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# MOBILE APPLICATIONS AS SNORE DETECTOR: TESTING, EVALUATION AND ANALYSIS



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Abstract

## Mobile Applications As Snore Detector: Testing Evaluation And Analysis

Recent studies have shown the dramatic effects of snoring on people's lives. Detection and diagnosis of snoring and other sleep disorder used to depend solely on polysomnography recording which often requires that the patient remain in the hospital or laboratory as the case maybe for several days which is uncomfortable and time-consuming.

Recently Smartphone application software available on the Apple store, Google Play and Windows Phone Store render great benefits for both specialist and patient. These applications have been developed for out patient use and make it possible to avoid inconvenient, time consuming and expensive polysomnography, which can be reserved for critical situations.

This thesis explores various snore detecting application software for Android, Windows and iOS and some of these applications were tested using three different smartphones: HTC Desire, Nokia Lumia, and iPhone 5 respectively at the same time. This aims at determining which application gives better accuracy and on which platform and it also suggests which position is more suitable to place the Smartphone for a more accurate result.

Lastly, the thesis reviews the latest technological innovations in the treatment of snoring as well as possible treatment solutions, and it examines the causes and factors that increase the risk of snoring.

KEYWORDS: Snoring, Sleep Apnea, Application, Software.

# FOREWORD

I give thanks to all mighty God for giving me the knowledge, understanding and strength to complete this thesis. Also, my gratitude goes to all my friends, family and critics that challenged me to see the success of this thesis. My appreciation goes to Patric Granholm who also happens to be my supervisor for shedding more light to this study. My gratitude also goes to Mr Johnson Oyefaderin for his contributions. Finally, I appreciate the supports of my lecturers most especially Poppy Skarli, Balsam Almurrani and Hazem Al-Bermanei for their guidance and support that see me through concluding this study.

2013, Turku

Afeez Kamorudeen

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## **ACRONYMS, ABBREVIATIONS AND SYMBOLS**

OSA	Obstructive Sleep Apnea
Apps	Applications
SD	Secure Digital
OS	Operating System
PRO	Professional
PDA	Personal Digital Assistant
PMP	Portable Media Players
PSG	Polysomnography
CPAP	Continuous Positive Airway Pressure
TAP	Thermal Ablation Palatoplasty
LAUP	Laser Assisted Uvulopaloplasty



# 1. INTRODUCTION

High blood pressure is a global phenomenon that has diverse causes such as snoring among others. Snoring is believed to be an early warning sign of Obstructive Sleep Apnea (OSA).

Normally, snoring is caused by vibration or weakness of the two main structures in one's throat, the uvula and the soft palate vibrate and create snoring sound whenever one cannot get enough air through the breathing passage and since the human nasal cavity is connected to all this as well an obstruction here will cause snoring too. It has posed a number of social and health problems. Snoring can be treated by surgical and therapeutic means but it also requires that the snoring sound is evaluated to know what treatment is suitable for the snorer.

Despite the existence of different treatment methods, the determination of the treatment success is a common problem for both snoring and apnea patients. One way to assess the success of the applied medical treatment is by the use of a medical machine called polysomnography which is expensive and requires that the patient remain in the clinic for the entire period of recording which simply means that it is also time-consuming. Therefore, an alternative method to this process is required. This new method is user-friendly and enables the snorer to do the recording at home while other activities continue as normal and also gives the analysis and result immediately after recording. Meanwhile, the polysomnography can be reserved for critical situations.

In the light of these, this study examines the causes, effects, success of applied medical treatment to snoring.

Finally, it also tests several snore detecting applications on different OS to determine which of them gives more accurate results and analysis and on which mobile device.

## 1.2 METHODOLOGY

The methodology employed in this thesis is usability inspection in the form of heuristic estimation and research based methodology. This aimed at determining which application meets the specification close to Polysomnography and how

efficient they are. This result can be achieved with testing different applications using three different Smartphones with each having different mobile Operating Systems.

### 1.3 RESEARCH QUESTIONS

This study seeks to provide answers to the following research questions.

- (1) What are the available snore detecting mobile applications in the market up till date? How effective are they?
- (2) What position is the best to place the Smartphone to optimize results.
- (3) Which application and on which platform could be recommended for the patient and specialist?

### 1.4 RESEARCH HYPOTHESES

(a) Hypothesis 1:

Null Hypothesis

- (i) There is no relationship between the snorer and the position of the Smartphone.

Alternative Hypothesis

- (ii) There is a relationship between the snorer and the position of the Smartphone.

(b) Hypothesis 2:

Null Hypothesis

- (i) There is no relationship between the intensity of the snore sound and the position of the smartphone.

Alternative Hypothesis

- (ii) There is a relationship between the intensity of the snore sound and the position of the smartphone.

### 1.5 STATEMENT OF THE PROBLEMS

Snoring can cause sleep disruption for both the snorer and anyone who is awakened by the snoring. Many of the telltale signs of insomnia and sleep deprivation are present in the chronic snorer as well as daytime drowsiness, fatigue, irritability and lack of focus are the main symptoms. This study posed the following questions:

- (1) How can snoring be detected and analyzed more quickly, conveniently and cheaply?
- (2) Which of these detectors is/are more effective?
- (3) What are the major causes and effects of snoring?
- (4) Which effective treatment or device can minimize the impacts?

### 1.6 PURPOSE OF THE STUDY

The main purpose of this study was to examine the treatment success of applied medical treatment among others. The specific objectives are:

- (1) To determine which snore detecting application software gives better analysis and result. And to determine the best position to place it to optimize the result.
- (2) To determine the causes of snoring

### 1.7 SCOPE

The scope of this thesis is limited to the following:

- (1) Exploring various snore detecting application software available on three different OS.
- (2) Testing of some of these software to determine which provides better analytical result and on which platform.
- (3) Recording real snoring sound accurately using the phones with snore detector apps on it.
- (4) Evaluating the result to be sure it actually recognizes snore sound while discarding other sounds.

- (5) Determination of the causes and other factor that increase the snoring rate.
- (6) Exploring possible treatment available up till date both medically and otherwise.

Note: Medical devices used to detect snoring and the development of the application software are beyond the scope of this study.

## 1.8 ARRANGEMENT OF WORK

The thesis is divided into six major chapters as described below:

Chapter one: This chapter gives an overview of the thesis. it consists of an introduction, methodology, research questions, research hypotheses, statement of the problems, aims and purpose of the study, significance of the study, scope of the study, and arrangement of work.

Chapter two: This chapter briefly explains mobile applications. It also explores all mobile applications whose functions are to record and analyze snoring sound in both sound and graphical format aiming at substituting or complementing Polysomnography.

Chapter three: This chapter describes the testing of the snore detector application software using real snoring sound generated overnight.

Chapter four: This chapter gives a clear explanation of the causes of snoring, the tissues involved and the factors that increase the risk of snoring.

