Optimization of the Effectiveness of Smartphones in Fighting Relapse during Smoking Cessation

by

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April 10, 2015

Abstract

This thesis investigates the effectiveness of smartphones in fighting against relapse during smoking cessation. There are two phases in this research, where the first is the design and development of a smartphone app and the optimization of its effectiveness and the second is the evaluation of the effectiveness against smoking relapse through formal trials. A controlled deep breathing is an effective exercise for smoking withdrawal. Hence, a smartphone app called the Breathing Instructor was developed in order to advise a breathing exercise for the users. A trial was performed on real people in order to identify the effectiveness of the breathing exercise in reaching relaxation, a state desirable for fighting relapse. 20 samples were collected in total where all participants were asked to score how relaxed they feel before and after the exercise. The result of the trial indicated that on average, the participants agreed that they felt more relaxed after performing the breathing exercise delivered by the app. Therefore, smartphones are effective in fighting against relapse in smoking cessation and this thesis lays groundwork for further optimizing its effectiveness.

Acknowledgements

I would like to thank Professor Jonathan Rose for his contribution to this thesis as a great supervisor and a mentor.

I would like to thank all the 20 participants of the trial of the Breathing Instructor app for their willingness to contribute their time and opinion to this thesis.

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1 Introduction

Tobacco smoking is an addictive behavior that increases chance for diseases related to heart, liver and lungs. It kills over 37,000 people in Canada each year, which is more than the deaths attributed to all murders, alcohol-related deaths, car accidents and suicides [1]. The addictive nature of smoking is not only caused by the nicotine contained in the cigarettes, but also by its link to many social activities [2]. Aside from the usage of available medications, the traditional clinical approach in smoking cessation has been through one-on-one counseling with the smokers. However, the expense in both time and money for this process calls for a more effective method to provide help for the smokers who are trying to quit. With the trend towards constantly being connected, one way to connect with these patients could be through the Internet. With the recent advancements in mobile technology, smartphones have proven to be popular with the consumers with its worldwide sale overtaking that of the traditional cellphones [3]. This introduces a possibility that smartphones can be an effective medium in out to the smoking population in order to distribute clinician-approved treatments.

That has lead to investigating the effectiveness of smartphones as an actor in smoking cessation. This research began four months prior to this thesis. Smartphones can distribute the treatment in the form of an app and its design was endeavored with insights provided by the professional clinicians. To minimize delays from miscommunications between different experts in this interdisciplinary project, the development is engaged in a spiral process. This is a design process model that is driven by iterations of initial designing by the engineer followed by feedbacks from the clinicians.

However, the time constraint of this thesis would not allow for many feedback exchanges with the clinicians to take place. For this reason the objective of the thesis was narrowed down to focus on a regaining control during the inevitable relapse, a sub-problem of smoking cessation. Hence, the objective of this thesis is to optimize the effectiveness of smartphones in assisting users to fight relapse in order to maintain their quit state. A smartphone app is developed and tested to evaluate its effectiveness in relieving users from the urge to smoke. Many researches indicate that deep breathing is an exercise effective in abstaining from smoking. Therefore an app that acts as a breathing instructor to advise the users to breathe in a specific pattern was designed and developed. Trials tested for the app's effectiveness in relaxing the users, a desirable state in order to regain control during relapses.

2 Background - Literature Review

2.1 Therapeutic method of Smoking Cessation

The addiction of smoking can be partly treated through the use of medication. These include off-the-shelf products such as nicotine replacement therapies (NRT), Zyban, and Champix. However, smoking cessation through personal efforts, unaided by these medications has shown be the most crucial factor in permanently quitting smoking [1].

To encourage the patients to stay committed in the quitting process, therapeutic assistances such as individual counseling with clinicians and organized group counseling are offered. But as previously described, these services are costly for both the patients and the healthcare professionals. A cost efficient platform to provide the appropriate assistance to the patients is in need and smartphones that are already owned by many smokers may be the answer.

2.2 Smartphone as Platform for Smoking Cessation

With the growing popularity of smartphones, reflected by its worldwide sales of 968 million units in 2013, it has become the most widely used form of mobile phones [3]. From the meetings with clinicians from the Centre of Addiction and Mental Health (CAMH), it was decided that the target audiences of this research are smokers wanting to quit who are typically in the age group of 40-60 years old. The clinicians have confirmed that sufficient portion of their patients in this age group use smartphones, which emphasizes the its potential as an effective platform. The treatment program will be in the form of a smartphone app, which can be developed through software engineering and distributed through the smartphone app store. For this project, we will be developing for Google's Android OS smartphones for its largest market share and ease in programmability compared to its competitors such as iPhone from Apple. Enlisting custom apps on the Google Play Store costs only a one-time fee of $25 USD [4]. The Play Store can show interesting statistics of the app such as its download counts and amount of usage, in addition to allowing direct communication with the users. This is a feature that traditional counseling cannot offer, and it makes the distribution of the app effortless while promoting continuous feedback for improvements. But given these advantages in using smartphones as the platform for smoking cessation, naturally there are already many apps that attempt to do the same. However, most of these apps lack the clinical validation in its effectiveness for smoking cessation.

2.3 Ensuring Clinical Value in the App

Although there are many apps for recovery from addiction in general, many appear to lack formal clinical evaluation in terms of their effectiveness. An experiment conducted by Savic et al from Monash University investigated 87 addiction recovery smartphone applications on the Google Play Store. Savic et al reported that these apps had contents, which were typically information on recovery, enhancement of motivation, and tools to monitor progress, which were rated to be useful by the users according to the online review. However, very few displayed a sign of formal evaluation and research is necessary to verify their effectiveness as stand-alone interventions for smoking cessation [5]. To ensure clinical validity in the app, the research and development was conducted in collaboration with the smoking cessation clinicians from CAMH.

2.4 Summer Work

This research began during the summer of 2014, when a smartphone app was developed based on the therapeutic booklet distributed by CAMH called My Change Plan (MCP) with another undergraduate student from University of Toronto. The MCP tries to act as a counselor during the absence of actual clinicians. The app is not simply a digitized version of MCP, but rather offers dynamic features that take advantage of the programmability of smartphones. These features include the daily-savings-from-quitting calculator, heat map of locations of relapses occurrences and image/video/audio input capability for visual reminder of the reasons for quitting, such as a picture of the patient's child. This work over the summer has commenced the research for the grand objective of optimizing the effectiveness of smartphones for smoking cessation. This thesis investigates the sub-problem of this objective due to the time constraint.

This thesis began in the fall of 2014 and the objective is to optimize the effectiveness of smartphones in relapses during smoking cessation. A relapse is an urge to smoke that is experienced inevitably by the smokers who are in the quitting process. The MCP tried to address this problem through manual logging in a journal, but as previously justified, smartphone apps will be able to provide better support for the patients.

