

# Does Long-Term Headphone Use Affect Hearing Ability?

by Catherine Helferty

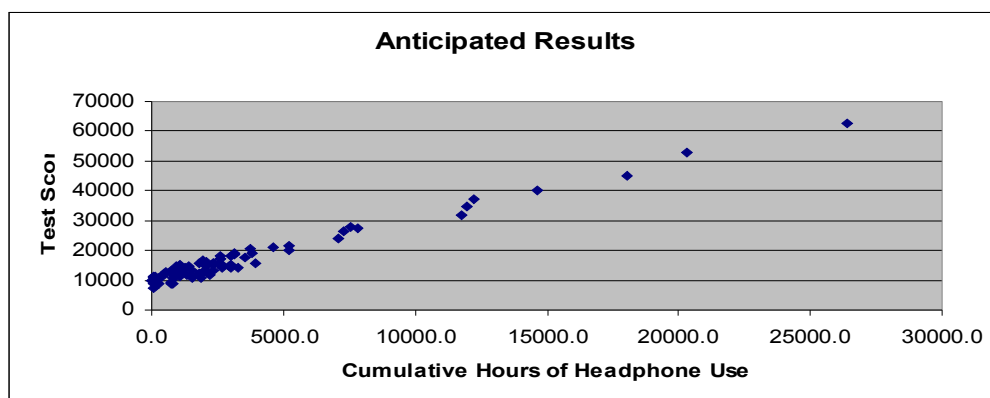
## Background, Purpose and Hypothesis:

The use of headphones for listening to music has increased tremendously over the past 25 years. Sony introduced the first Walkman, a portable stereo cassette tape player with headphones, on July 1, 1979, and it quickly became a social phenomenon, with enormous support from young users. Over the years, the cassette player has been replaced by a CD player or MP3 player, but all of these devices still use headphones or ear buds for personal listening.

Due to the widespread use of these personal listening devices, especially among high school students, and the high volume level I have occasionally noticed some students using, I wondered if some students were damaging their hearing ability.

The purpose of my experiment was to explore the relationship between long-term headphone use and hearing ability. **My hypothesis: An increase in cumulative hours of listening to headphones will result in poorer hearing ability.**

In the hearing tests used for this experiment, volunteers with poorer hearing ability would score higher than volunteers with normal hearing ability. Therefore, I was expecting perhaps a linear relationship between *cumulative hours of headphone use* and *test score*, like the graph below.



## **Procedure:**

### **Preparation of hearing test computer program:**

My first step was to prepare a method for testing the hearing of my student volunteers. I used a computer program called WavePad to create six 60-second hearing test wave files with the following characteristics:

<b>Test</b>	<b>Description</b>
100 Hz Test	100 Hz, 1 second pulses, slowly increasing from 0 amplitude
440 Hz Test	440 Hz, 1 second pulses, slowly increasing from 0 amplitude
1000 Hz Test	1000 Hz, 1 second pulses, slowly increasing from 0 amplitude
3000 Hz Test	3000 Hz, 1 second pulses, slowly increasing from 0 amplitude
Low Frequency Test	Frequency slowly increasing from 20 Hz to 100 Hz, constant amplitude
High Frequency Test	Frequency slowly decreasing from 15000 Hz to 3000 Hz, constant amplitude

These files were incorporated into a Turing computer program that allowed me to collect biographical data from each volunteer, and then record the volunteer's response time when listening to each of the six hearing test wave files through headphones. A longer response time would indicate poorer hearing ability. The following data was collected from each volunteer: sex, birthdate, any known hearing damage, name of school currently attending, number of years using headphones, average number of hours of headphone use per weekday, average number of hours of headphone use per day on weekend, type of headphones used, score on 100 Hz test, score on 440 Hz test, score on 1000 Hz test, score on 3000 Hz test, score on Low Frequency test, score on High Frequency test.

### **Appointments:**

After receiving approval of my project from the appropriate authorities, I used school announcements and sign-up sheets to get student volunteers. I was able to get 125 volunteers and I used three school days to conduct the tests. Out of 125 appointments, 24 students forgot to

attend, so I have results for 101 students.

**Feedback:**

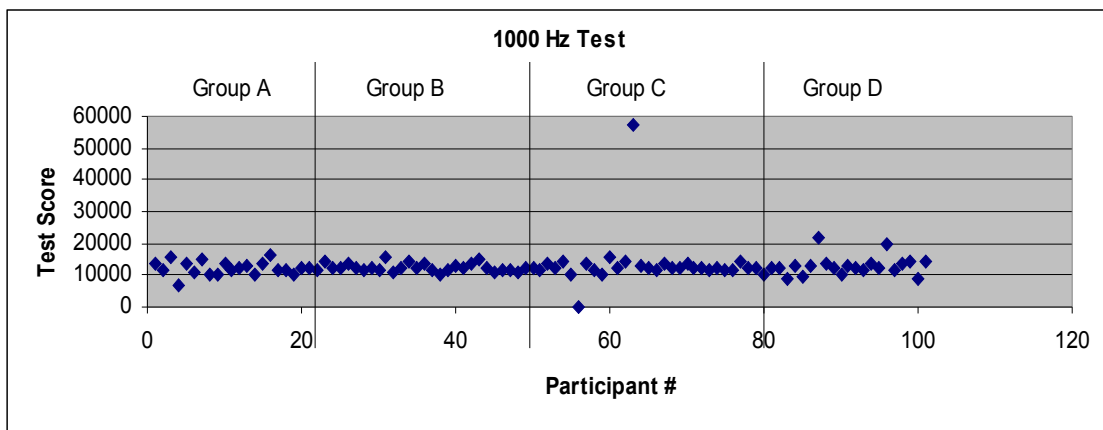
When the experiment was completed, each volunteer received a four-page report containing the general results and conclusions, and their personal results in tabular and graphical form, showing how their results compared with all of the other volunteers.

