
Changing pathological neuronal activity associated with tinnitus perception & sustainability

Neuromodulation techniques are theorised to work by inducing neural plasticity & disrupting aberrant neural networks responsible for tinnitus
Non-invasive Neurological Methods

• rTMS: *(Anders, et al., 2010)* A randomized, placebo controlled study

• rTMS: *(Khedr, et al., 2009)* A one-year follow up of patients with chronic tinnitus

• *rTMS: (Marcondes, et al., 2010)* A double-blind controlled, clinical and neuroimaging outcome study

Non-invasive Neurological Methods

Cochrane Review (Meng, et al., 2009):

Transcranial magnetic stimulation for tinnitus

Data search retrieved 283 articles. Five trials comprising 233 tinnitus patients, inclusion criteria & included in the review.

MAIN FINDINGS:

- Of the 5 studies included, 3 applied low-frequency rTMS
- Of those 3, only 1 study revealed 'partial improvement' in tinnitus severity & disability
- This improvement was not replicated in two other studies that applied rTMS at the same, low-frequency
- Considering all 5 studies, it was impossible to show an improvement in tinnitus loudness in patients undergoing rTMS
- rTMS is a safe treatment for patients with tinnitus in the short-term, however no data were available to verify safety in the long-term.
Non-invasive Neurological Methods

- Transcranial direct current stimulation (tDCS)
- High-definition, transcranial direct current stimulation (HD-tDCS)
Non-invasive Neurological Methods

(Shekhawat, et al., 2015)
HD-tDCS ($n = 27$)

- HD-tDCS has not (yet) been used extensively in tinnitus research
- The conventional large sponges are replaced with smaller gel electrodes
- 4 electrodes encourage current flow limited to areas below the placement sites (more focal)
- Present research looking at parameters most effective at inducing tinnitus relief

**RESULTS:** Left temporoparietal & DLPFC placements equally effective at reducing tinnitus loudness & annoyance

“Does provide a change in excitability in underlying cortical activity, but for tDCS 
& rTMS, it does not last”

(Searchfield, 2015)
Polymorphism & plasticity

- BDNF – Brain-derived neurotrophic factor
- Protein, in humans, encoded by the BDNF gene. BDNF is a part of the neurotrophin group of growth factors
- Neurotrophic factors are located in the brain & the periphery
- Like “Miracle Grow” for the brain
- But, there can be polymorphism in genes related to plasticity
- BDNF polymorphism is associated with abnormal reaction to training (e.g., rTMS – some will not show the same response & vary as a function of genotype)
- **Know the patient or participant genotype or ability to metabolise, before medication, treatment or training...**

(Kleim, 2015)
Psychological and Counselling Therapies

(Westin, et al., 2011)

Acceptance and Commitment Therapy versus Tinnitus Retraining Therapy in the treatment of tinnitus: A randomised controlled trial

- \( n = 64 \) Participants with normal hearing & tinnitus, randomised to ACT, TRT, or wait-list control (WLC) groups
- ACT required 10 weekly 60 min sessions
- TRT required one 150 min session, one 30 min follow-up & continued daily use of wearable sound generators for a recommended period of at least 8 h/day for 18 months
- Assessments were made at baseline, 10 weeks, 6 months & 18 months.

Tinnitus Handicap Inventory (THI) average scores during the study period
Sound ‘therapy’

Used in conjunction with other strategies (directly or indirectly)

• Includes the use of:
  – Background sound (lowest level that provides the greatest subjective benefit)
  – Hearing aids
  – Total or partial masking (relief, control)
  – Music therapy

• Plays a role in:
  – Reducing the attention drawn to the tinnitus
  – Reducing subjective loudness of the tinnitus
  – Substituting a less disruptive noise (background sound) for an unpleasant one (tinnitus)
  – Provides a shift in locus of control (back to patient/client)
(n = 200) Per survey “Difficulty with hearing?” (YES/NO) and subjective impression (HIGH/LOW) abilities per the Speech, Spatial & Qualities questionnaire

People in the YES (hearing difficulty) but HIGH (abilities) groups also scored significantly higher on a question about tinnitus incidence, suggesting that “hearing difficulty” extends to audibility of unwanted, internally-generated noises

Does treating “hearing difficulty” with hearing aids help with tinnitus?