2.5 Breathing Against Relapse

According to the paper authored by McClernon et al, controlled deep breathing is effective in repressing relapses. An experiment was undertaken where 21 healthy volunteer smokers participated in performing a specific breathing pattern in a controlled environment. After refraining from smoking for a certain period of time, the participants were instructed to breathe in the following pattern: five seconds of inhale, two seconds of holding, then five seconds of exhale. This is an imitation of the breathing pattern that is carried out during actual smoking. The subjects performed this exercise several times over the course of four-hour session and each time a questionnaire was answered subsequently for evaluation. The result was that the subjects experienced lower craving for a smoke after the breathing exercise [6]. While it seems natural from this that a smartphone app that instructs users to perform controlled deep breathing exercises to combat relapse should be developed, it is important to note the limitations in this study. Firstly, because the participants were fully informed of the purpose of this study, they may have experienced a relapse different from what they would in a natural environment. Moreover, since the participants were not trying to quit smoking and they understand that they can resume smoking after the experiment, the relapse experienced may not have been severe. Secondly, the evaluation method of questionnaire is subjective due to the difficulty in assessing the degree of craves.

Despite these limitations, the potential of breathing exercise as treatment for smoking should not be overlooked. There are many other researches that point to breathing exercise as effective tool in smoking cessation. For example, Chia-Liang Dai et al has investigated the efficacy of breathing yoga in smoking cessation and the result indicated that it was effective in reducing craving and number of cigarettes smoked during the cessation [7]. For these reasons, the smartphone app will instruct the users through a controlled deep breathing exercise in order to relieve the relapse that they are experiencing.

3 Design

3.1 Thesis Objective

This thesis explores the optimization of the effectiveness of smartphones in fighting relapse during smoking cessation. A smartphone app called the Breathing Instructor is developed to help the users to combat relapse through a breathing exercise. It is designed in such a way that its effectiveness is optimized and it is evaluated through trials on real people.

3.2 Smartphone App Design

3.2.1 Intervention

When the Breathing Instructor app is opened, it will display four buttons in its home menu: Start, History, Instructions and Exit. If the Start button is clicked, the user is taken to a setup page where user is asked to input the duration and the target number of breaths per minute (BPM) for the exercise. Since the users may not have an intuition around BPM values, the app will recommend users to target 8 BPM for their first time. The duration and the target BPM value are used to configure the Breathing Guidance System, the user interface (UI) during the exercise, which indicates the timing at which the users should be inhaling or exhaling. Once user begins the exercise, they are taken to a screen where the Breathing Guidance System guides them through the breathing exercise by indicating when they should inhale or exhale into the microphone of the smartphone. If the user successfully follows the guidance, they have breathed at the target BPM that was set. This exercise ends after the inputted duration and the user is taken to a result page where the actual BPM that the user breathed at is displayed. The BPM and the rating is saved to be used for recommending appropriate target BPM for the next exercise. The result of past exercises can be viewed by clicking the History button in the home menu.

A block diagram that shows the complete navigation within the app and the database accesses is shown in Appendix A.

3.2.2 Type of Breathing Exercises

The Breathing Instructor app offers two types of breathing exercises, one that focuses on achieving a specific BPM and another that focuses on imitating the breathing pattern that is engaged in during actual smoking of cigarette. These types of exercise are called the BPM based exercise and the 5-2-5 based exercise, respectively.

In the BPM based exercise, the user inputs the target BPM that they would like to achieve. During the actual exercise, the Breathing Guidance System will compute and guide the users on when to inhale or exhale in order to achieve this number. The goal of the BPM based exercise is to achieve a low BPM breathing. 3-5 BPM is said to be optimal BPM for resisting relapse [7]. But it is important to note that this is not an easy task. The user should perform the exercise with higher BPM at first and slowly lower the target BPM as he gains experience.

The 5-2-5 exercise was inspired by the experiment by McClernon et al discussed in the section 2.5, where the participants were instructed to breathe in a specific pattern: five seconds inhale, two seconds hold and five seconds exhale (hence the name 5-2-5 based). By performing the breathing exercise with this pattern, the users will be mimicking the cigarette smoking with the smartphone.

3.2.3 Detecting Inhale and Exhale

The microphone on the smartphone is used to detect the exhalation and inhalation during the breathing exercise. Because exhale produces a high sound level while an inhale produces a low sound level, a simple threshold is applied to distinguish the two.

In Android apps, UI processes can only run in the main thread, the initial thread of execution. Therefore, processes such as database queries should be ran on a separate thread, as it will block the UI processes [8]. In order to do so, a new thread is spawned when the exercise starts to collect the 16 bit audio information from a buffer that is populated by the AudioRecord object, which samples the microphone at 8000Hz. An array is used to collect the incoming raw audio information from the buffer.

The raw audio information contains noise that prevents the threshold to classify the breathing state (inhale/exhale) correctly. In order to remove the noise, a low pass filter (LPF) based on the following difference equation is used:

```
y[i] := α * x[i] + (1-α) * y[i-1]
```

Array “y” is the noise-free output, “α” is the smoothing factor and array “x” is the raw audio. This LPF was chosen for its simplicity and its only need to keep the prior value of the output. The “α” value was chosen to be 0.05 from calibration. The threshold to distinguish between the inhale and exhale was also chosen through calibration.

3.2.4 Saved Data

For each instance of a complete exercise, the following information collected into a BreathingData object:

1. *Date and Time:* Used to organize the data
2. *Age:* Basic user profile
3. *Gender:* Basic user profile
4. *Whether you smoke or not:* For trial purpose
5. *Duration:* Longer exercises are better. This information can be used to recommend longer duration if the user has been performing short exercises.
6. *Exercise type:* BPM based or 5-2-5 based
7. *Target BPM:* relevant only for BPM based exercise
8. *Number of breaths taken:* This number is used for calculating BPM
9. *BPM:* The performance measure for the BPM based exercise. This is important because it is the only scientific number that users can see to reflect on their performance.
10. *Level of calmness (before and after):* For trial purpose
11. *Level of restlessness (before and after):* For trial purpose
12. *Level of distress (before and after):* For trial purpose

Item 4, 10, 11, 12 is used for the trial process, which will be explained in detail in section 3.3.

The BreathingData object is stored into a database allocated privately for the app using the SQLiteOpenHelper class. The read and write operation to this database is performed on a dedicated thread that is spawned each time.