Chapter five: This chapter treats the possible solutions to snoring. It discusses the success of the solution up till date.

Chapter six: Conclusion.

## 2 MOBILE APPLICATION

A Mobile Application is a piece of software designed to run on mobile devices such as Smartphones, mobile computers, Portable media players, wearable computers, personal digital assistant et cetera. They are often available for download on the mobile OS distribution such as Google Play, Apple Store, BlackBerry App world and Windows Phone Store for Android, Apple, Black Berry, and Windows-based OS respectively. Some applications are completely free; some are free for trial version while others are available for sale. Examples of these applications are Opera Mobile, Quick Office, Remote Control, Bible, Quran, Dictionary, Navigator, Voice Recorder, Heart Beat Analyzers, Snore Detectors and many more. Development of these software applications requires good knowledge of programming languages such as C#, C, C++, Objective C, Java, and so on.

### 2.1 SNORE DETECTING MOBILE APPLICATIONS

There are varieties of these applications on Google Play, Apple Store and Windows Phone Store whose functions are to record, evaluate and graphically analyze sound and vibration after being used. These qualities make them suitable as snore detector. Some of these products have already received recommendations from top health doctors while some are struggling to have bugs fixed.

### 2.2 ANDROID-BASED SNORE DETECTORS

There are a number of free applications on this platform that were deployed with the intention to detect and analyze snoring sound but users' feedback indicates that many of them are still struggling to have bugs fixed. Meanwhile, some applications are available in free and professional version. Two most suitable are Snore Recorder and Snore Clock while Stop Snore performs a similar function but also wakes the snorer whenever snoring is detected by vibrating. Snore Detector acts like every other voice recorder; therefore, it does not meet the requirement for the experimental testing. In light of this, the author focuses the experimental testing on both Snore Recorder and Snore Clock for android OS based devices.

### 2.2.1 SNORE RECORDER

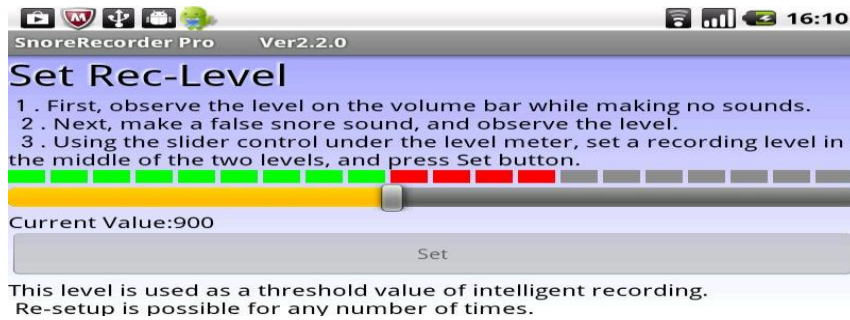
This application software records sound and vibration that exceeds the preset loudness level by the user. This means that sounds below the loudness level are omitted. Otherwise, the users need to set the loudness level zero in order to capture every sound especially if they want to use it as a voice recorder. The application is a pulse-code modulation format which digitally represents sampled analog signals. The descriptions of this product on the website show that some medical doctors already recommend it to patients.

Figure 2.1.1 shows the recording phase, in this case, the intelligent recording button is used to record the surrounding sound overnight and there is a stop button used to stop the recording when the sleeper is awake. The recording phase is also called the main screen. The play button is used to listen to the recordings. The recordings can be heard over and over again; they can be forwarded and can be rewound. The delete bin is used to delete the recordings when no more needed.

The professional version allows users to store the recordings on the SD card and also allow them to view the sound in a visual format [3].



**Figure 2.1.1.** *Recording Phase*



**Figure 2.1.2. Set Loudness Level**

Figure 2.1.2 shows the loudness level control panel, Figure 2.1.3 shows stop and playback phase, Figure 2.1.4 shows the signal generated including both the snore and other recorded signal. This signal can be zoomed to see the snore signals clearly. While Figure 2.1.5 represents the signal after zoom. The dotted spots indicate the snoring phase.



**Figure 2.1.3. Stop and Play Recordings**



**Figure 2.1.4.** *Visual Phase Before Zoom*



**Figure 2.1.5.** *Visual Phase After Zoom*

It is possible to save the recordings on both professional and free versions. In the free version the recordings are being saved by sending them to an e-mail address while the professional version does allow users to save to an SD card in addition to e-mail [3]. The professional version also allows users to view the visual signal phase which is not available on the free version. These differences in features make the free version more or less like an ordinary voice recorder.

## 2.2.2 SNORE CLOCK

The Snore Clock is a sleep analyzer that records snoring and other sounds through the recording periods. It automatically analyzes the data and evaluates the number of snoring phases [4]. It is available on both Google Play and Apple store [5]. The free version is available on Google Play and can be upgraded to the Plus version. Meanwhile, the Apple Store is only offering the Plus version which costs approximately 3 dollars [5]. The free version contains advertisements and delay start but can be removed by upgrading to the Plus version. This application gives users free access to



both the recording and signal phases but the signal phase can be seen only if the display setting of the device is set to automatic rotate. The screen shot is available to easily save the result pictures.

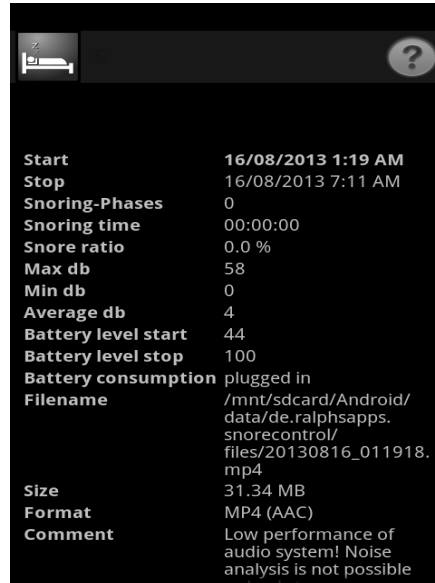
To use this application the user needs to press the record buttons before sleeping. Meanwhile, it requires continuous charging of the phone battery as it consumes the available power. The applications are made to playback at any interval of time. A Demo on how to use the application is available on the website but only in German text.

Figure 2.2.1 shows the recording phase, in this case, the red button is used to record the surrounding sound overnight and it is also used to stop the recording when the sleeper is awake. The recording phase is also called the main screen. The play button is used to listen to the recordings. The recordings can be heard over and over again; they can be forwarded and can be rewound. The delete bin is used to delete the recordings when no more needed.