(Nobel, et al., 2012)
Sound Provision (Audiological)

Hearing aids as an adjunct to counseling: Tinnitus patients who choose amplification do better than those that don’t

• All received group counselling (n = 58)

AFTER COUNSELLING:
• Received hearing aids (n = 29); significant reduction THQ shifted from 59% to 37% (p < 0.0001)
• Opted not to proceed with hearing aids (n = 29); THQ shifted from 51% to 41% (Not Significant)

(Searchfield, Kaur & Martin 2010)
Sound Provision
(Audiological)

• (n = 1440) patients fit with 1 or 2 hearing aids depending on clinical presentation & amplification needs
• Not an experimental design
• (n = 554; unilaterally aided) or 67% and (n = 424; bilaterally aided) or 69% - reported some improvement in tinnitus after aiding
• Significant improvement in tinnitus, when comparing outcomes following the adoption of digital (versus analogue) hearing aid fitting - unilateral (p < 0.001) and bilateral (p < 0.001)

Considered the improvement due to broader bandwidth & improved tinnitus masking at higher frequencies

(Trotter & Donaldson, 2008)
Sound Provision (Audiological)

Average, subjective tinnitus pitch-match with right and left hearing thresholds plotted in red and blue respectively (N = 192)

(Shekhawat, Searchfield & Stinear, 2013)
Sound Provision (Audiological)

2002 – Present: University of Auckland Hearing & Tinnitus Clinic

• Not an experimental design
• Those with hearing loss & tinnitus with more preserved low-frequency hearing generally receive improvement in tinnitus with hearing aids
• Those with poor low-frequency hearing tended to receive little improvement in tinnitus with hearing aids & did better with other strategies (e.g., combination devices)
• Those with high-frequency tinnitus, pitch-matched to a frequency region above/outside the bandwidth provided by device may not perceive as much benefit, due to lack of sufficient tinnitus masking

(Searchfield, 2015)
Sound Provision (Customised)

- Neuromonics
• Case or category-dependant, generally designed as a 6-month protocol but may take longer for those not ideal Tier 1 candidates (e.g., Ménière’s)

• Desensitization via passive listening with tinnitus embedded in spectrally-modified music (music + BBN in Phase 1 of treatment)

• Music features slow tempo to facilitate relaxation; uses extended bandwidth (12.5 kHz)

• Uses variety of counselling styles addressing ‘Patient Expectation’ & ‘Nurturing’ & promotes interactive patient discussion

• Relate case history to individual tinnitus experience, supply equipment training, determine goals, manage expectations, provision of tinnitus information/self-help & hand-outs

• Requires clinician(s) to undergo training to deliver the technique
An Independent Review of Neuromonics Tinnitus Treatment Controlled Clinical Trials

JAMES A. HENRY¹,² AND JOE ISTVAN¹
¹ VA RR&D National Center for Rehabilitative Auditory Research, VA Medical Center, Oregon, United States of America
² Department of Otolaryngology/Head and Neck Surgery, Oregon Health & Science University (OHSU), United States of America


• Used the Consolidated Standards of Reporting Trials (CONSORT) as the framework – providing a rigorous review criteria for randomised clinical trials

