The Tinnitus And Hyperacusis Research Laboratory: From Basic Mechanisms To Clinical Intervention

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Résumé

Cet article présente le Laboratoire de recherche sur les Acouphènes et l'Hyperacousie établi à l'Université de Montréal, Montréal, Québec, Canada. Nos intérêts de recherche couvrent le domaine des sciences de l'audition allant des mécanismes fondamentaux impliqués dans la perception de la sonie jusqu'aux études d'intervention pour les acouphènes et l'hyperacousie. La compréhension des interactions sensorielles et centrales est une caractéristique essentielle de notre programme de recherche. Notre laboratoire possède des équipements et une expertise uniques pour étudier le système auditif de la cochlée jusqu'au cerveau.

Mots clefs : Acouphène, Hyperacousie, Sonie, cochlée, cerveau, système auditif, facteurs non-auditifs

Abstract

This paper introduces the Tinnitus and Hyperacusis Research Laboratory established at the Université de Montréal, Montréal, Québec, Canada. Our research interests span the auditory science domain from basic mechanisms of loudness perception to intervention studies for tinnitus and hyperacusis. Understanding peripheral sensory-central interactions is a hallmark of our research program. Our laboratory has unique facilities and expertise to investigate the auditory system from cochlea to brain.

Keywords: Tinnitus, Hyperacusis, loudness perception, sensory-central interactions, cochlea, brain

1 Introduction

The Tinnitus and Hyperacusis Research Laboratory (http://www.brams.umontreal.ca/labohebert/en/) is nested within the International Laboratory for Brain, Music, and Sound Research located at Université de Montréal, Montréal, Canada, which is jointly affiliated to Université de Montréal and McGill University. We conduct fundamental and clinical research related to tinnitus and hyperacusis, and develop instruments to better characterize normal hearing as well as hearing pathologies.

2 Research themes

Our research focuses on two hearing problems increasingly recognized as major public health issues, namely tinnitus and hyperacusis, and their co-morbidities. Tinnitus – defined as a sound perceived in the ears or head in the absence of an external sound source – presents with variable pitch (humming, whistling) and loudness (soft or loud) qualities. Tinnitus affects approximately 10 to 12 % of the general population, with prevalence rates increasing up to about 30% after age 50 [1] and even higher among workers with occupational hearing loss. Our laboratory develops psychoacoustical methods to better characterize tinnitus [2, 3], in order to improve its diagnosis and study how the tinnitus percept is modified by intervention.

Although tinnitus is well tolerated by most of the affected people, 1 to 2 % experience severe distress. Why this is so is poorly understood. The notion that non-auditory factors play a critical role in tinnitus-related distress is a central theme of our research program, emphasizing the necessity of distinguishing between the sensory (percept) and affective (distress) dimensions of tinnitus. The lack of correlations between the psychoacoustic loudness of tinnitus and distress shown in our work [3] and previous ones [4] is consistent with this idea. Accordingly, our research also focuses on tinnitus co-morbidities such as stress [5-7] and sleep problems [8, 9], and how they can either modulate or be modulated, by the presence of tinnitus- a typical (and intriguing) chicken and egg conundrum.

Hyperacusis is defined as abnormally excessive intolerance to common sounds in the environment, in spite of normal or near-normal hearing. For instance, a hyperacusis sufferer cannot tolerate certain sounds perceived as normal by others, nor tolerate noisy environments. In other words, the person becomes hypersensitive to, and behaviourally ill affected by environmental sounds. Remarkably, there is no consensus concerning the prevalence of hyperacusis, partly because of a lack of objective criteria and variable definition from one study to another.

We have shown that individuals with tinnitus, even the ones displaying normal audiograms, are more sensitive to sounds than individuals without tinnitus [2], suggesting shared mechanisms for tinnitus and hyperacusis; avowedly, there would be a need to consider some pathophysiological differences since hyperacusis can also present without tinnitus. Hyperacusis is at times distinguished from misophonia- a hatred for specific sounds -, and phonophobia – a fear of sound. However, misophonia and phonophobia are ill defined in terms of their symptomatology, nosology (psychiatric *versus* neurological), and pathophysiology.

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Tinnitus and hyperacusis can be viewed as pathologies of loudness perception, which is the attribute of an auditory percept that can be ordered on a scale from quiet to loud. Although the main determinant of loudness is sound intensity, its normal perception can be modulated by non-auditory factors as well as acoustic conditions [see 10 for a recent review]; we are therefore interested in exploring how normal loudness is encoded in the brain and how it can be modulated in normal hearing listeners. In order to better understand the mechanisms of normal loudness, tinnitus and hyperacusis, and to plan intervention studies, our laboratory recruits highly qualified people from a wide range of disciplines: we recruit and welcome graduate students with an Audiology, Neuroscience, Psychology, Music, Engineering, and Life Sciences background.

3 Available Equipment

Laboratory facilities include highest quality audiological clinical equipment, custom-made devices developed over the years, as well as equipment and software used to produce and analyze sound, study physiological responses, and conduct non-invasive brain stimulation.

A quite unique feature of the laboratory is the audiological testing suite allowing the assessment of hearing function from periphery to cortex. Table 1 summarizes the available equipment and assessed hearing functions.

Several specific in-house devices have been developed to conduct research on loudness, tinnitus, and hyperacusis – some of which are the object of exploratory knowledge transfer endeavours with private partners. One such device assesses the spectrum and loudness of tinnitus with a high degree of test-retest reliability [3, 11], an indispensable instrument for conducting intervention studies that target the sound of tinnitus. Another device under development in our laboratory is the psychophysical adaptive task measuring loudness function growth to assess loudness perception [2] using the Tucker-Davis Technology-3 system, a real-time signal processing system.

Through the BRAMS there is on-site access to five BIOPAC mobile systems for the recording of physiological responses such as respiration heart rate, galvanic skin response, five 64-channel BioSemi EEG systems for high-density recording of electrical brain activity, and non-invasive brain stimulation devices such as transcranial magnetic stimulation (TMS) and transcranial direct current stimulation (TDCS). This is only an overview of the available equipment. The whole list of available equipment at the BRAMS is available at http://www.brams.org/en/equipment/.

4 Conclusions

The auditory system and its disturbances provide a unique heuristic vista to explore the relationships between sensory inputs and central processing. Our studies are based on the hypothesis that tinnitus (and hyperacusis) develops from central maladaptive responses thriving on the substratum of disturbed peripheral hearing abilities.

Table 1: Equipment to assess hearing function from cochlea to brain.

Equipment	Tests
Interacoustics AC40 clinical audiometer (calibrated yearly to norms) in soundproof clinical booth	Audiometric tests (free field or headphones)
Otoscope	Ear canal and middle ear
IL 0292 USB-2 – Otodynamics Ltd	Inner ear function: spontaneous otoacoustic emissions and distortic product growth of otoacoustic emissions
Interacoustics Titan tympanometry device	Middle-ear and tympanum functioi
Bio-Logic commercial system in two electrically shielded booths (+ EEG technician)	Auditory brainstem responses (sho and middle latencies)
Larson Davis sound level meters, AEC101 artificial ear, earphones (insert, open-set, closed set)	Sound level measurement and calibration
Ear impression and fitting workstation	Fitting hearing aids, noise generators, custom-made earplugs

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