**Figure 2.2.1.** *Recording Phase*

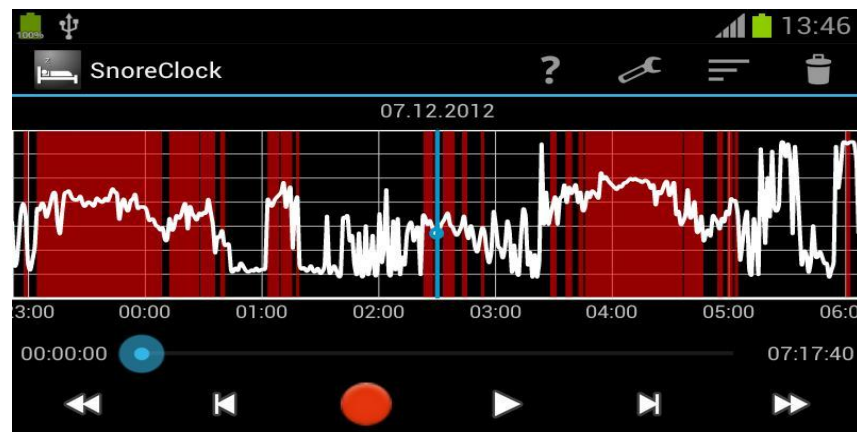
Figure 2.2.2 shows the result and analysis of the whole signals. It also displays the time of start and end and also summarizes the result base on the signal generated.



Start	16/08/2013 1:19 AM
Stop	16/08/2013 7:11 AM
Snoring-Phases	0
Snoring time	00:00:00
Snore ratio	0.0 %
Max db	58
Min db	0
Average db	4
Battery level start	44
Battery level stop	100
Battery consumption	plugged in
Filename	/mnt/sdcard/Android/ data/de.ralpsapps. snorecontrol/ files/20130816_011918. mp4
Size	31.34 MB
Format	MP4 (AAC)
Comment	Low performance of audio system! Noise analysis is not possible

**Figure 2.2.2. Result Phase**

Figure 2.2.3 shows the signal generated including both the snore and other recorded signal. This signal can be zoomed to differentiate the actual snore signals from other sound. The red spots indicate the snoring part [4]. Meanwhile the actual method of detecting the snoring is not available.



**Figure 2.2.3. Signal Flow**

### 2.3 iOS BASED SNORE DETECTOR

The aforementioned Snore Clock is one of many snore-detecting software applications available on Apple Store. The Snore Clock, Snore Check, and Snore Monitor Sleep Lab meet the specifications required by this thesis while Snore Sleep Inspector

contains an additional alarm system which makes it beyond the scope of this study. Therefore, the experimental testing focuses on Snore Check and Snore Monitor Sleep Lab only.

### 2.3.1 SNORE CHECK

This application serves the same purpose as Snore Clock but has a unique approach to reach the goal. The steps involved are as follow:

Download the application

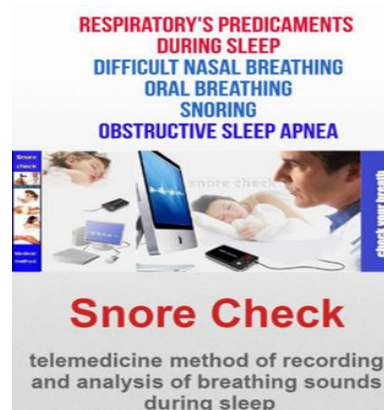
Answer some questions to obtain a unique snore check code.

Record all night sleep to get all sound and snore ready.

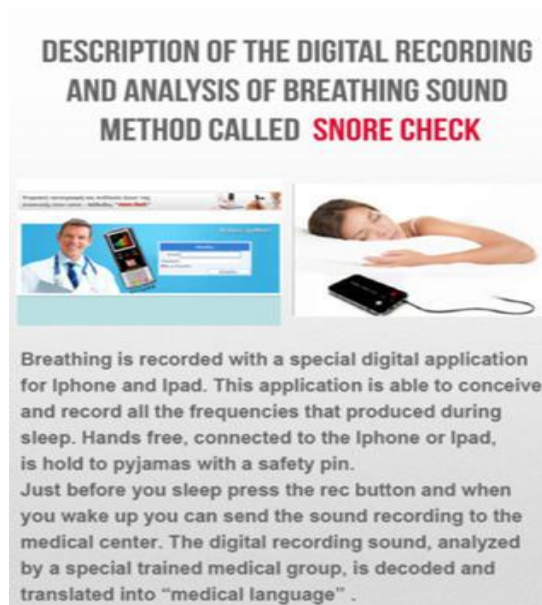
Upload the recordings using the unique code.

A doctor will analyze the recording by decoding into medical language and give feedback later [6].

This approach looks good with the fact that a doctor is actually involved to give results but, on the other hand, a fee will be charged for this service and the feedback might reach the user late which is some kind of delay in processing. Figures 2.3.1 - 2.3.2 give a full description of what the application measures.



**Figure 2.3.1.** *Application Description*



**Figure 2.3.2. Working Process**

### 2.3.2 SNORE MONITOR SLEEP LAB

This application is available in its free and professional version which aims at the following functions [11]:

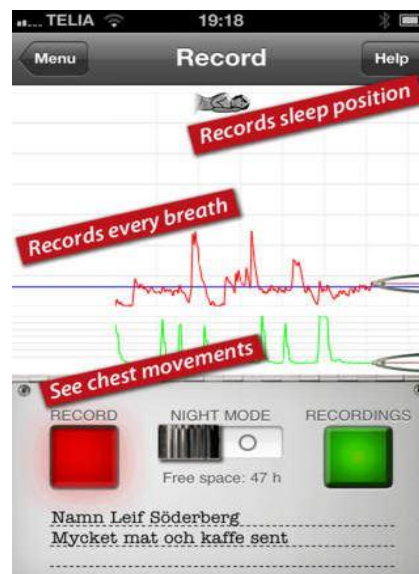
- Record overnight sleep sound and snoring.
- Analyze the recording and provide a graph showing the signal process.
- Display the chest movements graphically.
- Display sleeping positions during different phases of snoring.

The diagrams below give detailed explanation of the product.



**Figure 2.4.1.** *Menu page*

Figure 2.4.1 shows the menu page of the application. This page makes it possible to record and monitor the graphs.



**Figure 2.4.2.** *Graphical and Positioning Representation of Signals*

Figure 2.4.2 shows the sleeping position together with the graphs of the chest movements and sound signals. While Figure 2.4.3 can be generated by zooming out the results from Figure 2.4.2.



**Figure 2.4.3.** Detailed Signal Graphs

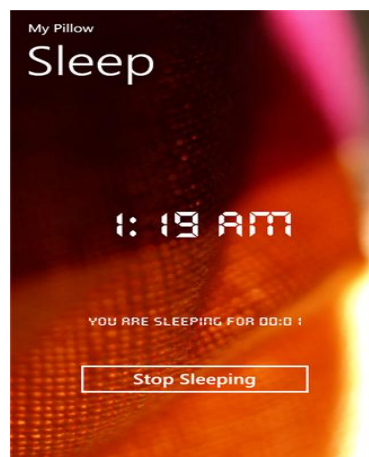
## 2.4 WINDOWS-BASED SNORE DETECTOR

Snore Tracker and Snore Detective are the two software applications that satisfy the requirement of this thesis while others do only voice recording.