**Results/Observations and Conclusions:**

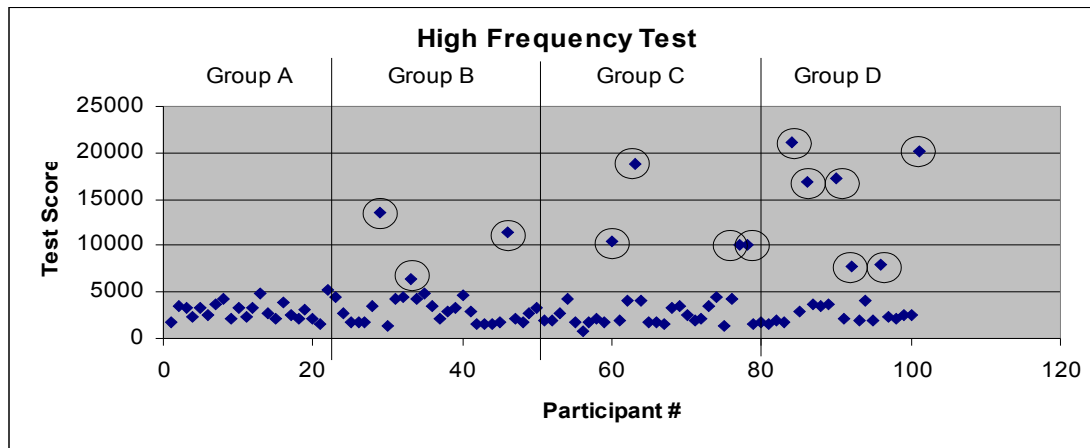
To make the data easier to analyse, it was imported into a Microsoft Excel spreadsheet and sorted in increasing order according to cumulative hours of headphone use. Then each volunteer was assigned a Participant number, from Participant #1(0 hours of headphone use) to Participant #101(26384 hours of headphone use). These were divided into four groups:

Group	Headphone Use	Participant Numbers
A	No headphone use	1 – 22
B	0 – 1500 cumulative hours	23 - 50
C	1500 – 3000 cumulative hours	51 - 79
D	Over 3000 cumulative hours	80 -101

Five of the hearing tests showed no significant difference between headphone users and non-users. For example, the graph below shows the results for the 1000 Hz test, with most volunteers scoring within the same range.



However, the high frequency test showed significantly different results for some headphone users.



This test showed that 13 headphone users have significantly poorer hearing ability, (test scores over 6000), in the extended frequencies, above 3000 Hz. None of the non-users scored over 6000 on this test. To determine the significance of these results, I asked a mathematician to calculate the probability of having no students exhibit poorer hearing ability in Group A, if the 13 high scores were distributed randomly among the four groups. The probability is  $\frac{88}{101} \times \frac{87}{100} \times \frac{86}{99} \times \dots \times \frac{68}{81} \times \frac{67}{80} = 0.032$ . Since these results are very unlikely on a random basis, it is reasonable to conclude that *poorer hearing ability is related to headphone use*.

The distribution of the 13 high scores suggests three other conclusions. First, there were almost twice as many users with poorer hearing ability in Group D, compared to Group B and Group C. This suggests that *poorer hearing ability is more likely to occur among users with a higher number of cumulative hours*.

Secondly, some users in Group B with a relatively low number of cumulative hours exhibit poor hearing ability, while most of the users in Group D with a relatively high number of cumulative hours show normal hearing ability, suggesting that *cumulative hours is not the only variable linked to poorer hearing ability*. Perhaps the user's regular volume setting is another factor affecting hearing ability among headphone users. This factor was not investigated in this

experiment.

Thirdly, the averages of the high scores on the High Frequency test in each group were as follows:

<b>Group</b>	<b>Number of High Scores</b>	<b>Average of High Scores</b>
A	0	n/a
B	3	10468
C	4	12355
D	6	15218

This suggests that *for users who exhibit poorer hearing ability, the damage increases as cumulative hours increase.*

To summarize, a significant percentage, 16% in this experiment, of headphone users appear to have poorer hearing ability than non-users of headphones. Further, increased use of headphones appears to increase the risk of damage and the amount of damage. It appears that another factor, perhaps the user's regular volume setting, may have a significant impact on whether there is any or much damage.

### **Acknowledgements:**

Mr. Jaimie Perry, Principal, Saint Joseph's High School, Renfrew, ON – provided quiet room for conducting hearing tests and supervised the appointment process

Mr. Leonard Helferty, Teacher, Saint Joseph's High School, Renfrew, ON – provided materials and guidance, wrote the Turing computer program to collect biographical and hearing test data from each student volunteer, assisted with mathematical analysis of data

### **Proof of Requirements:**

Forms 4.1B, 4.1C and 4.1D have been completed by the appropriate individuals and are being shipped to the Chief Judge.

**Bibliography:**

<http://www.sony.net/SonyInfo/News/Press/199907/99-059/>

<http://www.chs.ca/info/noise/book3.html>