3.2.5 Recommendation System

It is important to assume that the users do not have an intuition around the BPM value he or she should be targeting. The ideal BPM of 3-5 BPM is indicated in the instruction page but it is likely that the user will have no idea about the difficulty in achieving it. To overcome this problem, the app will recommend a specific BPM for the users to aim. When the user first uses the app, it will recommend a value of 8 BPM by default. For the later exercises, it will recommend a BPM based on the following pseudo code:

```
if(targetBPM > 3):
    targetBPM := previouslyPerformedBPM – 1;
else:
    targetBPM := 3;
```

Hence, a BPM that is one lower than the previous exercise will be recommended and 3 BPM is the lowest that the app will recommend. The app always recommends the users to spend one minute for the exercise, as shown in the following figure:

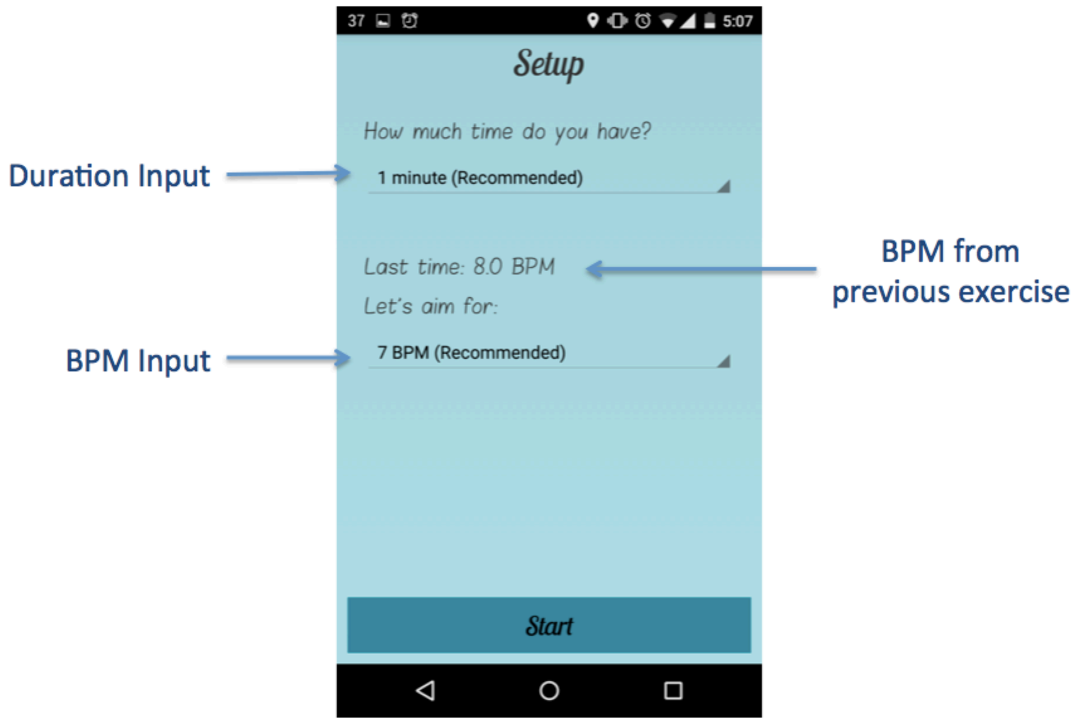


Figure 1: Setup page of the app. The recommended BPM is one less than the previously recorded BPM, slowly bringing the users to the ideal 3-5 BPM.

3.2.6 Breathing Guidance System

In addition to making recommendation, the app will guide the users to breathe at the target BPM chosen. The basic elements in the UI of the Breathing Guidance system are the object that depends on specific UI (e.g. balloon) and its outline. In order to guide the users through the exercise, the size of the outline is systematically adjusted and the user is asked to match it with the size of the object that they can control via breathing into the microphone. By having the users to inhale and exhale at certain rate, the target BPM can be achieved. The duration of the exhale and inhale is computed by the following formula:

```
Duration of Exhale = Duration of Inhale
                   = Duration of Exercise / (2 * targetBPM)
```

The CountDownTimer object starts the central count down timer that tracks the time left for each instance of inhale/exhale and the entire exercise. Aside from the object outline, the timing of the breathing is also narrated in text to allow users to anticipate the next steps in the exercise. The figure below is the Breathing Guidance System with the Balloon Interface.

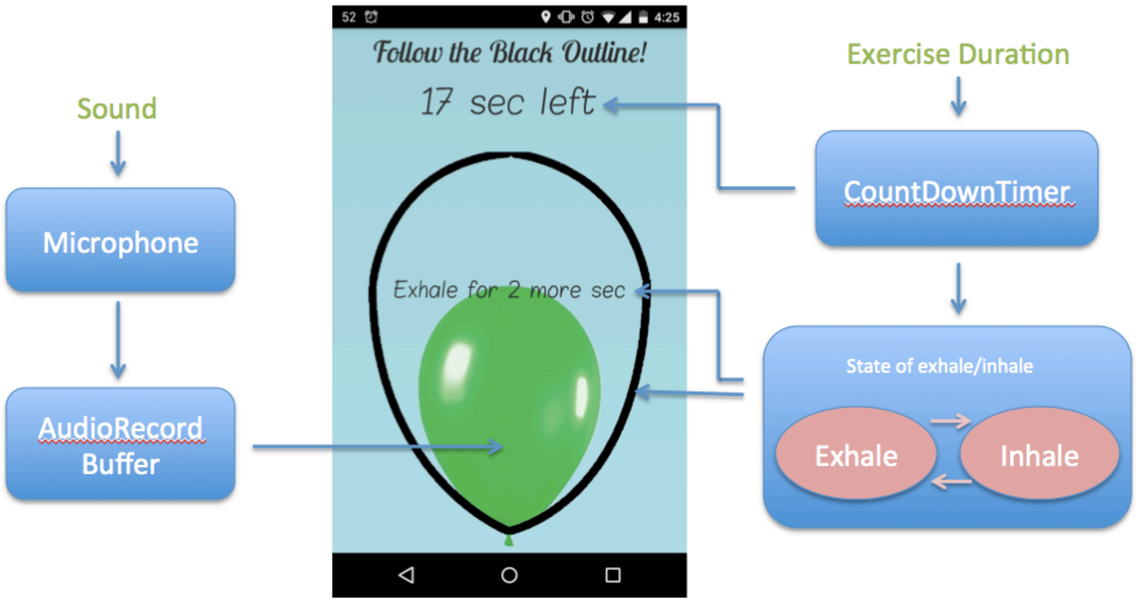


Figure 2: The Breathing Guidance System. The sound levels from breathing is displayed is the image of the balloon. The CountDownTimer object keeps track of the time left for the exercise and the state of breathing by the users, exhale or inhale.

3.2.7 User Interface and Experience

3.2.7.1 General User Interface

This app follows the UI design recommended by the Android Developer Manual that enhances user experience [9]. These include specific overall color scheme, unique fonts, touch feedback buttons and non-UI related processes running in the background. A good UI is invaluable in good apps and it is necessary for the overall optimization of effectiveness of smartphone in fighting relapses.