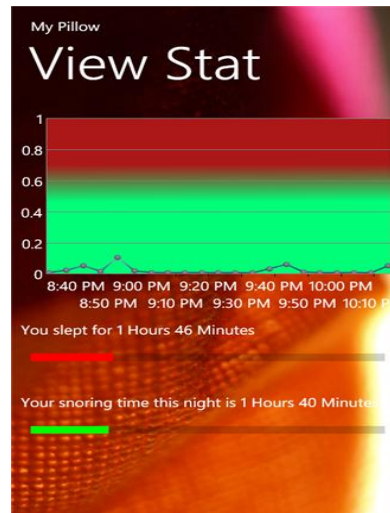
### 2.4.1 SNORE TRACKER

This application records, analyzes and graphically represents sounds. The developer has fixed some bugs resulting in the deployment of a new version and also stated that coming version will be able to plot two night graphs on the same page. It has a trial and a paid version [7].

Figure 2.5.1 shows the recording phase while Figure 2.5.2 shows the graphical phase.



**Figure 2.5.1.** Recording Phase

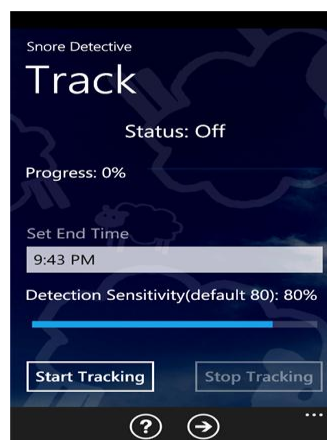


**Figure 2.5.2.** *Graphical Phase*

#### 2.4.2 SNORE DETECTIVE

Snore Detective performs the same function as every other applications discussed in this thesis. It has also comes with a trial and a paid version. The trial version contains full functionality except that it only keeps one history at a time, meaning that a new recording overwrites any existing one [8]. On the other hand, the paid version keeps all records intact. The latest version is v1.2. It is very easy to use with start, stop, delete, statistic and history menu.

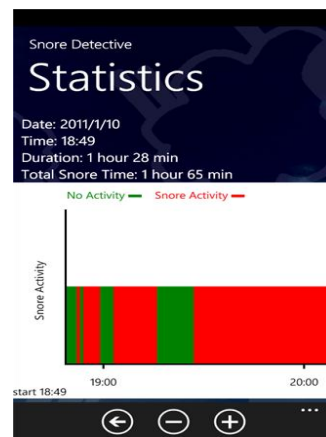
Figures 2.6.1-2.6.3 illustrate the way this application works.



**Figure 2.6.1.** *Recording phase*



**Figure 2.6.2.** *Recording History*



**Figure 2.6.3.** *Statistics and Graphs*

### 3 USABILITY INSPECTION OF THE APPLICATIONS

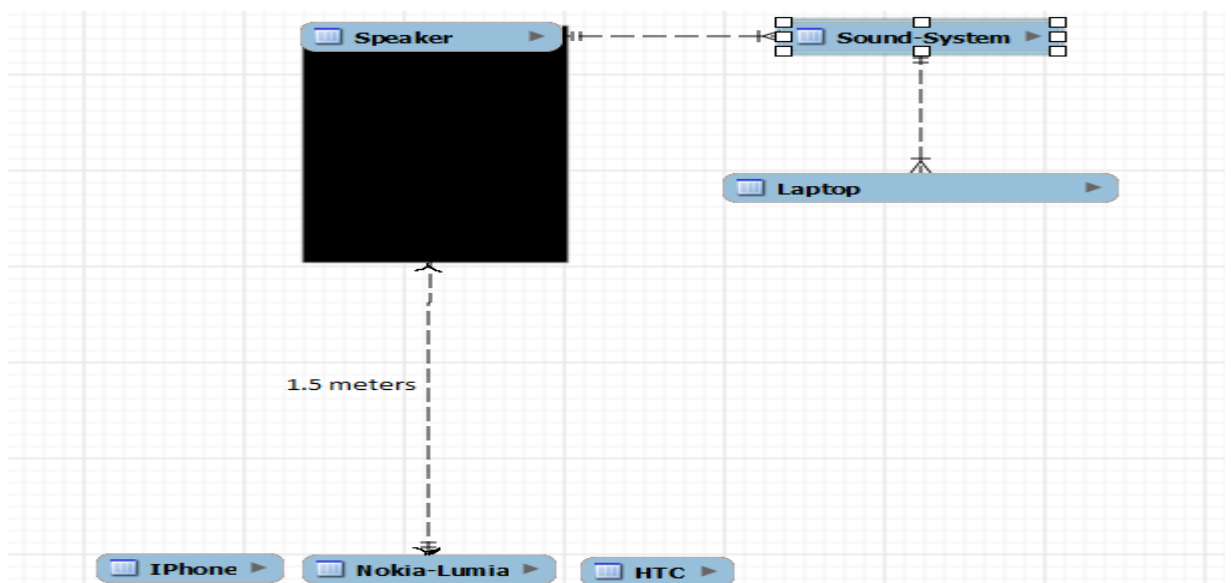
According to Albert Einstein “No amount of experimentation can ever prove me right; a single experiment can prove me wrong”. Therefore, the testing is carried out in two phases; in the first, data was obtained with the three phones placed one and a half meters from the speaker while second data was obtained with the three phones attached to the speaker. See Figures 3.1 and 3.2 for details.

The testing follows the following steps:

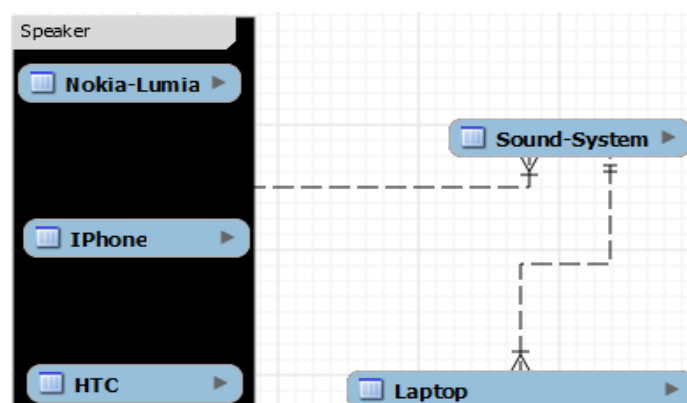
- The snoring sound was recorded over night from a volunteered known snorer.



- The recording was played on an audio device with the standing speaker having three speakers' space available on each.
- Three smartphones were placed one and a half meters away from the speaker for the first phase.
- Three smartphones were attached to the speaker for the second phase.
- The application on each smartphones was used to record the sound at the same time.