• Cited a lack of methodological transparency, & the proprietary nature of Neuromonics as limitations with regards to evaluating the merit of Neuromonics
<table>
<thead>
<tr>
<th>#</th>
<th>Study</th>
<th>n</th>
<th>Description</th>
<th>Location</th>
<th>Success</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T1 – Feasibility</td>
<td>30</td>
<td>Neuromonics, Single Arm</td>
<td>AUS</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>T2 – NTT vs. SOC (Ear, Nose &amp; Throat J 2008)</td>
<td>50</td>
<td>Neuromonics, TRT vs. counseling alone (RCT)</td>
<td>AUS</td>
<td>86%</td>
</tr>
<tr>
<td>3</td>
<td>T3 – 1 vs. 2 Phase (Ear &amp; Hearing 2007)</td>
<td>35</td>
<td>Neuromonics, Dose Study (RCT)</td>
<td>AUS</td>
<td>90%</td>
</tr>
<tr>
<td>4</td>
<td>Private Practice (Annals of Otol, Rhin, &amp; Laryng 2008)</td>
<td>470</td>
<td>Neuromonics, Multiple Tiers of patients</td>
<td>AUS</td>
<td>92%</td>
</tr>
<tr>
<td>5</td>
<td>Lions Ear Institute (2008)</td>
<td>29</td>
<td>Independent, Single Arm</td>
<td>AUS</td>
<td>75%</td>
</tr>
<tr>
<td>7</td>
<td>Tavora-Vieira et al (Internat. Journal of Audiology 2011)</td>
<td>26</td>
<td>Independent, Single Arm, non-std high-hearing loss subjects</td>
<td>AUS</td>
<td>84.6%</td>
</tr>
<tr>
<td>8</td>
<td>Vieria et al (International Tinnitus Journal 2011)</td>
<td>70</td>
<td>Independent, Single Arm, registry</td>
<td>US/AUS</td>
<td>76%</td>
</tr>
<tr>
<td>9</td>
<td>Wazen et al (Otology &amp; Neuro-Otology 2011)</td>
<td>51</td>
<td>Independent, Single Arm</td>
<td>US</td>
<td>81%</td>
</tr>
<tr>
<td>12</td>
<td>AUS Veterans</td>
<td>57</td>
<td>Independent &amp; Neuromonics, Single Arm, patients who failed prev. Tx</td>
<td>AUS / DVA</td>
<td>74%</td>
</tr>
<tr>
<td>11</td>
<td>DoD Study (Ft. Rucker)</td>
<td>140</td>
<td>Independent, NTT vs. iPod/ TRT counseling</td>
<td>US / DoD</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>NAL/Macquarie University</td>
<td>?</td>
<td>Independent, pre/post MEG</td>
<td>AUS</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Haven/Oasis II</td>
<td>?</td>
<td>Private Practice/ VA/ DVA</td>
<td>USA/AUS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>1017</td>
<td></td>
<td></td>
<td>AVG</td>
</tr>
</tbody>
</table>

(Provided by Paul Davis, 15TH July 2015)
Self-help and Pervasive Healthcare Approaches

Pervasive Healthcare
Paving the Way for a Pervasive, User-centered and Preventive Healthcare Model
B. Arnrich; O. Mayora; J. Bardram; G. Tröster

Pervasive Healthcare as a Scientific Discipline
J. E. Bardram
IT University of Copenhagen, Copenhagen, Denmark

(Arnrich, et al., 2010; Bardram, 2008)
Neuroplasticity & Training Models

- Cascade
- Reorganisation
- Spontaneous
- Synchronous
- Resultant “mimicry”
- Sound template mismatch
- Perceptually stands out
- Non-auditory factors
What is common?


Assessed from database for eligibility (n=50).

Randomised.

Allocated to experimental group “Terrain” game (n=15).
Did not receive allocation (n=10) [pulsatile Tinnitus (n=1), tinnitus not problem (n=1), vertigo (n=1), conductive hearing loss (n=1), family illness (n=1), unavailable time (n=4)].

No participants lost to follow up.

Analysed (n=15).

Allocated to control group “Tetris” game (n=16).
Did not receive allocation (n=9) [hearing asymmetry (n=4), tinnitus not problem (n=1), insufficient computer skills (n=1), unavailable time (n=2), illness (n=1)].

No participants lost to follow up.