3.2.7.2 UI for Breathing Guidance System

Great considerations were taken into account for what to display during the exercise. The initial UI was a real-time line graph of the noise-free sound levels sensed by the microphone, which was powered by the AChart engine library. A step function between two levels was displayed concurrently, which represented the sound levels of inhale and exhale, guide the users through the exercise. While this graphical interface allows the users to clearly see that their breathing is being detected, it requires literacy in line graphs to follow the guidance properly. Since the target audience of this app may not have such, this Graphical UI was removed.

In order for users to intuitively follow the guidance provided by the app, the help of animations was needed. The very first implementation of the animation was simply switching between two images of a yoga instructor inhaling and exhaling, henceforth called the Flipping Image UI. This interface allows the users to simply mimic what the yoga instructor is doing and successfully doing so means that the user is breathing at the intended BPM. The weakness of this interface is that there is no microphone feedback for the users to see whether they are breathing properly.

Combining the above implementations finally lead to the Balloon Interface. The controllable balloon image and the size-changing outline addresses the problems faced in the previous interfaces. The users can utilize the microphone feedback reflected in the size of the balloon to follow the guidance represented in an animation in the form of balloon outline. But while this interface allows users to intuitively follow the breathing guidance, the idea of proper posture and diaphragm breathing not reinforced.

It is better to perform the exercise while straightening the back and using the diaphragm to breathe. In order to convey this idea through the Breathing Guidance System rather than through text in the instructions page, the Lung Interface was implemented. This interface is similar to the Balloon Interface in the sense that the user tries to match the size of an object with its changing outline. But instead of the balloon, it is an image of a lung with an image of a yoga instructor in the back. By having the yoga instructor with the proper posture and arrows indicating her diaphragm movement, she acts as a “breathing instructor” for the users to copy.

But t is important to note that the choice between the Balloon and the Lung Interface is a tradeoff between simplicity and more information. The Balloon Interface is simple to follow because the only object displayed is the balloon and its outline. In comparison, the Lung Interface has the lung, its outline, the yoga instructor and arrows for the diaphragm movement. The preference between the two interfaces is determined by the trial that was performed on real people.

The four different UI that was described above is shown in Appendix B.

3.3 Evaluation of Effectiveness

3.3.1 Formal Trial

To reiterate, the objective of this thesis is to optimize the effectiveness of smartphones in guiding the users through a breathing exercise to better deal with relapses in smoking cessation. Hence, an evaluation is essential in assessing the effectiveness of the Breathing Instructor app and it is natural to do so by having actual people use it by conducting a formal trial. The most appropriate sample profile would be the smoking patients from CAMH. However, this is infeasible for the scope of this thesis since it is expensive in both time and money to get the right ethics approval and to collect the right participants for experiment. In order to circumvent this issue, an assumption is made where relaxation is the desirable state in combatting relapse. This is justified by a study that suggests that relaxation improves positive mood and increases awareness in a person [7]. This effect should help the users experiencing relapse to regain their consciousness and remind them of their goal to quit. This assumption greatly simplifies the sample collection because the trial can now be done not only on smokers but also non-smokers since it is how well the app can relax the user that is tested.

3.3.2 Methodology

To formalize, the objective of the trial is to evaluate the effectiveness of solely the breathing exercise delivered by the app in bringing users to relaxation. Hence, the breathing exercise needs to be isolated within the app in order to eliminate external factors. To achieve this, the participants of the trial are asked to answer the same questionnaires immediately before and after the exercise. This way, the effect of the solely the breathing exercise is reflected in the change in the questionnaire answers.

The same trial procedure was endeavored for each participant in order to best eliminate the cross sample variances. First, a specific instruction with a one-time demo is given to the participant. Then, a pre-exercise questionnaire is asked. After the questionnaire is answered, the participants performed the BPM based breathing exercise for 1 minute with a target of 5 BPM. Once the exercise is done, the post-exercise questionnaire is answered in order for comparison. Lastly, the participants are asked to fill out a survey on general improvements for the app.

The flow diagram of the trial method is shown in Appendix C.

3.3.3 Questionnaire

The questionnaire that was answered before and after the exercise is derived from an established scale for calmness rating, called the Vancouver Interaction and Calmness Scale (VICS) shown in Appendix D. This scale contains a total of 10 questions based on Likert Scale of 1-6. The 10 rating is summed and the calmness of the surveyor is scored from out of 60. The VICS could not be directly used for the evaluation of the breathing exercise because it includes questions irrelevant in this context, such as how well the patient slept, which cannot be asked from the participants before and after the exercise. A person who is observing the patient scores the 10 ratings in the VICS. But in the context of this trial, the change in relaxation is hard to be observed from the outside because the trial time is very short and it is not conducted in a controlled environment.

With those in consideration, the irrelevant questions in VICS were discarded and the custom questionnaire asks the participants to score themselves on three items on the scale of 1-6: the calmness, restlessness, and the level of distress that they are experiencing at that moment. The change in the rating between the pre- and post- exercise questionnaire shows the effectiveness of the breathing exercise on the level of relaxation of the participant. This complete custom questionnaire is shown in Appendix E. Due to the insertion of the two questionnaires, the version of the app used for the trial is different from the standalone version of the app shown in Appendix A.

3.3.4 Survey

In addition to the questionnaire, the trial participants are asked to fill out a survey on paper. In the survey, the participants are asked to comment on the breathing exercise, the readability of the UI during the exercise and any other aspect of the trial. This survey is shown in Appendix F.

The purpose of this survey is to gain the perspective of the users on the app in order to identify biases or negligence that may have occurred during the development process. This is particularly important in this thesis where there is only one developer and the effectiveness of what is being developed is subjective to personal preferences. Although the development process has been undertaken with constant feedback from the thesis supervisor and colleagues, this survey collects more formal constructive criticism.

3.3.5 Samples

A total of 20 samples were collected, 10 with the Balloon Interface and another 10 with the Lung Interface. The samples were students found in the Engineering Science common room located in the Bahen Centre of Technology in University of Toronto.

4 Result and Discussion

4.1 Trial Results

4.1.1 Sample Profile

As described above, the 20 samples were students of Engineering Science program at the University of Toronto. For the Balloon Interface, the average age of the 10 samples was 22.2 and 9 were male and one was female. Similarly, for the Lung Interface, the average age of the 10 samples was 22.1, where 7 were male and 3 were female. None of these samples considered themselves a smoker, but again, this information is irrelevant due to the assumption made about the link between relaxation and fighting relapse.