**Figure 3.1.** *Test A Setup*



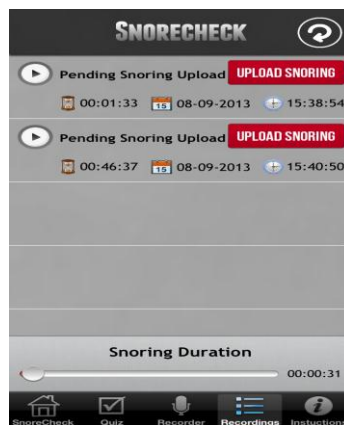
**Figure 3.2.** *Test B Setup*

### 3.1 DISCARDED APPLICATIONS

Three of the six applications selected for testing were discarded and the following reasons:

Snore Recorder, an Android-based snore detecting application was tested and discarded because it requires that the user buy the product before having access to its full functionality. It gives the users access to the only the recordings, while graphs and analysis have to be bought.

Snore Check, an iOS-based application was tested and discarded because it requires that the user send the recordings via a generated code and that a doctor will analyze the sound and then give results and feedback but payment is requested in the process.



**Figure 3.3.** *Snore Check after recording*

Snore Tracker, a Windows-based application was discarded because it is either not available or not available for download in Finland.

This implies that Snore Clock, Snore Monitor Sleep Lab and Snore Detective are the three snore-detecting applications ready for usability inspection for Android, iOS and Windows phones respectively.

### 3.2 TEST A

This testing requires that three phones are placed one and a half meters from the speaker ( SeeFigure 3.1). After this experiment, the following results were generated.

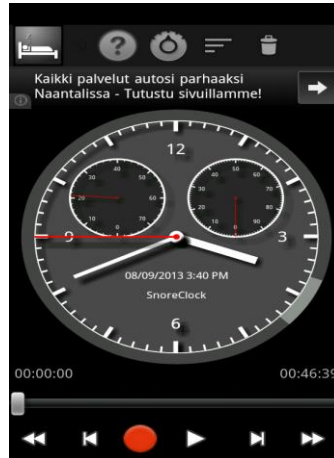


Figure 3.4.1. *Snore Clock Recording Phase Test A*



Figure 3.4.2. *Snore Clock Analysis Phase Test A*

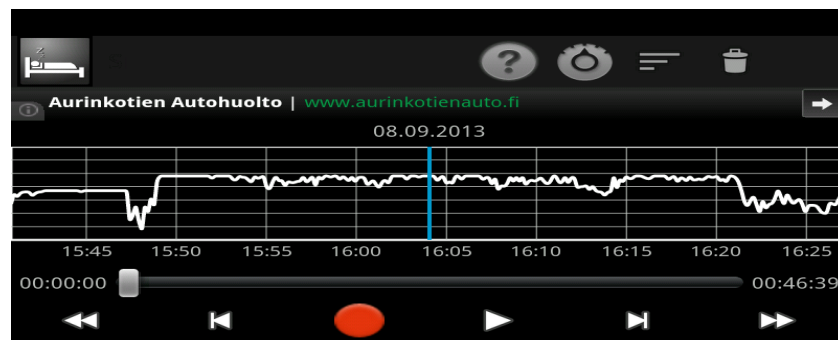
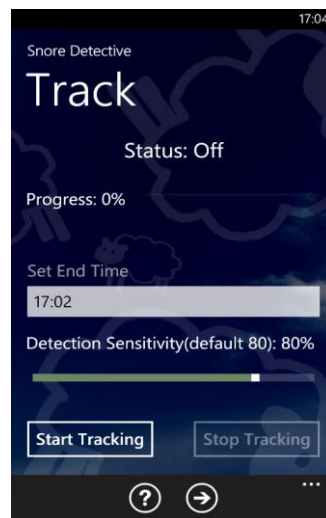


Figure 3.4.3. *Snore Clock Graphical Phase Test A*

### 3.2.1 OBSERVATION ON SNORE CLOCK PHASE A

The following were observed based on the results shown in Figures 3.4.2 - 3.4.3:

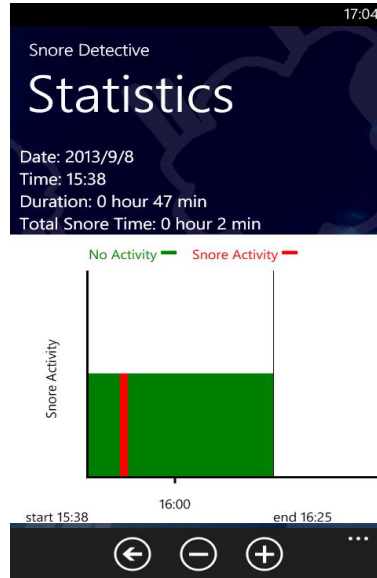
1. Snore Clock does not show records of Snoring-Phases, Snoring time and Snoring ration from the Analysis phase.
2. It does not display the red snoring phase from the graphical phase which means that it recognizes all the snoring as normal sound.



**Figure 3.5.1.** *Snore Detective Recording Phase A*



**Figure 3.5.2.** *Snore Detective Graphical Phase A*



**Figure 3.5.3.** *Snore Detective Graphical Phase A Zoomed Out*

### 3.2.2 OBSERVATIONS ON SNORE MONITOR SLEEP LAB PHASE A

Figures (3.5.2-3.5.3) show that the snoring phase is 2 minutes out of the 47-minute recording time. This result implies that the application recognizes most of the snoring part as an ordinary sound.



**Figure 3.6.** *Snore Monitor SleepLab Positioning, Recording and Graphical Phase A*

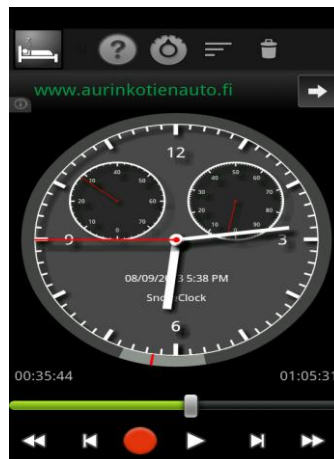
### 3.2.3 OBSERVATIONS ON SNORE DETECTOR PHASE A

1. Figure 3.6 shows most of the recordings as snoring. It displays most of the snoring sound as ordinary snoring( See the appendices). This result implies that the application recognizes most of the snoring and can differentiate between snoring sound, ordinary sound and apnea.

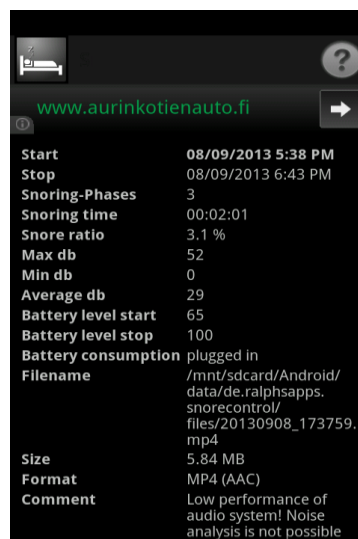
2. It also displays the signal for chest movement together with the snorer's sleeping position at as the time of snoring.