Analysed (n=16).
<table>
<thead>
<tr>
<th></th>
<th>Training group (Terrain, n=15)</th>
<th>Control group (Tetris, n=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>52.3 (10.6)</td>
<td>62.3 (4.6)</td>
</tr>
<tr>
<td>Gender</td>
<td>3 Female, 12 Male</td>
<td>7 Female, 9 Male</td>
</tr>
<tr>
<td><strong>Questionnaires</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TFI</td>
<td>30.7 (17.1)</td>
<td>25.6 (17.1)</td>
</tr>
<tr>
<td>THI</td>
<td>25.5 (16.0)</td>
<td>18.6 (10.9)</td>
</tr>
<tr>
<td><strong>Rating scales</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Problem</td>
<td>2.7 (0.7)</td>
<td>2.6 (0.7)</td>
</tr>
<tr>
<td>Loudness</td>
<td>4.8 (1.9)</td>
<td>5.1 (2.3)</td>
</tr>
<tr>
<td>Uncomfortable</td>
<td>4.9 (2.3)</td>
<td>5.3 (2.3)</td>
</tr>
<tr>
<td>Annoying</td>
<td>4.9 (1.8)</td>
<td>5.1 (2.7)</td>
</tr>
<tr>
<td>Ignore</td>
<td>6.1 (2.7)</td>
<td>4.9 (2.6)</td>
</tr>
<tr>
<td>Unpleasant</td>
<td>5.2 (1.6)</td>
<td>5.1 (2.4)</td>
</tr>
<tr>
<td></td>
<td>Training group (Terrain, n=15)</td>
<td>Control group (Tetris, n=16)</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>------------------------------</td>
</tr>
<tr>
<td>**p&lt;0.05 = *  p&lt;0.01 = **</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychoacoustic measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitch kHz</td>
<td>7.8 (3.3)</td>
<td>7.5 (3.0)</td>
</tr>
<tr>
<td>MML Right</td>
<td>9.7 (8.0)</td>
<td>5.5 (6.5)</td>
</tr>
<tr>
<td>MML Left</td>
<td>8.5 (8.2)</td>
<td>7.3 (7.3)</td>
</tr>
<tr>
<td>DASS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>6.1 (6.0)*</td>
<td>1.9 (3.7)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>3.1 (3.3)</td>
<td>3.4 (4.3)</td>
</tr>
<tr>
<td>Stress</td>
<td>10.1 (6.77)</td>
<td>6.1 (6.7)</td>
</tr>
<tr>
<td>MMSE</td>
<td>29.8 (0.4)</td>
<td>29.5 (0.6)</td>
</tr>
<tr>
<td></td>
<td>Training group (Terrain, n=15)</td>
<td>Control group (Tetris, n=16)</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>CSFA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deal with problem style</td>
<td>56.8 (16.3)</td>
<td>68.4 (12.8)</td>
</tr>
<tr>
<td>Non-coping style</td>
<td>44.9 (14.1)</td>
<td>45.75 (13.6)</td>
</tr>
<tr>
<td>Optimism style</td>
<td>44.3 (21.4)</td>
<td>63.5 (12.9)**</td>
</tr>
<tr>
<td>Sharing style</td>
<td>56.7 (29.2)</td>
<td>37.6 (22.0)</td>
</tr>
<tr>
<td><strong>SSQ</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speech Hearing</td>
<td>103.8 (23.17)*</td>
<td>80.81 (36.5)</td>
</tr>
<tr>
<td>Spatial Rating</td>
<td>141.4 (22.01)</td>
<td>127.9 (31.7)</td>
</tr>
<tr>
<td>Sound qualities</td>
<td>141.2 (41.2)</td>
<td>139.8 (33.8)</td>
</tr>
</tbody>
</table>
• Capitalise on cortical plasticity
• Un-do negative forms of plasticity to de-emphasize tinnitus
• Engage attentional centres to reduce tinnitus focus (selective attention)
• Pervasive Healthcare
Game – Calibration phase

- **Day 1, Level 1**
  - START
  - DEMO (for admin)
  - STOP

- Does your tinnitus locate LEFT or RIGHT?
  - LEFT
  - RIGHT

- Is your tinnitus pitch lower or higher?
  - LOW
  - HIGH

- Does your tinnitus sound LOUDER or QUIETER?
  - QUIET
  - LOUD
Tetris (N = 16), Control