4.1.2 Questionnaire Result

The questionnaire showed that the breathing exercise was able to make the users feel more relaxed. The graph below shows the change in the three ratings before and after performing the exercise with the Balloon Interface.

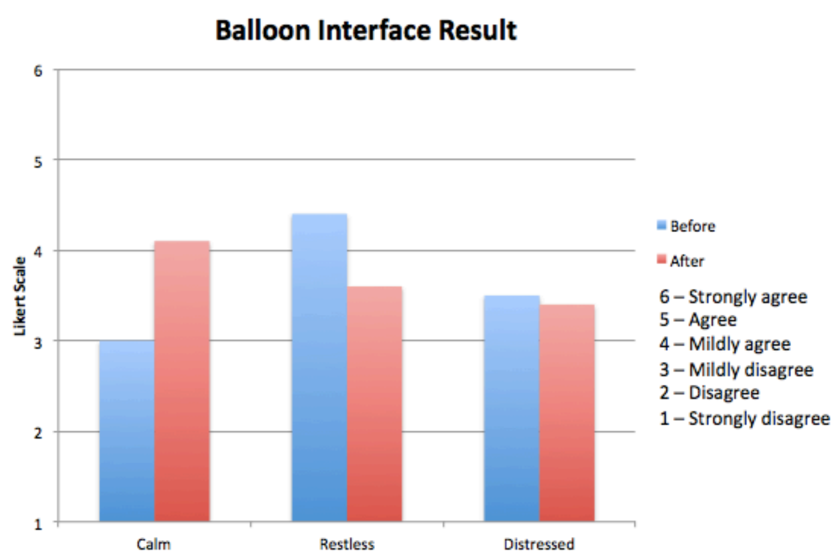


Figure 3: The average score of calmness, restlessness and level of distress before (blue) and after (red) with the Balloon Interface

The average level of calmness increased from 3 to 4.1, level of restlessness decreased from 4.4 to 3.6 and the level of distress decreased from 3.5 to 3.4. Again, aside from the minimal change in the level of distress, the change in the rating indicates that the breathing exercise helped the participants to feel more relaxed.

A similar result was obtained with the Lung Interface. The below graph shows the change the breathing exercise with the Lung Interface had on the three measures of relaxation.

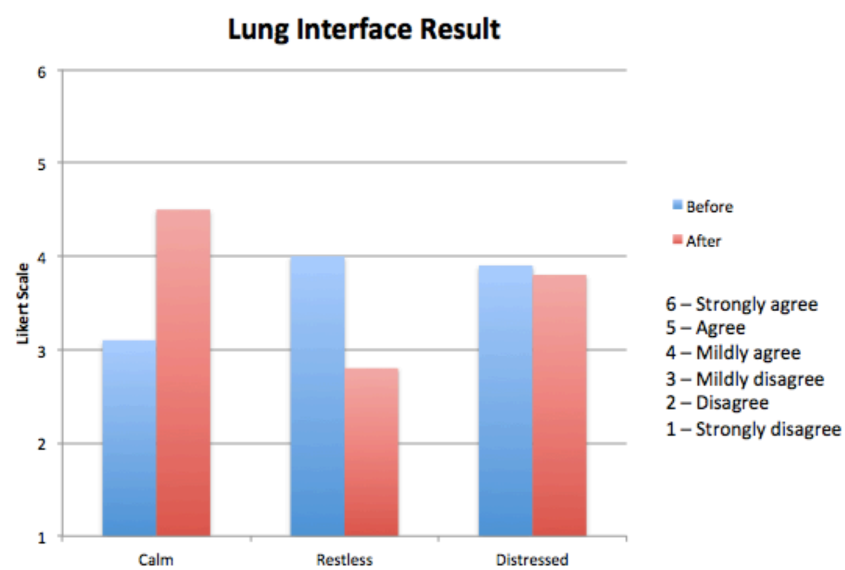


Figure 4: The average score of calmness, restlessness and level of distress before (blue) and after (red) with the Lung Interface

For the Lung Interface, the average level of calmness increased from 3.1 to 4.5, level of restlessness decreased from 4 to 2.8 and the level of distress decreased from 3.9 to 3.8. The change in the level of calmness and restlessness implies again that participants on average agree that they felt calmer after performing the exercise.

The actual BPM that the app collected from the participants were 10 BPM and 5.8 BPM for the Balloon and Lung Interface, respectively. This indicates the need for recalibration on the applied threshold and the smoothing constant on the LPF for the Balloon Interface. But again, since the actual BPM of the exercise is recorded in the background during the exercise and displayed only after the questionnaire, it has no effect in skewing the relaxation scores. The questionnaire result that the above graphs were constructed from is shown in a tabular form in Appendix G.

4.1.3 Survey Results

The survey that was asked in the end suggested many improvements for the app, such as:

- Ready timer that indicates when the exercise starts
- Audio instruction for guidance during exercise
- Music to accompany the exercise
- Angle to breathe into the microphone is not intuitive

In addition some feedbacks went on further to comment on the general app as a standalone product. Furthermore, some of the feedbacks led to realization of the flaws in the evaluation method that were not overlooked during its design.

4.2 Limitations of Evaluation

Although the result directly indicates that the breathing exercise delivered by the smartphone is effective in relaxing the users and hence helping them better at dealing with relapse, the limitations of the evaluation method must be noted.

One of the limitations is that the trial participants were asked to specifically perform the exercise for 1 minute with a target of 5 BPM. This is the ideal BPM for fighting relapse but it is challenging to achieve this on the first try. Consequently, the participants might have been out of breath instead of feeling relaxed, defeating the purpose of the exercise. Because all participants must be trialed with the same BPM for consistency, asking to perform the exercise with a less demanding BPM may have been more suitable.

Another limitation is that the samples that were collected were all Engineering Science students at University of Toronto. While they are applicable in testing the effectiveness of the breathing exercise, their literacy in terms of using the smartphones and following the instruction given is likely to be higher than the actual target audience who are struggling to quit smoking. Therefore, a mixture in the academic background of the samples might have made the collect results more relevant.

There was also a flaw in the design of the questionnaire page. Because the values are chosen using a slide bar that was preset to 3 (Mildly disagree), the participants could have wrongly had the impression that it was the neutral level of relaxation. In order to avoid this bias, the method of input should have been a drop-down menu so that the relaxation values do not have to be preset.

Finally, it is important to mention the subjective nature of self-rating the level of relaxation that is experienced. Everyone has a different definition of what relaxation is and furthermore, calmness, restlessness and level of distress are terms that intuitively mean the same thing. Therefore, participants were forced to answer the questionnaire based on their definition of those terms, which makes the questionnaire subjective to each participant.