### 3.3 TEST B

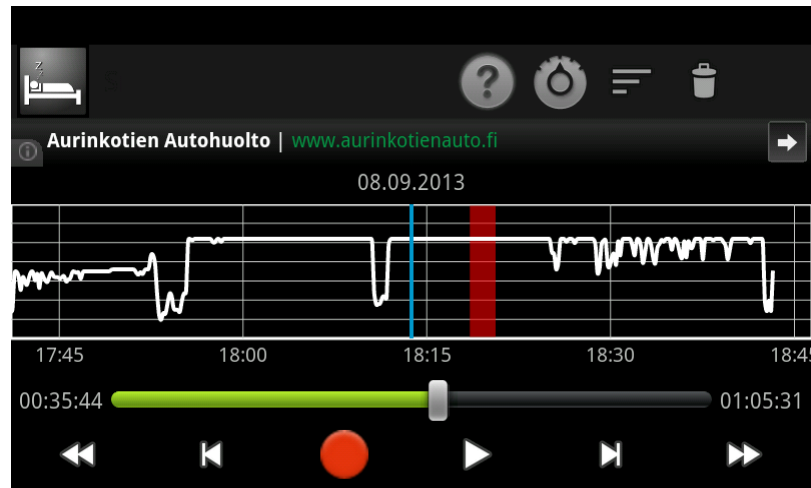
In this test the three phones were attached to the speaker with the same loudness level as in test A. See the test setup as shown in Figure 3.2. After this experiment, the following results were generated:



**Figure 3.7.1.** *Snore Clock Recording Phase Test B*



**Figure 3.7.2.** *Snore Clock Analysis Phase Test B*

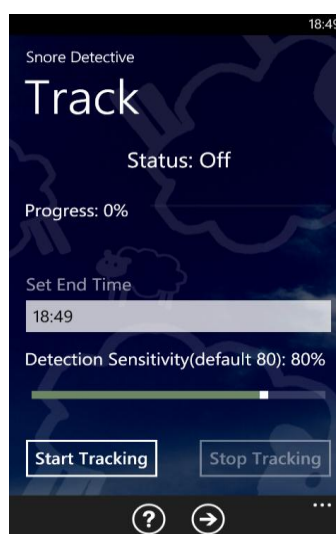


**Figure 3.7.3.** *Snore Clock Graphical Phase Test B*

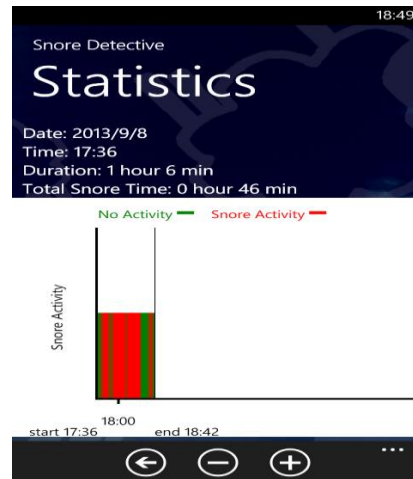
### 3.3.1 OBSERVATION ON SNORE CLOCK PHASE B

The following were observed based on the results shown from Figures 3.7.2 - 3.7.3:

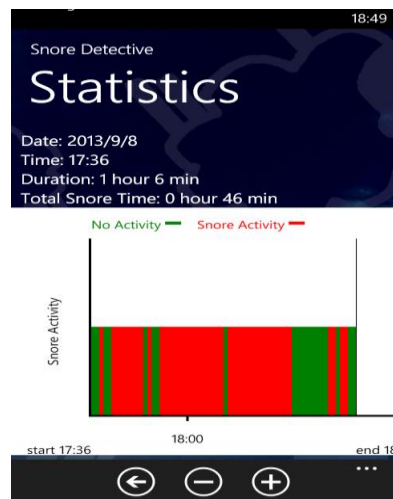
1. Snore Clock recognized 3 snoring phases, 2.01 minutes as Snoring time and 3.1% as Snoring ration from the Analysis phase. This analysis is not close to the expected value.
2. It displays the red snoring phase from the graphical interpretation which means that it recognizes some of the snoring phases.



**Figure 3.8.1.** *Snore Detective Recording Phase B*



**Figure 3.8.2.** *Snore Detective Graphical Phase B*

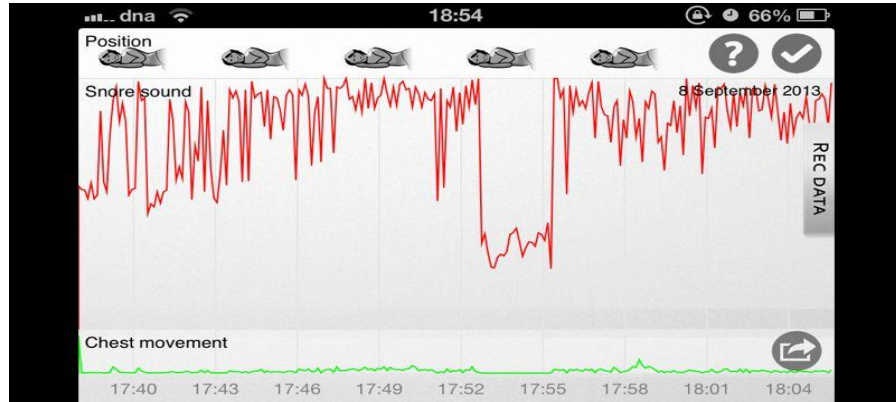


**Figure 3.8.3.** *Snore Detective Graphical Phase B Zoomed Out*

### 3.3.2 OBSERVATIONS ON SNORE MONITOR SLEEP LAB PHASE B

Figures (3.8.2-3.8.3) show that the snoring phase is 46 minutes out of the 1 hour and 6-minute recording time. This result implies that the application recognizes most of the snoring phases.





**Figure 3.9.** *Snore Monitor SleepLab Positioning, Recording and Graphical Phase B*

### 3.3.3 OBSERVATIONS ON SNORE DETECTOR PHASE B

1. Figure 3.9 shows most of the recordings as snoring. It displays most of the snoring as apnea( See the appendices). This result implies that the application recognizes most of the snoring and can differentiate between snoring sound, ordinary sound and Apnea.
2. It also displays the signal for chest movement together with the snorer's sleeping position at as the time of snoring.

## 4 CAUSES OF SNORING

Snoring is caused by the vibration of the soft tissue(s) between the head and neck during sleeping. The vibrations occur following a continuous or interval blockage of air passage [1]. See appendices for a detailed diagram.

