# Effects Of Noise Exposure On Hearing Health Evaluated Through Short Interval Otoacoustic Emission Monitoring

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## 1 Introduction

Current advances in hearing research showed that noise exposures that were thought benign for decades are not without any risks [1]. Moderate levels of noise exposure might not induce hearing threshold changes in quiet conditions in the short term, but damage to inner hair cell's synapses and the auditory nerve fibres might occur. These hidden damages to the ear are usually detectable within a few days and usually impede speech intelligibility in noisy conditions [2, 3]. However with current techniques, effects on humans' synapses and auditory nerve fibres are only detectable once the damage is irreversible. Therefore, the methods to detect the hidden hearing damages do not actually prevent them. Fortunately, changes in otoacoustic emission levels are usually detectable within minutes post-exposure and might give insight on the risk of possible underlying damages and therefore it may be possible to take action before it is too late.

The current study was designed to monitor short-term effects of noise exposure on hearing health through close monitoring of otoacoustic emission levels. The growth function parameters of distortion product otoacoustic emissions (DPOAE) measurements were selected to detect changes that could be related to synaptopathy or other inner-ear pathologies onset in industrial workers.

## 2 Monitoring otoacoustic emissions growth functions

Growth function DPOAEs can be used to evaluate two characteristics of OHC damage: 1) the decline in absolute DPOAE level and 2) the linearization of the cochlear amplification. However, testing the entire growth function on the whole DPOAE spectrum on workers *in-situ* in a factory would be time consuming and inefficient. Since the cochlear compression in humans occurs mostly around $L_2$ varying from 50 to 60 dB (SPL) [1], these stimuli levels would be sufficient to observe the onset of changes in cochlear mechanics.

The growth functions were measured with $L_2$ levels increasing from 50 to 60 dB(SPL) in 5 dB step to monitor outer hair cell activity about every 20 minutes. The measurements were performed on $f_2$ frequencies from approximately 4.0 to 6.2 kHz in order to save a few minutes, since DPOAE measurements are time sensitive [4] and DPOAE changes due to noise exposure are mostly detected in high frequencies [5]. The absolute DPOAE levels at $L_1/L_2$ = 65/55 dB(SPL), can be easily extracted from the growth function measurement and compared with other DPOAE measurements over the duration of the noise exposure. As a result, more valuable data is recorded within each measurement.

Participants for the study were selected based on their best ear at the pure-tone audiometry test. Before their work shift, participants were asked to record their DPOAE growth function as a baseline. During their daily noise exposure at work, a timer was set to alarm them every 20 minutes to start a growth function measurement. Unprotected and protected noise exposure levels were respectively recorded continuously with the outer-ear and inner-ear microphones of the hearing protector equipped with electronic components to perform otoacoustic emissions measurements. At the end of their work day, participants recorded a growth function every 3 minutes for 24 minutes.

The low-exposure group consisting in four participants aged between 21 and 31 years old was tested in quiet laboratory conditions at their office desk, with ambient noise levels fluctuating generally between 40 and 65 dB(A). The moderate-exposure group consisting in 3 participants aged between 36 and 44 years old in a CNC machining workshop, was exposed to noise levels fluctuating between 45 and approximately 100 dB(A) at their workplaces.

## 3 Preliminary experimental results

Results from a typical day of measurements on the moderate-exposition group and low-exposition group is displayed in Fig. 1. Measurements at $t_1$= 0 minutes, $t_2$= end of their work shift and at $t_3$= $t_2$ + 30 minutes are shown in order to observe the evolution of the DPOAE levels input/output functions. From left to right an increase in the DPOAE levels should occur due to the increase in DPOAE stimuli levels from $L_2$=50 to 60 dB(SPL). Using the second order polynomial fitting function, the cochlear gain functions can be evaluated for each subjects for the tested frequencies. The second order polynomial function $p(x) = p_1x^2 + p_2x + p_3$ was compared across the various moments in the day (at times $t_1$, $t_2$ and $t_3$) as shown in Fig. 2. The $p_1$ coefficient represents the compression of the cochlear function and is therefore the most interesting in this study.