5 Conclusion

Despite the limitations of the evaluation method discussed above, the result of the questionnaire still indicates that the breathing exercise was able to help the participants to relax. Consequently, the Breathing Instructor app is effective in helping the users reach the state optimized for fighting against smoking relapse. The survey showed a mixed opinion on the possible improvements on the Breathing Instructor app, especially in the choice of the UI for the Breathing Guidance System. This calls for a more formal approach in UI design from the human-computer interaction field.

The time constraint of this thesis prevented the Breathing Instructor app to be evaluated by the expertise of smoking cessation clinicians. Nevertheless, the positive result of the trial will be of interest to the clinicians and will fuel the potential of smartphones not only in smoking cessation, but also in addiction and mental health in general where there are still issues with proper diagnosis and patient monitoring.

The ability of smartphones to help users fight against relapse shown by the trial result along with the ideas for improvement to further optimize its effectiveness that this thesis describes provides a solid groundwork for further research in the potential of smartphones as an actor in smoking cessation.

References

[1] Simon Chapman and Ross MacKenzie, "The Global Research Neglect of Unassisted Smoking Cessation: Causes and Consequences," School of Public Health, University of Sydney, Australia. PLos Med. 7(2). Feb 2010.

[2] June 2011. *General Smoking Facts* [Online]. American Lung Association. Available: http://www.lung.org/stop-smoking/about-smoking/facts-figures/general-smoking-facts.html

[3] Natasha Lomas. (2014, Feb 13). *Gartner: Smartphone Sales Finally Beat Out Dumb Phone Sales Globally in 2013 With 968M Units Sold* [Online]. Available: http://techcrunch.com/2014/02/13/smartphones-outsell-dumb-phones-globally/

[4] *Get Started with Publishing* [Online]. Available: http://developer.android.com/distribute/googleplay/start.html

[5] Michael Savic et al., "Exploring the Focus and Experiences of Smartphone Applications for Addiction Recovery," Turning Point Alcohol and Drug Centre, Eastern Health and Eastern Health Clinical School, Monash Univ., Melbourne. 2013.

[6] McClernon et al. "The effects of controlled deep breathing on smoking withdrawal symptoms in dependent smokers," Dept. of Psychiatry, Nicotine Research Program and Dept. of Medicine, Smoking Research Laboratory, Duke Univ. and Durham VA Medical Centers, North Carolina. 2004.

[7] Chia-Liang Dai and Manoj Sharma, "Between Inhale and Exhale: Yoga as an Intervention in Smoking Cessation," Journal of Evidence-Based Complementary & Alternative Medicine. Jan 2014, vol. 19.

[8] Processes and Threads [Online]. Available: http://developer.android.com/guide/components/processes-and-threads.html

[9] Android Design Principles [Online]. Available: http://developer.android.com/design/get-started/principles.html

Appendix

Appendix A – Breathing Instructor App Block Diagram

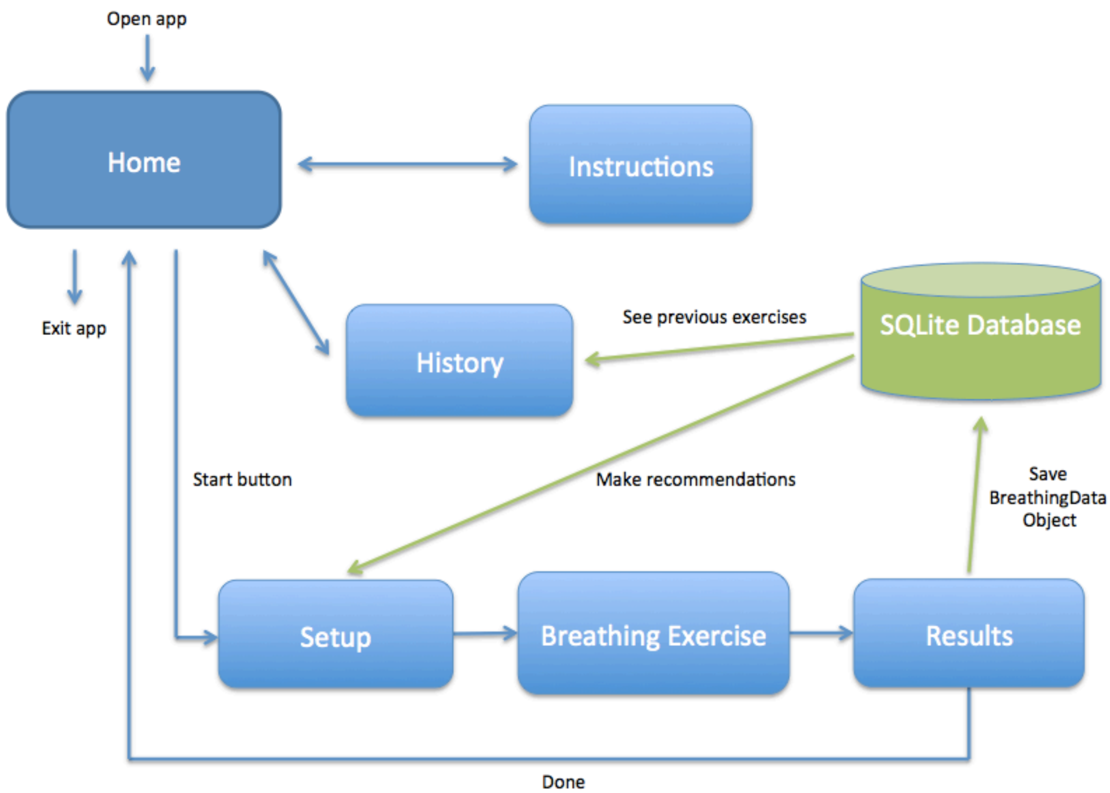


Figure 5: Block diagram of the smartphone app. The blue blocks shows the pages the users can navigate between. The green block shows the app's interaction with device internal database.

