Continuous monitoring of otoacoustic emissions: a tool to prevent...

Vincent Nadon
Co-author: Jérémie Voix

École de technologie supérieure,
Montreal, Quebec, Canada
Context

[foodmanufacture.co.uk]

[selectsafetysales.com]

Despite all efforts for hearing conservation

[“NIOSH Releases Noise Measurement Database,” 30 September, 2014]

[www.ab-health.co.uk/audiometry/]
still a major occupational issue!
Presentation outline

✓ Context

• Research problem
• Observations from the pilot study
• Objectives of the upcoming study
• Instrumentation and Experimental design
• Conclusions
Research Problem (1)

Measurements are conducted on too long intervals

Usually after the hearing damage has appeared
Research Problem (2)

The risk of hearing trauma, assessed by the current legislation, does not consider the frequency spectrum nor the temporal fluctuations of the noise.
Research Problem (3a)

Recommended maximum 8-hours noise exposure may not be suitable for every individual

Due to their own susceptibility to Noise Induced Hearing Loss (NIHL)
Research Problem (3b)

Noise doses thought harmless for decades might cause damage to auditory nerve fibers (ANF) and inner hair cell (IHC) synapses

[Bharadwaj et al. 2015]

[Sergerenko et al. 2013]

Synapse

Orphan ribbon (Disconnected from ANF terminals)
Simultaneously measure the cumulative dose and the resulting hearing fatigue continuously during exposure.

To assess each worker’s own susceptibility to NIHL.
Distortion product otoacoustic emissions (DPOAEs)
Protective role of the Medial Olivocochlear (MOC) reflex affects outer hair cells

[Kujawa and Liberman, 2015]

It also minimizes neuropathy possibly due to the feedback reduction of cochlear amplification

[Maison et al., 2013]
Monitor growth function of OAEs during noise exposure to detect changes in the cochlear amplification curve

[Research problem → Proposed solution (2)]

[Bharadwaj et al. 2015]
Research problem → Proposed solution (2)

Measure Contralateral Acoustic Stimulation (CAS) DPOAEs post-exposure
➢ observe the onset of MOC reflex (feedback) changes
Pilot experiment: Brief description

• Monitoring DPOAEs
  ➢ during controlled 4h noise exposure
  ➢ with the designed system on 5 human subjects
  ➢ and a reference system on 4 subjects

• Participants wearing hearing protection were exposed on different days to:
  1. White noise ($L_{Aeq,4h} = 85dBA$ in the room)
  2. Industrial noise ($L_{Aeq,4h} = 85dBA$ in the room)
  3. Silent conditions ($L_{Aeq,4h} = \sim45dBA$ in the room)

• Measurements pre and post-exposure:
  A. Pure-tone audiometry (PTA)
  B. Acoustic Reflex Thresholds (ART)
  C. CAS DPOAEs
Pilot experiment: General observations

• Hearing threshold level shifts positive $\rightarrow$ Inconclusive

• Acoustic reflex thresholds $\rightarrow$ not significant fatigue of the middle ear

• MOC reflex the suppressor effect $\rightarrow$ Intersubject variability

• Negative DPOAE level changes in noise conditions $\rightarrow$ Objective of this project
Model showing evolution of DPOAE levels with noise exposure duration

[Adapted from Nadon et al. 2017]
Objectives of the upcoming study

1. Test the designed hearing health monitoring system with Growth function and CAS OAEs monitoring capabilities

2. Observe changes in OAE levels on workers in their real life working conditions/environment over a work week

3. Establish relationship between changes in hearing status and the noise exposure
   A. look for differences between low-exposure and high-exposure groups

4. Observe signs of “hidden hearing loss” in DPOAE measurements with the Growth function and CAS DPOAEs
Instrumentation and Experimental design
Instrumentation:
Auditory Research Platform (ARP)
<table>
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<th>Audio specifications (Soundcard)</th>
<th>• 4 Microphone inputs with signal conditionning circuit</th>
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<tr>
<td></td>
<td>• 4 outputs (loudspeakers)</td>
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<td>• 44.1kHz sampling rate</td>
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<td>• 24 bits audio resolution</td>
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First DPOAE measurements

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<th>Second Measurement</th>
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Experimental design

Monitoring DPOAEs and Noise Exposure levels:

• on about 15-20 subjects continuously through a work week

• in their noisy working conditions

• with the designed DPOAE system + additional reference dosimeter

• Continuous growth function \( \frac{L_1}{L_2} : 60/50 \rightarrow 65/55 \rightarrow 70/60 \text{ dB} \) DPOAE measurements every 20 minutes

• CAS (60 dBA wide-band noise) DPOAEs post-exposure
Typical working day

Pre-exposure tests
15-20 human subjects (normal hearing)
Growth function DPOAE

Inside working environment
Exposure
Growth function DPOAE monitoring
Noise exposure monitoring

Outside working environment
Post-exposure tests
Growth function DPOAEs
CAS DPOAE measurement
Conclusions

• Pilot study

  ➢ changes in absolute DPOAE levels observable during noise exposure

• Upcoming study (~march-april-june 2018)

  ➢ Growth function and CAS DPOAEs will be monitored during and after noise exposure

  ➢ Noise exposure levels will be monitored outside and inside subjects’ ears
Applications and Future work

• Monitoring noise exposure dose + effects on hearing will benefit:
  1. Industrial Workers
  2. Musicians
  3. Military

• Future
  • Daily follow-up of Auditory Brainstem Response (ABR) and Frequency Following Response (FFR) to observe other signs of Hidden hearing loss
STAY TUNED!

Contacts:

Université du Québec, ÉTS, Montréal
jeremie.voix@etsmtl.ca
vincent.nadon@etsmtl.ca

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