The following tissues can be affected:

- **Nasal Passage:** This is the hole of the nose use for breathing. It has some hairs surrounding it that makes it possible to trap down dust, bacteria and other particles that follow the air.
- **Soft Palate:** It is a soft layer of tissues at the back of the roof of the mouth.
- **Base of tongue:** This tissue can be found under the tongue. It can be seen when the tongue is raised up.
- **Tonsils:** This tissue is situated at the back of the throat.
- **Uvula:** It is a cone-shaped small fleshy tissue projecting downward from the middle of the soft palate.

Colds and tonsils can also cause partially blocked airways thereby resulting in snoring.

According to experts, snoring will become worse without treatment since the vibration that occurs during sleeping may damage blood vessels that supply muscles in the head and neck over the years, therefore, reduces their ability to keep air passages open making the snorer to snore loud and often.

### 4.1 FACTORS THAT INCREASE RISK OF SNORING

The following factors increase high risk of snoring [1]:

- **Obesity:** The more the fat tissue on the neck the weaker the throat muscles and therefore increases snoring.
- **Drinking Alcohol:** Intake of alcohol two hours before sleeping relaxes the entire body muscles and therefore increases snoring.
- **Smoking:** Smoking irritates the nose and throat membrane which may block the air flow and lead to high risk of snoring.

- Allergic Rhinitis: Allergic reactions affects the lungs and also affect breathing which in turn increases snoring.
- Sleeping Position: Sleeping with back down in most cases locks the throat to the tongue and will increase snoring.
- Sleeping Pills: Using sleeping pills before sleeping relaxes the body muscles and will increase snoring.

## 5 POSSIBLE SOLUTION TO SNORING

Finding a solution to snoring is not easy as some snoring is caused by different reasons. Therefore, the snorer needs to know the reason why they actually snore. To do this, the snorer needs to take records of their snoring and this can be easily done with the help of snore detecting mobile applications which record the sleep overnight and gives analytical results [1].

There are many devices in the market that could stop snoring but the snorer needs to experiment as much as possible to determine which one is suitable for them. The disadvantage of many of such devices is that they could wake the snorer during sleep instead of preventing snoring which is making some of them unhealthy.

Meanwhile, many devices are proven effective but the problem is that not every device is right for every snorer. Basically, the snorer should be willing to try out different devices and also make some lifestyle changes.

Below are the possible categories of the solution to snoring:

- Precautionary measure
- Medical Treatment
- Device-based

### 5.1 TAKING PRECAUTIONS

It is recommended to try out some precautions related to lifestyle before taking the medical treatment option. The following are to do list if the snorer finds him or herself in such situation [9].

- Stop smoking: Smoking increases the high risk of snoring, this is done by irritating the nose and throat membranes and therefore blocking the air passage.
- Stop using sleeping pills and minimize alcohol: Intake of alcohol and the use of sleeping pills before sleeping relax the muscles in the throat and make snoring worse.

- Exercise: Doing exercises to work out all parts of the body also improves the throat muscles thereby causing less snoring.
- Repositioning: Use special designed pillow that helps to move the jaw and tongue forward and also ensure that the neck muscles are not squeezed. This pillow helps to raise the head high to about 4 inches. In addition, sleeping on the side could open the air passage.
- Avoid heavy meals and caffeine: These should be avoided especially two hours before going to bed.

## 5.2 MEDICAL TREATMENT

Scientists are discovering better treatments for snoring from time to time.

The following are possible medical treatment to snoring:

### 5.2.1 ORAL DEVICES

This device stops snoring by bringing the tongue or the lower jaw forward. It only functions when used otherwise the snore continues. It looks like the athletes' mouth guard. They are available in the online market and also in Pharmacies for approximately 60€. (See Figure 5.1)



**Figure 5.1.** *Oral Device*

### 5.2.2 CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP)

This is a machine that looks like a mask that snorer needs to wear just before sleeping. This device keeps the airways open during sleeping and it does this by providing a constant flow of air through the mask. This in turn eliminates snoring and breathing pauses caused by sleep apnea. Like the oral device, it does not solve the snoring problem it only stops the snoring while used during sleeping otherwise, the snoring continues. Figure 5.2 shows how it looks on the user [9].



**Figure 5.2.** *Continuous Positive Airway Pressure (CPAP)*

### 5.2.3 TRADITIONAL SURGERY

Traditional Surgery: The major reason for this surgery is to increase the size of the airways by surgically correcting errors or removing tissue. The traditional surgery could be Uvulopalatopharyngoplasty (UPPP), Thermal Ablation Palatoplasty (TAP), tonsillectomy, and adenoidectomy. This kind of surgery injects so much pain to the patients which make many people to be afraid of going through such process.

## 5.2.4 LATEST DEVELOPMENT

This is the removal or shrinking of the soft palate using Laser or Radio frequency signal. This aims at eliminating snoring. In this case, the patient gets little or no pain but the surgery is done in different stages.

### 5.2.4.1 LASER SURGERY FOR SNORING

This process is technically called Laser Assisted Uvulopalatoplasty (LAUP) and it is carried out in five stages to slowly shrink the floppy palate and remove the uvula.

This treatment takes about 30 minutes to finish in which a carbon dioxide laser is used to remove the Uvula and reduce the soft palate. This is done with anesthesia. This standard operation gives sore throat while eating for about ten days whereas speaking is not affected and the pain disappears afterwards. The disadvantages in this case are that it is very expensive costing more than 1000€ for the operation and secondly, it does not guarantee 100% solution for snoring since the tongue is also part of the problem causing snoring and sleep apnea [11].

### 5.2.4.2 RADIOFREQUENCY SURGERY FOR SNORING

This process is similar to that of the Laser Surgery except that it requires the use of low-intensity radiofrequency signal to shrink the tissues in the soft palate and that it is less painful. Both types of surgery also have similarity in disadvantages.

## 6. CONCLUSION

After studying the results critically and considering the usability and observations from the two test phases, the following deductions were made:

1. Better results were obtained while the smartphones were attached to the speaker than at one and half meter away from the speaker. This implies that the position of the phones depends on the accuracy of the results and vice versa.
2. Snore Monitor Sleep Lab of Apple Store is on top of the list followed by Snore Detective of the Windows Phone Store and thirdly is the Snore Clock which is also available on the Apple Store. This conclusion was reached based on the level of access to the functionality and the behavior of each app after used.

These applications can be improved by working on the audio part especially the Snore Clock while the discarded applications can make full functionality available for future testing.

Snoring is a serious health problem that shortens one's life span if not given the deserved attention and treatment. However, contributions of medical experts and professionals over the years in the areas of developing devices that detect snoring on one hand and looking for lasting solutions to the ailment cannot be overemphasized. Although a perfect complete solution to snoring has not been achieved, it can be safely concluded that with the amount of medical data available on the ailment coupled with recent discoveries and continuous rapid improvements made on innovative phenomena, a breakthrough would be achieved soon and snoring would be a thing of the past.