Appendix B – Evolution of Breathing Guidance System UI

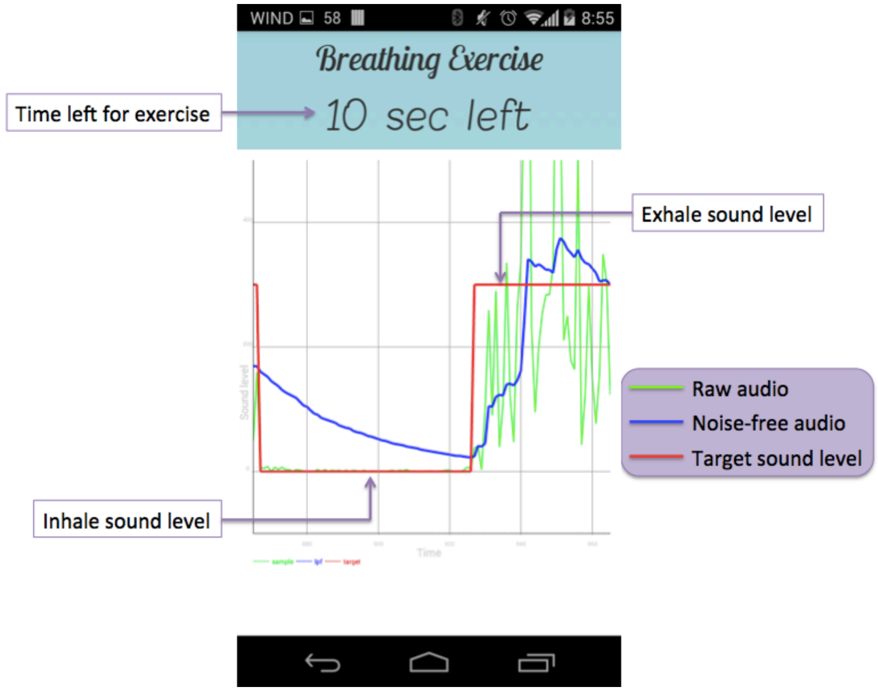


Figure 6: First UI developed for the Breathing Guidance System called the Graphical UI. This was discarded due to readability issue.

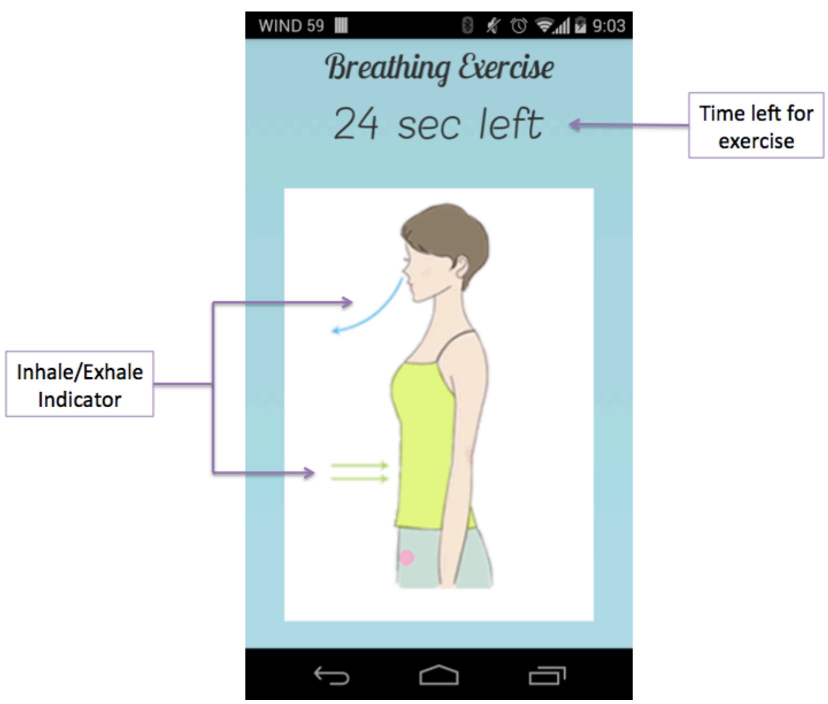


Figure 7: Second UI developed for the Breathing Guidance System called the Flipping Image UI. This was discarded due to lack of use of microphone input.

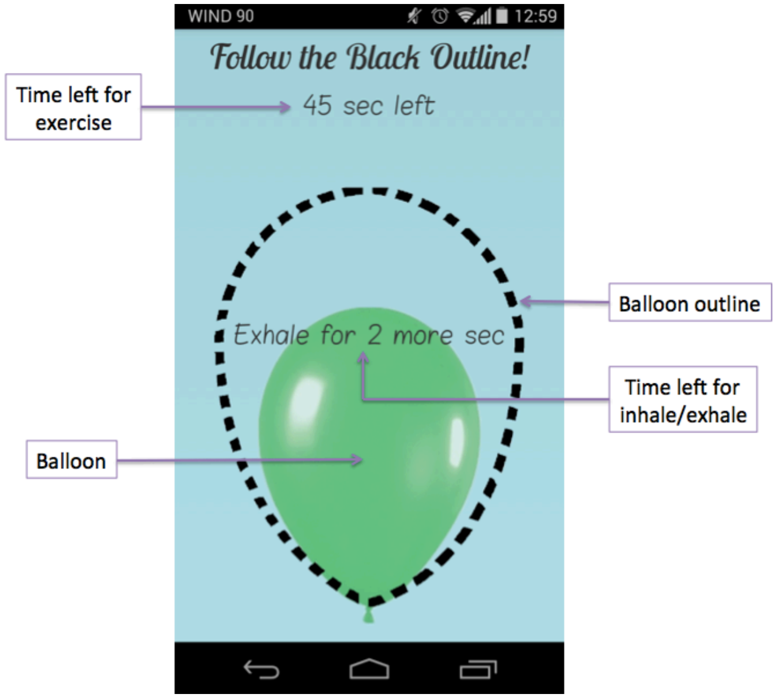


Figure 8: Third UI developed for the Breathing Guidance System called the Balloon Interface. This features simplicity that enhances readability during the exercise.

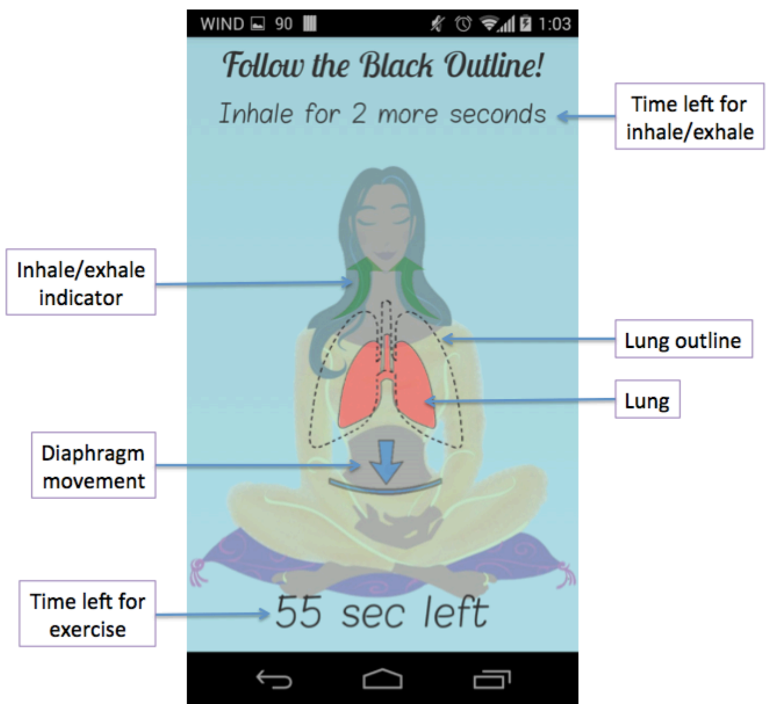


Figure 9: Fourth UI developed for the Breathing Guidance System called the Lung Interface. The yoga instructor in the background and the blue arrow reinforces the idea of proper posture and diaphragm breathing, respectively.