Terrain (N = 15), Experiment
Selective Auditory Attention & Perceptual training
RESULTS:

Mean reductions over time:

(A) Tinnitus Functional Index (TFI); (p<0.01)

(B) Tinnitus Handicap Inventory (THI); (p<0.01)

(C) Tinnitus Severity Numeric Scale (TSNS); (p<0.01)

TSNS-Ignore scale

Terrain: TFI was correlated with a reduction in N1 latency in the 630 Hz attend condition (r=0.55, p<0.05)

Tetris: No similar correlations found
Change in average time hits for the Comprehensive Attention Battery®
Mean reductions over time:

(A) AVMTv2 – faster visual-only task; (p<0.001)

(B) AVMTm2 – faster mixed auditory & visual task; (p<0.005)

(C) AVMTm2 – change in mean hits; (p=0.035)

- Terrain: faster & more accurate post-training
- When percentage of improvement that could be due to a learning effect was factored out...
Daily Tinnitus Calibration – observed shifts in tinnitus pitch (days 3→5):

- **Octave confusion** – between tinnitus percept & potential matching tone presented 1 octave removed from tinnitus pitch
- **Familiarisation** – Drop in tinnitus pitch, both training groups; more reliable indicator of tinnitus characterisation?
- **Implication for interpretation** – stability of current single-session pitch matching and its use after, as an indication or mechanism of effect; treatment focus
- **Implication for animal-based models** – require behavioural responses to tinnitus-matched sounds for identification of tinnitus presence
Conclusions

• Training effects may be due to improvement in: selective attention, overall supervisory or executive attention control (or perhaps, both)

• Attention found to significantly improve with training, for tasks with greater cognitive load - faster target presentation.

• Terrain participants had significantly better attention-related outcomes than Tetris – may be due to the type of attention primarily trained (selective) or due to training domain (auditory)

• Whether due to selective attention, the auditory domain or both, those that engaged in Terrain had a significantly greater reduction in TFI and the THI than Tetris
Conclusions

• Both games were reported as positive & enjoyable by participants consistent with calls for practical incentive-based training, capitalising on top-down functions such as intellect & personal drive.

Thanks
Completed the first game and got to level 3. Scored 23 points. Will persevere daily.

I couldn’t fit all this into the space in the log book! And you can see what I’ve been thinking about when playing the game as I wait for the next target sound to be played.

Score of 47, wow I am really amazed!
I have got the hang of it now and I did not get stuck once. There were a few times when I had to move around to work out which way to go. It helps to listen and see if you can detect small changes. This reduces the risk of straying too far “off course”.

• Format is consistent with a pervasive healthcare model
Conclusions

• N1 has been associated with enhancement due to attention, but here it does not appear to reflect or appear enhanced by, training-related change.

• Jacobson et al. (1996) found tinnitus participant’s demonstrated longer N1 latencies compared to normal controls, suggesting this a possible feature for individuals with tinnitus.
  – perhaps N1 latency, rather than the amplitude, is more sensitive to this type of training?

• Before & after these training-based paradigms, sensory gating appears normal for those with tinnitus.
Conclusions - overall

Only consider high-level, evidence-based treatments? Consider the individual; & clinically, medically-relevant effects

• Large scale, controlled research studies featuring an intervention & showing modest benefit are considered high-level evidence...

  ...but, such modest/small benefit may be clinically irrelevant for a particular patient

• If an intervention has been shown to halt tinnitus in certain case-series of a specific, rare, sub-form of tinnitus (e.g., carbamazepine treatment in “type-writer-tinnitus”), it is considered to be of relative low evidence...

  ...but, this treatment has absolute clinical relevance for the affected patient

(Langguth, et al., 2011; p. 432)
Only consider high-level, evidence-based treatments?

“Case studies can be salient & we can learn much [from them]...

...randomised control trials are not always, the ‘gold standard’ for everyone.”

(Kleim, 2015)
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- Macquarie University
- Australian Hearing Hub


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