## 4 Discussion

According to the compression curve presented in the litterature [1], more compression is expected in subjects with normal hearing thresholds. The smaller $p_1$ coefficient magnitude at $t_2$ in Fig. 2 indicates an increase in amplification, instead of compression. This is shown for $f_2$ = 4362 Hz with a participant in the moderate-exposure group. This indicates some

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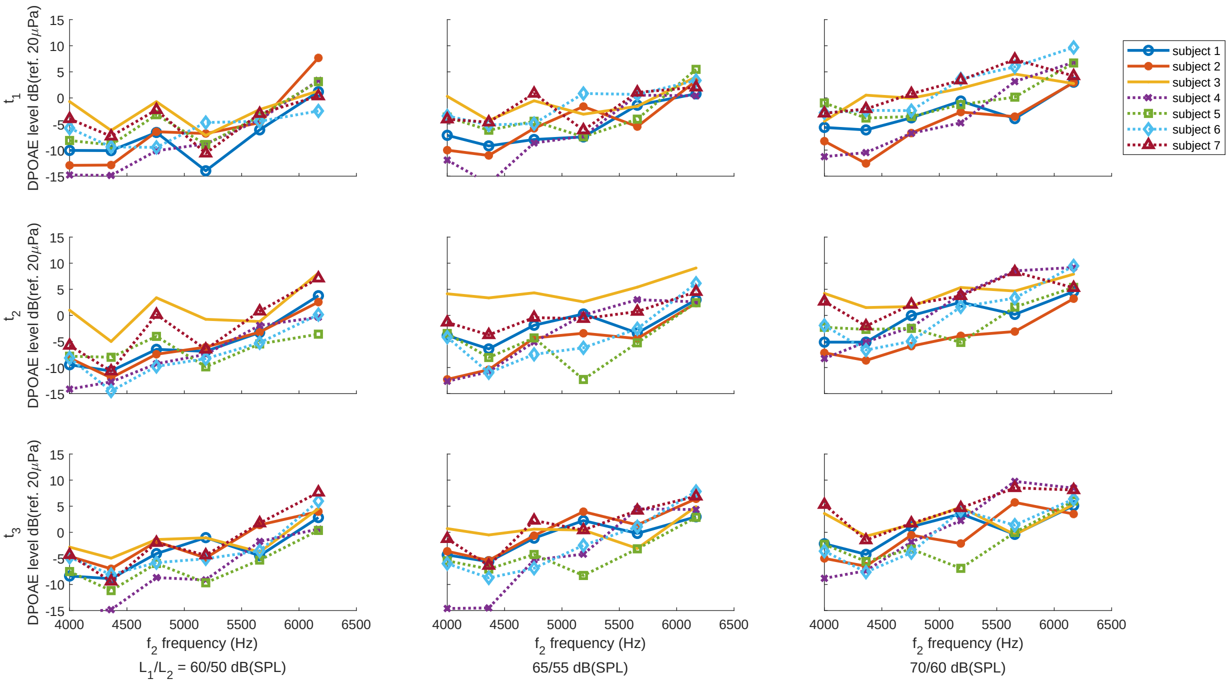


**Figure 1:** Growth function of DPOAEs for $f_2$ frequencies from 4000 to 6169 Hz with three participants from the moderate exposure groups (subjects 1 to 3 in solid lines) and four low exposure participants (subjects 4 to 7 in dotted lines) on a typical workday. Otoacoustic emission levels are displayed at $t_1$= 0 minutes, $t_2$= end of their work shift, $t_3$= $t_2$ + 30 minutes, from top row to bottom row respectively.

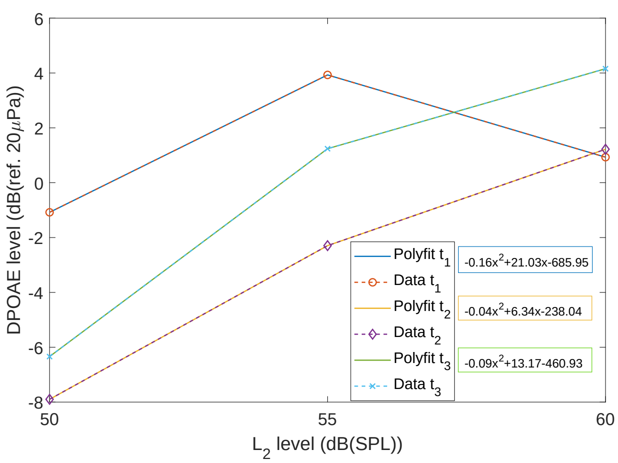


**Figure 2:** Typical growth functions of DPOAE levels with $L_2$ levels ranging from 50 to 60 dB(SPL) with a 5 dB step, displayed with their second order polynomial. These functions were measured at $t_1$, $t_2$ and $t_3$ on one measurement day.

effects of the noise exposure on the ear. More measurements throughout the day and over more days need to be analysed in order to get significant conclusions. Furthermore, participants and daily results should be classified by average levels of noise exposure in order to clearly see the differences in compression between conditions and link the changes to the condition. On the other hand, the results show that DPOAE levels are in general consistent with previously found results, and a good indicator of noise exposure.


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