Appendix C – Trial Method

Figure 10: Flow diagram of the procedure taken for all samples during the trial.

Appendix D – Vancouver Interaction and Calmness Scale

The Vancouver Interaction and Calmness Scale

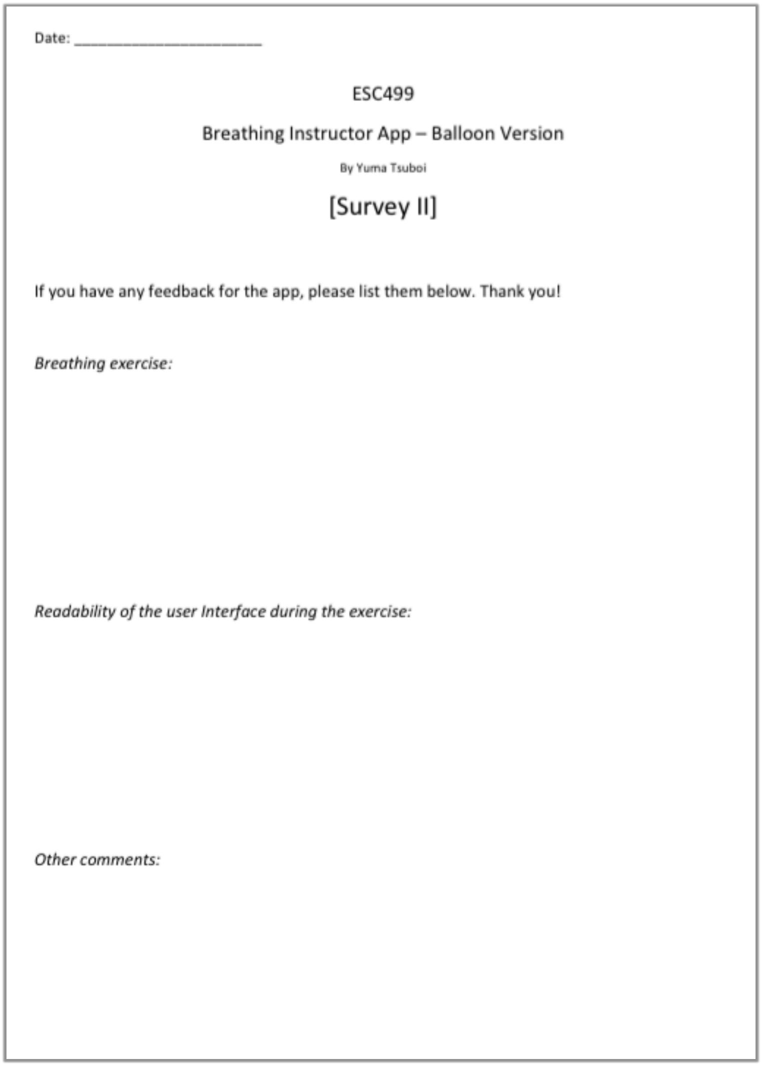
Interaction Score /30	Strongly agree	Agree	Mildly agree	Mildly disagree	Disagree	Stongly disagree
Patient interacts	6	5	4	3	2	1
Patient communicates	6	5	4	3	2	1
Information communicated by patient is reliable	6	5	4	3	2	1
Patient cooperates	6	5	4	3	2	1
Patient needs encouragement to respond to questions	1	2	3	4	5	6
Calmness Score /30	**Strongly agree**	**Agree**	**Mildly agree**	**Mildly disagree**	**Disagree**	**Stongly disagree**
Patient appears calm	6	5	4	3	2	1
Patient appears restless	1	2	3	4	5	6
Patient appears distressed	1	2	3	4	5	6
Patient is moving around uneasily in bed	1	2	3	4	5	6
Patient is pulling at lines/tubes	1	2	3	4	5	6

Figure 11: Established scale for rating calmness

Appendix E – Trial Questionnaire

Figure 12: Custom questionnaire asked to the trial participants before and after the breathing exercise.

Appendix F – Trial Survey



Date: ____________________

ESC499

Breathing Instructor App – Balloon Version

By Yuma Tsuboi

[Survey II]

If you have any feedback for the app, please list them below. Thank you!

Breathing exercise:

Readability of the user Interface during the exercise:

Other comments:

Figure 13: Survey completed by trial participants for general feedback on the breathing exercise and the UI.

Appendix G – Questionnaire Results

Balloon	1	2	3	4	5	6	7	8	9	10	Avg
Age	23	23	22	22	22	22	22	22	22	22	22.2
Gender	F	M	M	M	M	M	M	M	M	M	
Smoker?	No	No	No	No	No	No	No	No	No	No	
BPM	8	11	7	17	5	14	9	9	11	9	10
Calm (Before)	3	3	3	3	3	3	3	3	3	3	3
Calm (After)	5	3	3	3	5	3	6	5	5	3	4.1
Restless (Before)	5	3	6	4	5	6	3	5	4	3	4.4
Restless (After)	5	3	3	3	5	3	3	5	3	3	3.6
Distressed (Before)	3	3	4	4	4	6	3	3	2	3	3.5
Distressed (After)	5	3	3	3	3	3	3	5	3	3	3.4

Lung	1	2	3	4	5	6	7	8	9	10	Avg
Age	23	23	22	23	22	22	22	22	19	23	22.1
Gender	F	F	M	M	M	M	M	M	F	M	
Smoker?	No	No	No	No	No	No	No	No	No	No	
BPM	5	0	0	12	9	8	1	6	7	10	5.8
Calm (Before)	3	3	3	3	3	3	3	3	3	4	3.1
Calm (After)	5	4	5	5	5	3	6	4	3	5	4.5
Restless (Before)	6	3	2	5	4	3	6	3	5	3	4
Restless (After)	3	3	2	3	3	2	3	3	3	3	2.8
Distressed (Before)	3	3	4	5	4	5	6	3	3	3	3.9
Distressed (After)	5	3	2	5	4	4	3	3	5	4	3.8

1-Strongly disagree, 2-Disagree, 3-Mildly disagree, 4-agree, 5-Agree, 6-Strongly Agree

Figure 14: Result of the questionnaires from 20 samples. 10 samples were collected with the Balloon Interface (top) and another 10 samples were collected with the Lung Interface (bottom).