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## APPENDICES

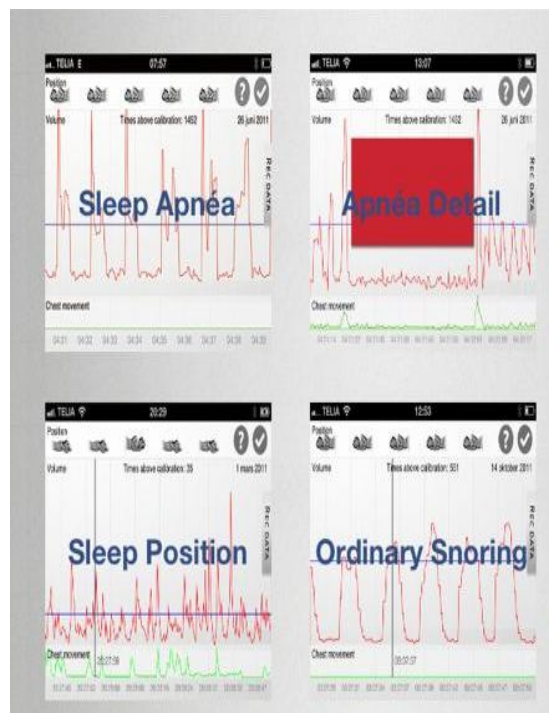


Figure 8.1.1. Wave signals

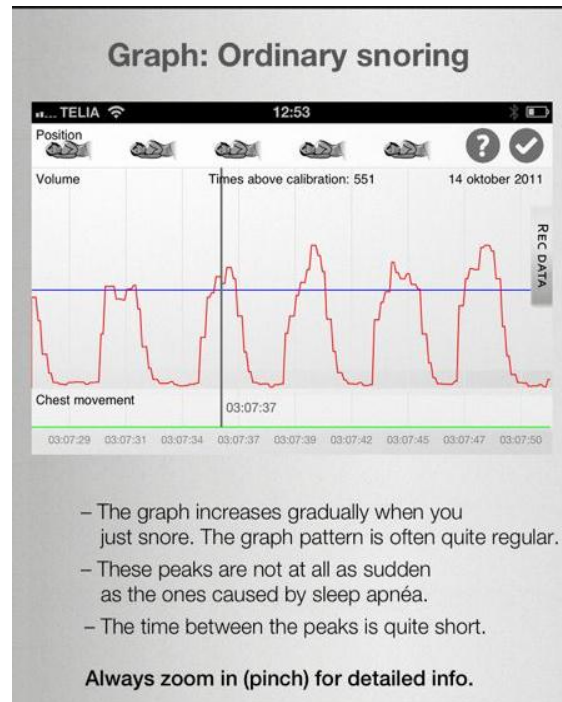


Figure 8.1.2. Wave Signal Of An Ordinary Snoring

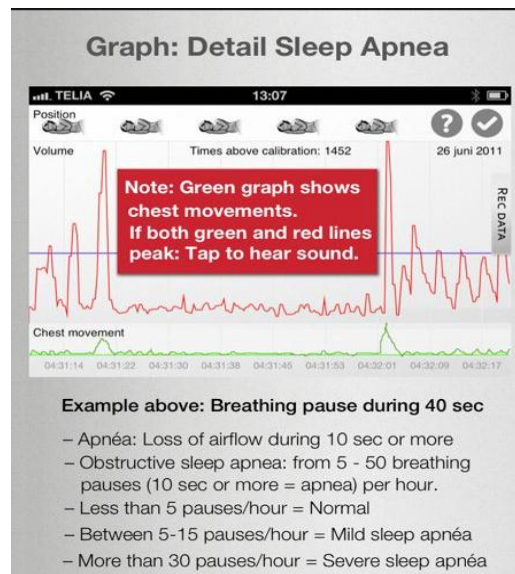
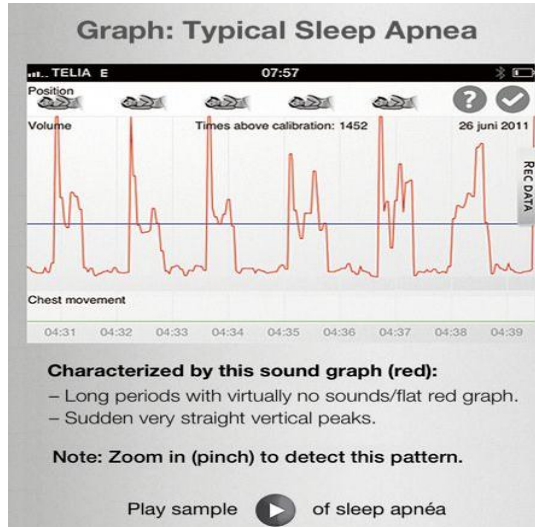
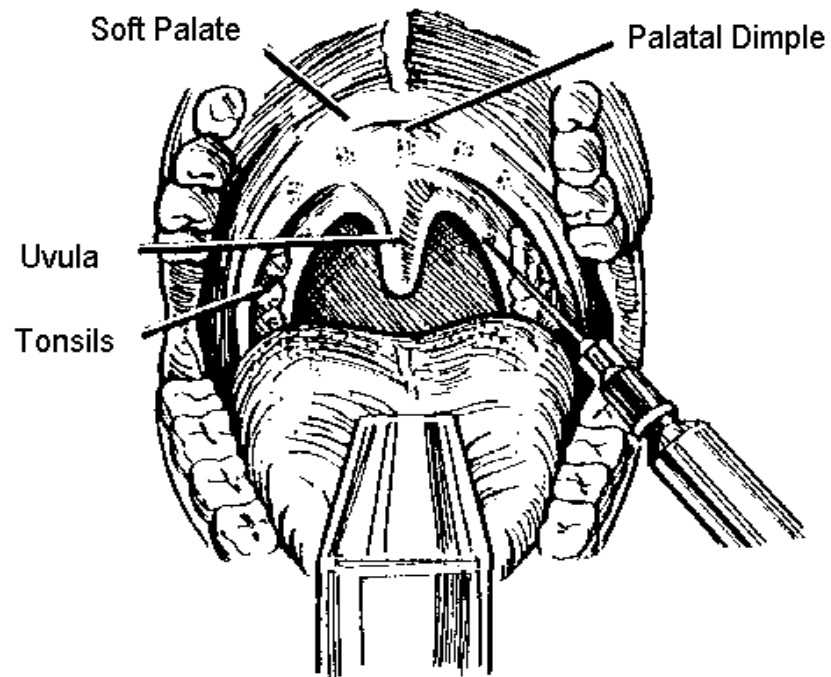


Figure 8.1.3. Wave Signal Of Sleep Apnea Zoomed Out



**Figure 8.1.4.** *Wave Signal Of Sleep Apnea*



**Figure 8.1.5.** *Mouth Tissue*